Intelligence and scientific expertise

Pierluigi Barrotta[1] · **Roberto Gronda**[1]

Abstract

In this article we develop a pragmatist-inspired notion of intelligence that should lead to a better understanding of the notion of scientific expertise. The notion of intelligence is drawn from Dewey and is therefore used here in its technical sense. Our thesis is that scientific knowledge is a necessary but not sufficient condition for scientific expertise; intelligence should also be added. Conceived of as the capacity to apply general knowledge to particulars, we reach the conclusion that intelligence is a necessary requirement for scientific experts in the wake of Dewey's logic of inquiry. In particular, we argue that an all-important task that scientific experts are asked to accomplish, and which puts their expertise to the test, is to transform indeterminate situations into problematic situations, and that such a goal can only be achieved if scientific experts succeed in paying attention to all the contingent and precarious aspects that make the situation they face unique.

Keywords Scientists vs. scientific experts · Intelligence · Epistemic and moral values · Indeterminate and problematic situation · Means-end relationship · Pragmatism

1 Introduction

When facing a technically complex problem—i.e., a problem in which technical and scientific components are essentially interwoven with social ones—it is natural to turn to a scientist or to a technologist for advice. It seems entirely rational to think

✉   Roberto Gronda
      roberto.gronda@unipi.it

      Pierluigi Barrotta
      pierluigi.barrotta@unipi.it

[1]   Università di Pisa, Pisa, Italy

that their deep knowledge of the discipline (or disciplines) relevant to the given context offers the best hope of solving the problem that hinders our plans and therefore prevents us reaching the desired well-being.

We wholeheartedly agree with the view that it is entirely rational to consult scientists and technologists to solve problems that require competences far superior to those possessed by ordinary citizens.[1] We, therefore, take it for granted that in many circumstances scientific knowledge is a *necessary* condition for solving problems of a certain complexity. At the same time, however, we do not believe that it is a *sufficient* condition: even though one cannot be a scientific expert without being a scientist, being a scientist is not enough to be a good scientific expert.[2]

The thesis that we want to put forward and defend in this article is precisely that being a scientist and being a scientific expert are by no means the same thing. More precisely, our thesis is that for a scientist to be a good scientific expert, she has to be endowed with *intelligence*, in the sense in which that notion is used by Dewey, a capacity that is not usually included among those scientific experts should have. The purpose of the present article is to clarify the nature of the intelligence required of scientists to play the role of scientific experts.

By focusing on that problem, we go against the grain of much of the existing literature in the field.[3] More importantly, we frame the question of scientific expertise

---

[1] This is not necessarily a trivial statement. Much literature in the Science and Technology Studies tradition shows considerable scepticism about the alleged ability of science to offer (albeit approximately) true or otherwise effective knowledge. As it has been observed, the scepticism of the STS has come to the conclusion that today "we are all experts": an apparently paradoxical way to deny a rationally founded distinction between scientific experts and laypeople (Collins, 2014). Though Collins and Evans have recently criticized the sceptical drift of the Second Wave of Science Studies, they are still hesitant to admit that science should be primarily conceived of as a truth-tracking activity (Collins and Evans, 2017; see also Collins, Evans, Durant and Weinel, 2020, Chap. 5). Their point can be formulated in a slightly different way, as saying that, since science is "so imprecise at best, and so much slower in reaching conclusions than the speed of politics at worst, that it mostly fails us as a political decision-making process", expertise (i.e., the use of scientific competence in political decision making) cannot but be "not-truth-like" (Collins and Evans, 2003, 436). Such a formulation has the merit of implicitly distinguishing between science and expertise, and in doing so it is close to our approach; yet we cannot agree with such denial of epistemic value to expertise. In any case, in this essay we will not directly engage in the discussion of the extensive literature that belongs to the STS—see Barrotta and Gronda (2019) for that; nor will we take into account the literature in the sociology of expertise—see, for instance, Eyal (2019) and Eyal and Pok (2011). We know that the lack of confrontation with those traditions has some serious drawbacks: in particular, we are aware that, by not paying due attention to the social and political factors that influence the activity of the experts, we end up with an excessively idealized image of scientific expertise. In other words, we realize that our perspective on the issue—which is concerned exclusively with *some* of its epistemic features—is partial and needs to be complemented with a more socio-political perspective. We also believe, however, that there is nothing in our approach that impedes such an integration.

[2] A word of clarification is needed regarding that distinction. It is apparent that, at least from a sociological point of view, being a scientific expert boils down to the fact of being hired or consulted as an expert. This is a purely descriptive stance, which investigates a specific feature of our contemporary knowledge societies. On the contrary, we are concerned with defining the conditions that make a scientific expert a *good* scientific expert. Our approach is, therefore, overtly normative.

[3] To our knowledge, Gundersen (2018) and Grundmann (2017) are the only clear attempts to draw a distinction between scientists and scientific experts similar to that which we defend here. Some ideas formulated in Whyte and Crease (2010) come quite close to our views—in particular, their insistence on the role played by trust in the interactions between science and society paves the way to the acknowledgment that "often what goes into making scientists appear credible or uncredible is not related to scientists'

in a way that is at odds with most of the current approaches. When seen from the perspective that we advocate, indeed, the issue of understanding the nature of scientific expertise does not boil down to the much-debated problem of understanding whether scientists and scientific experts know more, or are more successful in their predictions, or are more practically skilled, than novices. The point that we would like to make is that there are two questions, not just one, that philosophers of expertise should address: the first one deals with the conditions that define and constitute scientific *competence*; the second one deals with the conditions that define and constitute scientific *expertise*.[4] The traditional philosophical theories of expertise—the veritistic approach, the social-role account, the reputational analysis, and so on[5]—attempt to answer the former question; we are concerned with the latter, instead.[6] The two questions should be kept separate.

A final preliminary remark. Scientific expertise can be analyzed from a plurality of perspectives—epistemological, sociological, psychological, legal, institutional, and

---

values or research" (414). Nonetheless, they do not take the further step of distinguishing between being a scientist and being a scientific expert, which is the point that we would like to make. Stichter (2015) sketches a distinction, which he leaves unelaborated, between having expertise and being credited as an expert which is not far from the distinction between competence and expertise that we draw below: "Being credited as an expert is not the same thing as having expertise. There are a different set of questions that get raised when inquiring about who should be credited as an expert. Presumably the point of crediting people as experts is typically that there is something that we want from them" (125). In a similar vein, Turner emphasized that expertise implies some form of social recognition: it is not enough for an expert to be skilled or to possess reliable knowledge; she must be *acknowledged* as an expert by an audience. As he puts it, "[t]he experts whose expertise is employed are experts in the sense that they have an audience that recognizes their expertise by virtue of being trained by these experts" (Turner, 2014, 32). We agree with Turner that social recognition is a necessary condition for scientific expertise; nonetheless, we stress that, from a normative point of view, the process of social recognition should be responsive to some fundamental epistemic features of expertise.

[4] We are aware that, being slightly different from the traditional one, our use of the terms 'expert' and 'expertise' may cause some misunderstanding. We have nonetheless decided to use those words because any other word would have presented the same risk of confusion, while coining a new set of terms would have been misleading as well since it would have concealed the intrinsic relation between what we call expertise and the phenomenon of expertise as it is currently understood. We therefore ask the reader to bear in mind that in the present article scientific expertise refers exclusively to the fact, very well documented in Western contemporary societies, that scientists are often hired or consulted by private companies and public institutions to find solutions, give advice, provide new ideas on complex technical problems. Understanding what turns a good scientist into a good expert is the topic of this article. Moreover, it is worth remarking that we focus our attention exclusively on *scientific* expertise. It might be that all the different forms of expertise—sport expertise, cuisine expertise, teaching expertise, and so on—have something in common, but we prefer not to take a stance on that issue here, though we do not see any *a priori* reason for rejecting that possibility.

[5] The literature on the topic is quite large and is growing steadily. Some relevant truth-based accounts of expertise—to which the veritistic approach belongs—are Goldman (2001) and (2018), Coady (2012), and Fricker (2006). The social-role accounts are best exemplified by Agnew, Ford, and Hayes (1997) and Turner (2014). See Watson (2021) for a reasoned taxonomy of the various accounts of expertise; see Croce (2019) for a pondered discussion of the different methodological approaches that can be adopted to define what a cognitive expert is.

[6] By assuming that neither the sociological characterizations (the acquisition of academic qualifications, for example), nor the epistemological ones (the possession of superior knowledge) are sufficient to define what a scientific expert is, our approach has greater similarities with the equally vast literature that studies the cognitive processes involving the experts' skills. See, for instance, Anders Ericsson (2018) for a very useful introduction to the topic.

so on. A full-fledged theory of expertise is clearly expected to provide a consistent account of how all those aspects merge and interact with one another. Nonetheless, such a theory is yet to come. The goal of this article is, therefore, more modest: we set out to develop an idealized, normative analysis of what a scientific expert should be, in order to adequately perform the task for which they are consulted. We will therefore allow ourselves a certain degree of abstraction: for instance, we won't take into consideration the particular legislative framework regulating expert advice, though the kind of interaction permitted between scientific experts and laypeople is relevant to the understanding of the scope, limits and function of scientific expertise (Solomon, 2015, Chap. 2 and 3). We are aware that, as any abstraction, such an approach has some drawbacks; however, we hope that it helps bring to the fore some distinctive features of the phenomenon of scientific expertise that usually go unnoticed.

The article goes as follows. In the first paragraph, we briefly illustrate the main reasons in support of the distinction between scientists and scientific experts. In the second paragraph, we outline the philosophical framework in which we conceive of the notion of intelligence. In the third paragraph, we delve into the analysis of that concept, by relying on Dewey's notion of a problematic situation. In the fourth paragraph, we discuss two objections that are likely to be raised against our proposal.

2 Scientists and scientific experts

There are plenty of cases in which scientific experts failed (Collins, 2014).[7] Following the radioactive fallout from the accident at the Chernobyl nuclear power plant in 1986, scientific experts overlooked many important details of the local situation, thereby imposing ineffective and economically harmful restrictions on Cumbrian sheep farmers (Wynne, 1996). When the first drugs to treat AIDS were discovered, in the 1980s, scientific experts used the rigorous experimental protocols required by statistical theory, neglecting the dramatic situation that had occurred, with thousands of deaths and the growing concern of the sick and of their family members (Epstein, 1996). The engineers who built an imposing dam in the Vajont valley in Italy in the 1960s relied on their undisputed engineering knowledge, ignoring the unsuspected geological fragility of the slopes of the valley (Barrotta and Montuschi, 2018a).

Some questions naturally follow from the acknowledgment of the repeated failings of scientists to solve the problems they are asked to tackle. Why are scientists and technologists so unsuccessful when it comes down to solving complex technical problems? What type of knowledge do they lack, if any? And how are we supposed to trust them if they so often fail?

---

[7] A word of caution is needed here. As we said above, the analysis that we put forward in the article is strongly idealized. So, we will not take into account all those cases in which the failings of the scientific experts are due either to their lack of scientific competence or to any sort of moral misbehavior. Those cases are surely extremely relevant to a satisfactory theory of scientific expertise, but they fall outside the scope of our analysis. Our point is that, even in those cases in which scientists neither lack competence in their own field of research nor are morally wrong, they can still be poor scientific experts. Accordingly, in the following pages we will take it for granted that scientific experts are optimally competent and morally irreprehensible. This is a further layer of idealization that we ask the readers to bear in mind.

Those facts are startling since they are likely to undermine our confidence in the division of cognitive labor on which Western contemporary societies depend. And yet, a satisfactory account of those poor epistemic performances is still to be found.

It is at this point that the distinction between scientists and scientific experts chimes in. It ultimately relies on the now widely acknowledged fact that the explanation or prediction of a particular event is never (i.e., with the remarkable exception of artificial circumstances) deducible from general laws and initial conditions. There are various lines of reasoning that lead to that conclusion, but here we can limit ourselves to presenting the argument offered by Hempel in one of his last works (Hempel, 1988).[8] That argument has the advantage of showing how this conclusion can be reached by relying on a very classical approach to the nature of theories and explanation.[9]

According to the logical positivist tradition, the explanation and prediction of a certain event can be accounted for in terms of the so-called covering-law model. Thus, for example, the event "This iron bar will lengthen" is explained by deductively inferring it from a universal law[10]—such as "Heated iron bars lengthen"—and from a statement of the initial conditions—such as "This bar is made of iron" and "This bar is getting heated".

Clearly, logical empiricists were well aware that laws and initial conditions alone are not sufficient to guarantee that the event stated in the *explanandum* will follow, even in the happy case when all the elements of the *explanans* are true. For example, to take an example from Coffa (1973), a mischievous child could hammer both ends of the bar while it is being heated, thereby preventing the bar from lengthening. Given such possibilities, we cannot say that, given the law and a certain proposition concerning the facts of the case (this bar is heated), we can deductively infer the description of a particular event (this bar will lengthen).

A possible, often-suggested way out from such difficulty is to introduce *ceteris paribus* clauses. As is well known, a *ceteris paribus* clause shields the inference

---

[8] Hempel's argument was widely debated at the time and, in our opinion, it should be taken up and re-evaluated for its indirect support to the concept of intelligence in science. For a discussion of Hempel's thesis, see Coffa (1973), Giere (1988), Lange (1993), Lipton (1999), Schiffer (1991).

[9] In this article, we frame the issue of scientific expertise in terms of the application of general laws to specific cases. We know that that line of reasoning, which is quite classical, may sound outdated, as we are aware that in recent times the very idea of scientific laws has been strongly criticized, to such an extent that Cartwright spoke of a "dethronement of laws in science" (Cartwright, 2016). As a consequence of such suspiciousness towards the notion of laws, much attention has been paid to investigating the role and function of models in scientific practice. One may therefore be led to doubt whether our proposal depends on the particular image of science that we have adopted. We believe that that is not the case: indeed, the difficulties in the application of scientific knowledge to real-case scenarios are made more, rather than less, apparent when scientific models are given pride of place. Scientific models are made possible by abstractions and idealizations, and this feature has raised many doubts on their representational capacities. We do not want to take a stance on this issue, which would lead us astray. The point we would like to make here is that our emphasis on laws should not be considered as an easy way out of difficulties; rather, the opposite is true. See also fn. 11.

[10] We use "law" in an extremely broad fashion, so as to encompass all the sound generalizations that usually goes under the label of scientific body of knowledge. By using the term "law", therefore, we are not trying to smuggle in any distinction between genuine scientific knowledge (the one produced by hard sciences) and the kind of knowledge produced by social and human sciences.

by stating that no interference has occurred. For instance, it says that no relevant interference occurred on the metal bar while getting heated; consequently, we can conclude for the soundness of the inference that provides an explanation. Since all the propositions of the explanans are true—"Heated iron bars lengthen", and "This iron bar is getting heated"—we are warranted to conclude that the event asserted in the explanandum will take place. In other words, *ceteris paribus* clauses allow to apply the general law to the particular circumstances under consideration.

It is interesting to note that it was Hempel himself who acknowledged how inappropriate it would be to conceive of the function of *ceteris paribus* clauses in that way. His point was that *ceteris paribus* clauses should not be endowed with the overall power to shield the theory from any possible disturbing factors. In other terms, the deductive relationship between the premises and the conclusion of an explanation cannot be saved by relying on *ceteris paribus* clauses. Here is what he wrote in this regard:

> the idea of a ceteris paribus clause is itself vague and elusive [since it does not tell us] what other things, and equal to what […]. A [ceteris paribus clause] as here understood is not a clause that can be attached to a theory as a whole and vouchsafe its deductive potency by asserting that in all particular situations to which the theory is applied, disturbing factors are absent. Rather [the ceteris paribus clause] has to be conceived as a clause which pertains to some particular *application* of the given theory and which asserts that in the case at hand, no effective factors are present other than those explicitly taken into account (Hempel, 1988, 156–7 and 154; italics added).

What Hempel tells us is that in order to formulate a valid deductive argument we must have good reasons to believe that, during the application of our knowledge to the specific case under consideration, all the relevant factors have been correctly taken into account. It would be too rash to say that, *if* there are no disturbing factors, *then* our knowledge warrants the deduction of a phenomenon. The deductive model of explanation and prediction is different from hypothetical reasoning: the set of premises must actually explain or predict why a certain phenomenon has occurred "in the case at hand".[11]

The point that we would like to make is that it is possible to be highly *competent* in one field—to have a sound theoretical knowledge of the laws and principles of a scientific discipline and to perform well in it[12]—without thereby being able to act as

---

[11] The very same insight has been formulated by Nancy Cartwright in her criticism of the view of science as a "vending machine". According to that view, Cartwright remarks, "the theory is a vending machine: you feed it input in certain prescribed forms for the desired output; it gurgitates for a while; then it drops out the sought-for representation, plonk, on the tray, fully formed" (Cartwright, 1999, 247).

[12] In a pragmatist vein, we do not draw any relevant distinction between pure and applied science, nor between science and technology. On this point, see Hickman (1990) and Pitt (2011). From a sociological perspective, it is also important to stress that that distinction is often empirically useless, since much of the research on highly contested and controversial topics is carried out either in hybrid contexts, financed both by private and public sources, or exclusively by private companies. On this point, and its relevance for a theory of expertise, see Hess (2016).

a good *expert* in the case under consideration. What an expert is required to accomplish is to solve the specific problem that originated reflection and inquiry, and this entails paying attention to and taking into account the uniqueness of the features of the situation.

To take up one of (the many possible) examples mentioned above, the scientists hired by the UK Government to come up with a solution to the complex problems of the radioactive contamination from the fallout from the Chernobyl nuclear accident did not lack sound scientific competence. They knew very well the general laws that describe how caesium behaves in the different kinds of soil: for instance, they *knew* that in alkaline clay soils radiocaesium is quickly absorbed and then 'locked up' chemically and immobilized, which makes it unable to trickle into the vegetation. Accordingly, they predicted that a three-week ban would have been enough to restore the original situation, on the basis of empirical observations of the presence of alkaline clay soils in the area. Unfortunately, the scientists wrongly judged the chemical composition of the soil, and in doing so they "unwittingly transferred knowledge of the clay soils to acid peaty soil" (Wynne, 1992, 286). The reason for their failure as *experts* was therefore entirely due to their inability to grasp the specific features of the situation under consideration—a lack of attention and sensitivity that was reflected in their dismissive attitude towards the local knowledge of the Cumbrian farmers.

We draw a straightforward conclusion from those previous remarks. To be a good scientific expert, one has to be competent in her corresponding scientific field, and yet scientific competence is not enough. Something more is needed, and that is the capacity to apply scientific knowledge to the particular case at hand. Following Dewey's lead, we call such a set of skills *intelligence*.[13]

3 Intelligence and scientific expertise

In *The Quest for Certainty* (1929), Dewey defines intelligence as follows:

> Intelligence on the other hand is associated with judgment; that is, with selection and arrangement of means to effect consequences and with choice of what we take as our ends. A man is intelligent not in virtue of having reason which

---

[13] 'Wisdom' could have been a fine choice as well—actually, it was our first pick: see, for instance, Barrotta and Montuschi (2018b). However, as an anonymous reviewer has pointed out, the term 'wisdom' is too philosophically loaded to be used without further clarification. Our reviewer is right: the use of the word 'wisdom' to refer to the ability to apply scientific knowledge to the particular case at hand raises many different questions—not to mention the confusion that it may well bring about. First of all, speaking of wisdom in this context may lead many to believe that we are concerned with the moral character of experts, while we are interested in their epistemic capacities. Moreover, wisdom is an Aristotelian notion, while our approach is a pragmatist one, and the two traditions are not immediately compatible with each other when it comes to practical rationality. Again, the use of 'wisdom' would raise the problem of the relationship between epistemic and moral values, which is an issue of the utmost importance that we do not tackle in this article. Finally, since wisdom is a virtue, using that term would require us to take a stance on the debate on the epistemology of virtues. We believe that our approach falls squarely within the responsibilist camp, but we are not ready yet to provide a sound argument in support of our belief. For all those reasons, we opted for intelligence, which is a more neutral term. Nonetheless, we believe that those mentioned above are all very interesting lines of research that deserve serious investigation.

grasps first and indemonstrable truths about fixed principles, in order to reason deductively from them to the particulars which they govern, but in virtue of his capacity to estimate the possibilities of a situation and to act in accordance with his estimate. In the large sense of the term, intelligence is as practical as reason is theoretical (LW4, 170).

Leaving aside Dewey's reference to the notion of reason, which is part of his criticism of the traditional conception of philosophy as an activity concerned with the apprehension of a priori truths, and which is, therefore, not relevant for our purposes, the point of that definition is that 'intelligence' purports to pinpoint the capacity to cope with a specific situation, to perceive its possibilities and to deploy the means that are likely to attain the chosen end. It is in this sense that Dewey says that intelligence is practical; far from implying its lack of epistemic value, Dewey maintains that intelligence has much to do with the assessment of the facts of the case, as well as with the assessment of the general knowledge that is used as a set of means to lead the situation to its desired conclusion. The pragmatist notion of intelligence on which we aim to build our theory of scientific expertise revolves precisely around the epistemic irreducibility of the particular circumstances to the general knowledge, and the epistemic 'precariousness' that follows from such irreducibility.

In order to take a further step and provide a more detailed account of what intelligence is, we analyze that concept in the theoretical framework provided by Dewey's logic of inquiry.[14] First of all, let's start by recalling Dewey's definition of inquiry, as formulated in his *Logic: Theory of Inquiry* (1938). Inquiry is there said to be "the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole" (Dewey, 1938, 108–9).

Dewey's notion of inquiry is at odds with the contemporary epistemological approaches, for a plurality of reasons.[15] Some of them are direct consequences of Dewey's rejection of the traditional pragmatist assumption that inquiry is a process aimed at dispelling a state of doubt by generating a state of belief. Dewey believed the language of doubt and belief to be irremediably compromised by psychologism;

---

[14] To avoid confusion, we confess that our use of Dewey's logical theory is selective. The goal of Dewey's *Logic* is to identify a pattern shared by any possible inquiry, no matter whether practical or scientific. On the contrary, we take Dewey's theory of inquiry as a model for understanding scientific expertise, not as a general account of scientific activity. In this sense, the scope of our analysis is much more limited than Dewey's: for instance, we are not committed to Dewey's strong "continuist" theory that no structural difference exists between scientific and practical or common-sensical inquiries. At the same time, we do not explicitly reject that thesis; simply, we do not take a stance on the issue here.

[15] See Gronda (2020, Chap. 3); see also Levi (2010) for a lucid exposition of the differences between Dewey's idea of inquiry and his conception of belief revision. More recently, new attention has been paid to the notion of inquiry: see, in particular, Friedman (2017) and (2019), and Kelp (2021). Friedman, who does not refer to the pragmatist literature in her work, defines inquiry as an activity at whose centre is "a certain kind of mental state or attitude" (Friedman, 2019, 297). The difference between her approach and Dewey's is made evident by the following quotation from Dewey's *Logic*: "*belief* also means a personal matter; something that some human being entertains or holds; a position, which under the influence of psychology, is converted into the notion that belief is merely a mental or psychical state. Associations from this signification of the word *belief* are likely to creep in when it is said that the end of inquiry is settled belief" (Dewey, 1938, 15).

on the contrary, he held that the process of inquiry is objective in that it has to do with the modification and transformation of the external conditions that make up the problematic situation. According to Dewey, an inquiry cannot merely consist in the revision of a set of private beliefs: it has to bring about some changes in the situation that caused the inquiry to arise.

More relevantly to the present purposes, Dewey maintained that an inquiry is the solution of a *new* problem. Properly speaking, when the inquirer already knows how to handle the situation, the latter cannot be said to be genuinely problematic, no matter how much attention or reflection is needed to solve it. For a situation to be genuinely problematic, no habitual mode of action should be available to the inquirer: the solution to the problem has to be built up from scratch by taking into consideration the distinguishing features of the situation.[16]

Clearly, no inquiry would be possible if the inquirer could not rely on a pre-established body of knowledge. However, the indispensable role of scientific laws and generalizations should not conceal their limits. When we abandon the abstraction and idealization that make it possible to formulate scientific laws, and use them to make predictions for the future or to figure out possible courses of action, we enter a different world, one in which we are compelled to pay attention to all the contingent and precarious aspects of the problematic situation.[17] If those aspects are overlooked, the predicted outcome is likely not to occur. If that is the case, then, we can conclude that the specificity of the situation has not been successfully addressed: the inquiry is unsatisfactory because of the inquirer's poor epistemic performance. The inquirer lacked the epistemic qualities that were needed to properly handle the problem at stake; she lacked the capacity to carry out an accurate and methodical arrangement of the details into an inquiry. According to the terminology that we have adopted, she lacked intelligence.

Two relevant philosophical consequences can be drawn from those remarks. Firstly, as it should now be clear, Dewey's logic of inquiry does not purport to offer rules for mechanically deriving new hypotheses. Rather, it aims to clarify the processes that a scientifically educated agent must carry out if they want to get to the solution to the problems that called out inquiry. The solution to complex problems is not subject to mechanical procedures, but nevertheless it is subject to precepts that are acquired and refined through education in reflective and intelligent behavior. Dewey himself does not fail to underline this aspect of his logic in relation to education. In *How We Think*, for instance, he writes: "caution, carefulness, thoroughness, definiteness, exactness, orderliness, methodic arrangements are […] the traits

---

[16] We do not want to address this issue here, yet it is at least worth remarking that Dewey's logical theory is ultimately rooted in his metaphysics. As Dewey writes in *Experience and Nature*: "We live in a world which is an impressive and irresistible mixture of sufficiencies, tight completenesses, order, recurrences which make possible prediction and control, and singularities, ambiguities, uncertain possibilities, processes going on to consequences as yet indeterminate" (Dewey, 1925, 47). It is precisely this ontological vision that allows and at the same time requires the capacity of intelligence, since the contingent and the particular are always present alongside phenomena that allow the formulation of universal laws that organize experience. For a careful presentation of Dewey's metaphysics, see Boisvert (1988) and Alexander (2018).

[17] The notion of de-idealization has attracted considerable attention in current debates in philosophy of science. See, for instance, Knuuttila and Morgan (2019).

by which we mark off the logical form from what is random and casual on one side, from what is academic and formal on the other […] *intellectual end of education is entirely and only logical in this sense; namely, the formation of careful, alert, and thorough habits of thinking*" (Dewey, 1910, 225; italics in the original). To a certain extent, it can even be argued that Dewey's logic boils down to the analysis of how to gain an epistemic standpoint that makes the inquirer intelligent.[18]

Secondly, even though we have repeatedly stressed that intelligence is an epistemic notion, it would be wrong to draw the conclusion that it has no ethical content whatsoever. The problematic situations that scientific experts are called to handle are usually loaded with moral contents, and, as Dewey never gets tired of pointing out, every inquiry is made up of actions that have practical consequences in the sense of making changes to the existing conditions (Dewey, 1938, 175–6). Scientific experts must therefore evaluate the consequences of the actions they recommend in

---

[18] One of the problems that a full-fledged account of expertise has to address concerns the process of its acquisition. Within the pragmatist framework that we embrace, this means that an account of the acquisition of intelligence should also be provided. However, since our goal in this article is only that of firstly advancing some argument in support of the distinction between being a scientist and being a scientific expert and then locating the source of such a distinction, rather than developing a complete account of what makes scientific expertise possible, we have decided not to deal with that issue. Nonetheless, some remarks can be made even at this relatively early stage. It has been argued by a reviewer that the idea of a process of education through which an inquirer learns how to apply general knowledge to a range of particular conditions seems quite close to Dreyfus's five-stage model of the acquisition of expertise. On a general level, we agree with Dreyfus that expertise in the real world cannot be reduced to the possession of a body of reliable knowledge plus a repertory of heuristics (Dreyfus and Dreyfus 2005; see also Dreyfus and Dreyfus 1986). Acting in an uncertain world requires understanding the context in which scientific knowledge is to be applied. According to Dreyfus, an expert—as well as a proficient performer—*sees* what needs to be done: acquiring expertise implies the ability to "make more subtle and refined discriminations"; "with enough experience in a variety of situations […], the brain of the expert gradually decomposes this class of situations into subclasses, each of which requires a specific response", and this is what allows "the immediate intuitive situational response characteristic of expertise" (Dreyfus and Dreyfus 2005, 787). As will be highlighted in the next section, we also believe that intelligence is a matter of seeing things in a subtler and more refined way, and that is why we stress its epistemic value. Nonetheless, we think that there are a few points of disagreement between our pragmatist account of intelligence and Dreyfus's phenomenological account of the acquisition of expertise. Here, we limit ourselves to discussing two of them, which are particularly relevant. (1) Dreyfus's five-stage model is continuist (Selinger and Crease, 2006, 221): the instruction process starts with a very simplified environment, prepared by the instructor, and then goes on to get as much complexity as possible, up to the final stage. It is very difficult to map the acquisition of intelligence in this model, for a twofold reason. Firstly, scientific competence—i.e., the possession of general knowledge—cannot be identified with the first two stages, novice and advanced beginner, respectively. Learning how to apply scientific knowledge to real-world scenarios is, therefore, not the same thing as learning how to follow rules given by an instructor. Secondly, because of the complexity of the task that scientific experts are asked to tackle, it is very difficult to argue that the capacity of intelligence can be acquired by repetition of simpler activities, as Dreyfus's model would require. (2) According to Dreyfus, an expert not only sees what needs to be done; she also acts without reflection: as he puts it, "she also sees immediately how to achieve the goal" (Dreyfus and Dreyfus 2005,787). On the contrary, the acquisition of intelligence does not lead to an immediate decision, but rather stops acting out of habit: intelligence is the capacity to look at the situation under consideration and discover its relevant features; accordingly, it promotes further inquiry. So, all things considered, it seems that, in the case of intelligence, we are concerned with a higher-order capacity the acquisition of which cannot be understood through the model of the acquisition of skills, like playing chess or driving. That also means that intelligence does not fit into Dreyfus's descriptive model of expertise. See also Selinger and Crease (2006) for a detailed analysis of the main problems with Dreyfus's account.

situations that are always unique and potentially laden with moral consequences.[19] The key insight here is that there is no clear-cut distinction between what has moral content and what has not—that distinction, together with the one between pure and applied science, spins in the void. Anything can become public if its consequences affect the members of a community in a significant way.[20]

4 Indeterminate and problematic situations

The studies in philosophy of science from which we started left us with a negative result: knowledge of "universals" is not enough to successfully apply scientific laws in order to predict and explain phenomena. Intelligence is also needed, the lack of which had unequivocal moral implications, as shown in the case-studies sketched above. In the last paragraph, we argued that Dewey's theory of inquiry clarifies what intelligence consists of. Far from being concerned with the logical relationships between hypotheses and empirical evidence, such logic is concerned with the way one can hope to reach the solution of problems, whose character is at the same time epistemic and moral.

 With this material at hand, we now turn to a toy model of scientific expertise. Let's assume that a group of scientific experts is consulted to find the best way to provide a community with electricity; we initially leave the composition of the group unspecified—the reason will be clear in a moment. [21] Apparently, the task that scientific

---

[19] In recent times, much attention has been paid to the question of whether science is morally neutral or not (Elliott, 2017; Elliott and Steel, 2017). It seems that fewer and fewer scholars now believe in the moral neutrality of science. Be that as it may, the problem with which we are concerned is quite independent of the answer to the other question. There is no doubt, we believe, that the application of science to concrete situations has relevant moral consequences: we take the entanglement of factual and moral elements as a self-evident fact which does not require further analysis.

[20] This insight is true in the case of "pure" sciences too. Joliot-Curie decided to publish his research even though Leo Szilard begged him not to, because it could have helped the Nazis build the atomic bomb (Rhodes, 1986). Curie claimed he was interested in pure science alone and thought that was a good reason not to evaluate the details of the situation. However, nuclear physics had long since ceased to be a purely speculative enterprise (the search for the ultimate elements of the universe) and had become a morally relevant enterprise. The entanglement between what is "pure" and what is "applied" had become indissoluble. The scientists of the Manhattan project were engaged in complicated studies that could have been published in theoretical physics journals (Forge, 2008). At the time, the whole community of physicists had become well aware of that entanglement and its inevitable moral consequences. Curie proved "unintelligent" when, in the name of "pure" science, he refused to discuss and evaluate the details of the situation in which he was acting. See Barrotta (2018, 130) for a discussion of this point.

[21] It is important to note that our toy model of scientific expertise does not purport to *faithfully* represent the *entire* process of decision making, but only to shed light on the complexity of the situation that scientific experts are asked to address and the kind of activities that they have to perform in order to solve the problem at stake. We are ready to acknowledge that, when a group of scientific experts is consulted to find the best way to provide a community with electricity, a preliminary definition of the problem has already been made, which excludes any other possible alternative definition. Accordingly, the group of scientific experts is expected to act within the scope of the possibilities that the definition leaves open. We are also ready to acknowledge that the moment in which an expert is consulted and the task that she is asked to undertake make a great difference. It is easy to make a process of decision-making look impartial by fixing in advance what kind of problem the community is facing. We are aware of these problems, but we would like to make it clear that they do not follow from our account of scientific expertise; rather, they stem from

experts are asked to carry out is to compare, contrast and choose among the different ways in which energy can be produced—thermoelectric power plants, hydroelectric power plants, renewable-energy power plants, and even nuclear power plants. Suppose that, at the end of their inquiry, they came to the conclusion that the best way to produce the required energy would be by building a dam with a certain shape and in a certain place. The question we need to address is: what does an inquiry should look like to solve the problem of energy production and provision in a satisfactory way?

It seems clear that an inquiry that pays attention only to the geomorphology of the place—for example, the flow of the local river and its path, the possible places where to build the dam, the geological features of the land around the reservoir—or to the energy requirements of the community would not be adequate. Indeed, it does not take too much reflection to see that building a dam has important consequences on the community, at many different levels. So, for instance, scientific experts should examine the aesthetic impact of the dam, its economic benefits compared to, say, the destruction of the farmland, and so on. Or, to make another example, they should take into account the most relevant damages that the construction may cause to the local wildlife: it is a well-known problem that dams generally release colder waters coming from the bottom of the artificial basin, thus potentially endangering the reproduction of the fish species that are most sensitive to water temperature. The group of scientific experts would, therefore, be asked to figure out a possible solution to that problem, perhaps suggesting the purchase of devices that combine the coldest water from the bottom with the warmest water on the surface.

The point that our toy model is supposed to highlight is that, in such cases, technological, physical and value issues are closely intertwined, constituting the uniqueness of the situation that scientific experts should handle. It is precisely for this reason that we hold that scientific competence is not a sufficient condition for a person to be a scientific expert. It is not enough for the experts in our fictional scenario to be competent in their specific fields of research (for example, by having the theoretical knowledge necessary for the construction of dams, or the ecological knowledge of the behavior of the species living in that area), since the situation under scrutiny is made up not only of physical facts, but also of social values (aesthetic, economic, ecological). Evidence of this fact is that we feel that any decision that failed to take into account the plurality of aspects that are specific to the situation would be highly unsatisfactory: a project that would just address the technical engineering issues related to the building of the dam without paying any attention to its value consequences would be utterly incomplete.

Intelligence as we understand it consists in the capacity to grasp the internal complexity and uniqueness of the problematic situation under scrutiny and to find the best course of action that succeeds in satisfying its demands. Intelligent are those agents who are capable of discovering and correctly evaluating the demands of the situation. In this sense, intelligence amounts to a certain sensitivity to facts: intelligent scientific experts see the network of possible consequences that are already *there* in the situation, provided that the agent has acquired the capacity to search for them.

The connection between intelligence and perception is best captured by the distinction that Dewey draws between indeterminate and problematic situation (Brown, 2012). In his *Logic*, Dewey explicitly maintains that the problematic situation originates from a pre-existing indeterminate situation, which is called 'indeterminate' because no activity of inquiry has been carried out on its contents yet. The definition of the problem with which one has to deal is the most important step in the inquiry, as aptly expressed by the dictum that "a problem well put is half-solved". As Dewey remarks:

> To find out *what* the problem and problems are which a problematic situation presents to be inquired into, is to be well along in inquiry. To mistake the problem involved is to cause subsequent inquiry to be irrelevant or to go astray. Without a problem, there is blind groping in the dark. The way in which the problem is conceived decides what specific suggestions are entertained and which are dismissed; what data are selected and which rejected; it is the criterion for relevancy and irrelevancy of hypotheses and conceptual structures. On the other hand, to set up a problem that does not grow out of an actual situation is to start on a course of dead work, nonetheless dead because the work is "busy work" (Dewey, 1938, 108; italics in the original).

It is because of intelligence that the inquirer—or group of inquirers, as in the case under consideration—succeeds in understanding what the problem is "which a problematic situation presents to be inquired to". Things are there; objective conditions are there; nonetheless, it is the epistemic disposition of the inquirer that allows them to stand out and constitute a genuine problem, thus paving the way to a successful conclusion of the inquiry. If intelligence is lacking, some courses of action will be tried out anyway, but they won't lead to a satisfactory resolution of the situation.

Let's go back, then, to our toy model. As we said, the task for which scientific experts were consulted was to figure out the best way to supply a community with electricity. In Deweyan terms, this is the indeterminate situation which lies upstream of inquiry. The first step that scientific experts have to take is to turn the indeterminate situation into a problematic situation, which implies acknowledging that the original aim, "Find a way to supply the community with electricity", involves potentially conflicting goals and values. Thoroughly understanding the values at stake in the particular situation is a task that requires technical and scientific knowledge, as well as a considerable dose of intelligence to see which of the objective conditions of the situation may be of interest to the citizens. It is not merely a potential conflict between economic and environmental reasons. The same purpose of protecting the environment should be better specified, given the context in which one has to deliberate.

Values are often very broadly conceived, and one of the tasks of scientific experts is to try and better clarify such values in light of the specific situation.[22] There are those who consider wildlife protection as good in itself; others are concerned with saving tourism, which could support green economic development; others prize a production of electricity that mainly protects the quality of the air; and so on. All these ends are intertwined in different ways with the reasons of the economy and are potentially in conflict with them.

If scientific experts are intelligent, they come to realize that the problem they are asked to address is much more complex than was initially supposed: intelligence is the condition that makes it possible to successfully apply the body of existing scientific knowledge, firstly, to the definition and, secondly, to the solution of the problematic situation. The goal of the process of inquiry is, therefore, to bring to the fore, formulate and take into account the unique complexity of the problem at stake. Incidentally, it is for this reason that the composition of the group of scientific experts cannot be established in advance: it is open to change as the definition of the problem unfolds during the inquiry. The choice of which experts are relevant to the inquiry and the definition of the problem are really two faces of the same coin.[23]

5 Means-end relationships and the role of scientific experts

In this final section, we would like to address a couple of objections that are likely to be raised against the notion of intelligence put forward herein. Indeed, it might be argued that we are putting too much burden on the experts' shoulders, asking them to solve problems that are, first and foremost, public and political. Or, seen from a different perspective, it might be held that we are implicitly recommending a technocratic solution to public problems, which is at odds with the ways in which those problems are—or should be—dealt with in democratic societies. We believe that those two objections, which are strictly intertwined, rest on a serious misunderstanding of our views.

Let's start with the second objection, according to which ours is a technocratic approach to social problems. The reason why an objection along this line may look convincing is that much of the debate in the field of scientific expertise centers upon a clear-cut distinction between means and ends: it is commonly believed that, while the former are to be singled out by the experts, the latter are chosen by the members of the community through the channels of the political machinery. Consequently, it

---

[22] Following Dewey, Richardson (1994, particularly Chap. 7) rightly emphasized the importance of refining values in a deliberative process. On this issue, we part ways from many traditional accounts, included that of Collins and Evans, which are grounded on the assumption that scientific experts should not be allowed—neither should they be asked—to address any questions concerning ends and values, on the belief that any decision on those issues pertains exclusively to the public. On the contrary, we hold that facts and values, means and ends, are both discovered and determined in the course of the same inquiry.

[23] It goes without saying that in real-world scenarios scientific experts are not, to use Hamlin's incisive formula, "sitting cozily on the shelf, each tagged with a sign designating its appropriate domain of application, methodological loyalties", waiting to be consulted by the public (Hamlin, 2008, 172). The choice of a group of scientific experts as more adequate and reliable than the others is often the result of a struggle for recognition on the part of the experts.

seems straightforward to conclude that deferring to the scientific experts on values-related issues amounts to taking such issues away from the citizens' control, thus paving the way to a powerful form of technocracy.[24]

As pragmatists, we reject the clear-cut distinction between means and ends, together with the assumption that the goal of inquiry is given exogenously. On the contrary, we believe that means and ends are co-determined within the process of inquiry. Once again, we follow Dewey closely on this point, who in his *Theory of Valuation* firstly formulates the thesis that, in deliberative processes, means and ends are in principle inseparable:

> The standing objection against [my] view of valuation is that it applies only to things *as means*, while propositions that are genuine valuation apply to things *as ends*. [...] But it may be noted here that ends are appraised in the same evaluations in which things as means are weighed. For example, an end suggests itself. But, when things are weighed as means toward that end, it is found that it will take too much time or too great an expenditure of energy to achieve it, or that, if it were attained, it would bring with it certain accompanying inconveniences and the promise of future troubles. It is then appraised and rejected as a "bad" end (Dewey, 1939, 212).

The reason is that what Dewey usually calls an end-in-view—namely, the goal that the agent wants to pursue before starting the inquiry; in our toy model, the goal of supplying a community with electricity—has many unexpected consequences. Given a certain situation, the dull and unintelligent search for an end is more likely to create new and more urgent problems rather than a situation in which all the conflicting tendencies are eventually reconciled. If the group of experts of our model, who were consulted to solve the problem of electricity supply, interpreted that goal as exogenous and defined once for all, they would have to set themselves the task of finding the most efficient means to achieve that goal, no matter what its achievement could bring about. An inquiry that solves a problem at the cost of causing many others is certainly not what a successful inquiry looks like.

Facts and values are not severed as the philosophical tradition take them to be (Putnam, 2002). Scientific experts are faced with the various facts and values that characterize a unique, problematic situation. Their task is that of analyzing and better defining them in order to clarify their possible consequences within the particular situation at stake, with the aim of achieving a new unified situation in which conflicting tendencies cease. By searching for empirical facts and technical solutions, the pro-

---

[24] As Durant has pointed out, the fear of technocracy is grounded on the unquestioned assumption that scientific experts are exclusively guided by some sort of instrumental reason, to such an extent that they end up being almost completely unreflective about the social meaning of their activities. Durant convincingly shows that such an assumption is false: an empirical research conducted on two groups of scientific experts proves that "there are poor theoretical grounds for *generally* assuming experts are unreflective" (Durant, 2019, 48). According to Durant, the main reason why the image of scientific experts either as robotic or as dangerous is still held in some regards seems to be that it lends support to the view of the public as "practicing a socially sensitive form of flexible and adaptable reasoning", which is useful for fostering the contrast between scientific experts and the lay public (Durant, 2019, 38).

cess of inquiry brings to the fore and makes explicit the network of possible connections between different values. That does not entail that value-decisions are deferred to scientific experts; that entirely depends on the institutional setting in which public inquiries are carried out. Throughout an inquiry, the relations of dependence between means and ends are discovered and clearly formulated: who is in charge of the final decision is a wholly different question. Again, the notion of intelligence we attribute to scientific experts is distinctively epistemic; we do not hold that scientific experts are better, or more entitled, than citizens at deciding on a course of action. In the view we advocate, inquiry is to be conceived of as a process of conceptual clarification carried out by scientific experts along with the members of the community, who are responsible for the final decision.

We can now briefly turn our attention to the other objection, according to which our intelligence-centered account of scientific expertise forces scientific experts to participate in political discussion and debates. Here, a distinction has to be made between epistemic intelligence and political intelligence. A politically intelligent person is often the one who succeeds in showing how the different parties would benefit from accepting a compromise, which could avoid greater harm to them all. On the contrary, the task of an intelligent scientific expert consists precisely in trying to avoid that kind of compromises as much as possible. In fact, the more successful the scientific expert is, the fewer negotiations and compromises are needed. In the field of public policies, the aim of scientific experts is to find technical solutions that meet the needs of all the stakeholders involved in the problematic situation.[25] In our toy model, the group of scientific experts came to the conclusion of building a dam in a certain way and in a certain place because that solution could minimize the need for compromises among the stakeholders.[26] Clearly, this is not always possible; and yet good experts must try to get as close as possible to such ideal.[27] It is only when the scientific experts fail to accomplish the harmonious reconstruction of all the conflicting tendencies of the problematic situation that the need for political negotiation arises.

---

[25] Things are quite different outside the field of public policies. Indeed, it is not so uncommon for a company to hire an expert to achieve a given goal established by the firm's plan.

[26] These situations occur quite frequently, not only in our fictional scenario. Think of the recent pandemic, which would require careful study by philosophers too. Initially there was a furious debate between the supporters of economic reasons and the supporters of health reasons. It would be misleading to think that the debate was about achieving a compromise. Rather, a solution was sought that would have saved both reasons. For example, the experts proposed devices that would ensure the traceability of the people who had been in contact with those who tested positive. This gave rise to the protests of those who considered it a priority to safeguard another value, that of privacy. As a consequence, the experts tried to design devices that adequately guaranteed this value too. The task of the experts certainly did not consist in getting the parties to accept a compromise. Rather, their role was to avoid compromises as much as possible.

[27] Here, we find the figure of an expert that has been hitherto neglected by literature: the expert as a "reconciler" between different and potentially conflicting values (see also Pieke, 2007, who nevertheless addresses the issue from a somewhat different perspective). Having neglected this figure is in all probability a consequence of the received view, according to which ends are given exogenously to the experts. Admittedly, especially outside the field of public policies, it is sometimes possible for ends to be exogenously given to the expert. However, generalizing what is an occasional occurrence would be a serious mistake. In most cases, for experts an end is not exogenously given for the simple reason that they have the task of examining it critically.

6 Conclusions

In this article, we have tried to develop a pragmatist-inspired notion of intelligence through which the phenomenon of scientific expertise could be understood. Our thesis is that scientific competence is a necessary but not sufficient condition for scientific expertise; intelligence should also be added.

Within that framework of analysis, we could reach some results that may prove interesting. First of all, we have provided a constructive explanation of why scientists so often make mistakes when they are called to act as scientific experts. One of the merits of our explanation is that it does not lead to sceptical conclusions about scientific knowledge; another one is that it precisely locates the reasons for the experts' failure in their lack of intelligence; yet another one is that it provides an empirical thesis about where to intervene to improve the epistemic performances of those who are called to act as scientific experts.[28]

In addition, we have outlined the general form of the scientific experts' failures. Lack of intelligence can be defined as the incapacity to grasp the uniqueness and specificity of the conditions that define the problematic situation under consideration. Such an incapacity may be due to a lack of intellectual humility (which leads, for instance, to downplay the epistemic importance of local knowledge), lack of carefulness (which prevents the realization of how much the particular conditions differ from the idealized ones described by theoretical knowledge), lack of sensitivity (which leads to underestimate or completely overlook the moral consequences of technical decisions). In all these cases, what is lacking is the ability to perceive the real shape of the situation scientific experts are facing.

Finally, we have highlighted the main differences between the epistemic intelligence that is a necessary condition for scientific expertise and the kind of intelligence that is often specific to political activity. In doing so, any attempt to reduce the former to the latter is stunted, thus vindicating the autonomy of expert judgment.

---

[28] All these conclusions are compliant with the statistical surveys that have examined the criteria by which citizens decide to rely on third-party assessments (Eiser et al., 2009). According to these surveys, laypeople consider the understanding of their values and interests even more important than the competence of scientific experts. If a citizen is not sure that the experts have done their best to understand the problematic situation at stake, then it is more likely that she will trust her friends and relatives instead of the experts. The reason is that, even though those people are certainly less competent than the experts, they give her greater reassurances that her interests and concerns will be properly cared for. Our account of scientific expertise is capable of accommodating such empirical results.

References

Agnew, N. M., Ford, K. M., & Hayes, P. J. (1997). Expertise in context: Personally constructed, socially selected, and reality relevant?. In P. Feltovich, K. M. Ford, & R. R. Hoffman (Eds.), *Expertise in Context: Human and Machine* (pp. 219–244). MIT Press

Alexander, T. (2018). Dewey's Naturalistic Metaphysics. In S. Fesmire (Ed.), *The Oxford Handbook of Dewey* (pp. 25–52). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190491192.013.2

Anders Ericsson, K. (Ed.). (2018). *The Cambridge Handbook of Expertise and Expert Performance* (2nd ed.). Cambridge University Press

Barrotta, P. (2018). *Scientists, Democracy and Society A Community of Inquirers*. Springer

Barrotta, P., & Gronda, R. (2019). Scientific Experts and Citizens' Trust: Where the Third Wave of Social Studies of Science Goes Wrong. *Teoria*, XXXIX(1), 9–27. https://doi.org/10.4454/teoria.v39i1.54

Barrotta, P., & Montuschi, E. (2018a). The Dam Project: Who Are the Experts? A Philosophical Lesson from the Vajont Disaster. In P. Barrotta, & G. Scarafile (Eds.), *Science and Democracy. Controversies and Conflicts* (pp. 17–33). John Benjamins Publishing Company

Barrotta, P., & Montuschi, E. (2018b). Expertise, Relevance and Types of Knowledge. *Social Epistemology*, 32(6), 387–396. https://doi.org/10.1080/02691728.2018.1546345

Boisvert, R. D. (1988). *Dewey's Metaphysics*. Fordham University Press

Brown, M. J. (2012). John Dewey's Logic of Science. *Hopos: The Journal of the International Society for the History of Philosophy of Science*, 2(2), 258–306. https://doi.org/10.1086/666843

Cartwright, N. (1999). *The Dappled World. A Study of the Boundaries of Science*. Cambridge University Press

Cartwright, N. (2016). The Dethronement of Laws in Science. In N. Cartwright and K. Ward (Eds.), *Rethinking Order After the Laws of Nature* (pp. 25–51). Bloomsbury

Coffa, J. A. (1973). *Foundations of Inductive Explanations*. Ph.D. Diss., University of Pittsburgh

Collins, H. (2014). *Are we All Scientific Experts Now?*. Polity Press

Collins, H., & Evans, R. (2003). King Canute Meets the Beach Boys: Responses to the Third Wave. *Social Studies of Science*, 33(3), 435–452

Collins, H., & Evans R. (2017). *Why Democracies Need Science*. Polity Press

Collins, H., Evans, R., Durant, D., & Weinel, M. (2020). *Experts and the Will of the People*. Palgrave Macmillan

Coady, D. (2012). *What to Believe Now: Applying Epistemology to Contemporary Issues*. Wiley-Blackwell

Croce, M. (2019). On What It Takes to Be an Expert. *The Philosophical Quarterly*, 69(274), 1–21. https://doi.org/10.1093/pq/pqy044

Dewey, J. (1910). How We Think. In J. Dewey, J. A. Boydston (Eds.), *The Middle Works*, (Vol. 6). Southern Illinois University Press

Dewey, J. (1925). Experience and Nature. In J. Dewey, J. A. Boydston (Eds.), *The Later Works*, (Vol. 1). Southern Illinois University Press

Dewey, J. (1938). Logic: The Theory of Inquiry. In J. Dewey, J. A. Boydston (Eds.), *The Later Works*, (Vol. 12). Southern Illinois University Press

Dewey, J. (1939). Theory of Valuation. In J. Dewey, J. A. Boydston (Eds.), *The Later Works*, (Vol. 13, pp. 189–251).Southern Illinois University Press

Durant, D. (2019). Ignoring Experts. In D. S. Caudill, S. N. Conley, M. E. Gorman, & M. Weinel (Eds.), *The Third Wave in Science and Technology Studies* (pp. 33–52). Palgrave Macmillan

Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*. Free Press

Dreyfus, H. L., & Dreyfus, S. E. (2005). Peripheral Vision: Expertise in Real World Contexts. *Organization Studies*, 26(5), 779–792. https://doi.org/10.1177/0170840605053102

Eiser, J. R., Stafford, T., Henneberry, J., & Catney, P. (2009). 'Trust Me, I'm a Scientist (Not a Developer)': Perceived Expertise and Motives as Predictors of Trust in Assessment of Risk from Contaminated Land. *Risk Analysis*, 29(2), 288–297. https://doi.org/10.1111/j.1539-6924.2008.01131.x

Elliott, K. C. (2017). *A Tapestry of Values: An Introduction to Values in Science*. Oxford University Press

Elliott, K. C., & Steel, D. (2017). *Exploring Inductive Risk: Case Studies of Values in Science*. Oxford University Press

Epstein, S. (1996). *Impure Science. AIDS, Activism, and the Politics of Knowledge*. University of California Press

Eyal, G. (2019). *The Crisis of Expertise*. Polity Press

Eyal, G., & Pok, G. (2011). From a Sociology of Professions to a Sociology of Expertise. Columbia University Working Paper. Retrieved 30 August 2021 from http://expertdeterminationelectronicla-wjournal.com/wp-content/uploads/2017/02/Gil-Eyal-and-Grace-Pok-From-a-Sociology-of-Profes-sions-to-a-Sociology-of-Expertise.pdf

Forge, J. (2008). *The Responsible Scientist. A Philosophical Inquiry*. University of Pittsburgh Press

Fricker, E. (2006). Testimony and Epistemic Autonomy. In J. Lackey, & E. Sosa (Eds.), *The Epistemology of Testimony* (pp. 225–250). Oxford University Press

Friedman, J. (2017). Why Suspend Judging. *Nous*, 51(2), 302–326. https://doi.org/10.1111/nous.12137

Friedman, J. (2019). Inquiry and Belief. *Nous*, 53(2), 296–315. https://doi.org/10.1111/nous.12222

Giere, R. N. (1988). Laws, Theories, and Generalizations. In A. Grümbaum, & W. C. Salmon (Eds.), *The Limitations of Deductivism* (pp. 37–46). University of California Press

Goldman, A. (2001). Experts: Which Ones Should You Trust? *Philosophy and Phenomenological Research*, 63(1), 85–110. https://doi.org/10.2307/3071090

Goldman, A. (2018). Expertise. *Topoi*, 37 (1), 3–10. https://doi.org/10.1007/s11245-016-9410-3

Gronda, R. (2020). *Dewey's Philosophy of Science*. Springer

Grundmann, R. (2017). The Problem of Expertise in Knowledge Societies. *Minerva*, 55, 25–48. https://doi.org/10.1007/s11024-016-9308-7

Gundersen, T. (2018). Scientists as experts: A distinct role? *Studies in History and Philosophy of Science Part A*, 69, 52–59. https://doi.org/10.1016/j.shpsa.2018.02.006

Hamlin, C. (2008). Third Wave Science Studies. In M. Carrier, D. Howard, & J. Kouranty (Eds.), *The Challenge of the Social and the Pressure of the Practice* (pp. 160–185). University of Pittsburgh Press

Hempel, C. (1988). Provisoes: A Problem Concerning the Inferential Function of Scientific Theories. *Erkenntnis*, 28(2), 147–164. https://doi.org/10.1007/BF00166441

Hess, D. J. (2016). *Undone Science*. The MIT Press

Hickman, L. (1990). *Dewey's Pragmatic Technology*. Indiana University Press

Kelp, C. (2021). *Inquiry, Knowledge and Understanding*. Oxford University Press

Knuuttila, T., & Morgan, M. S. (2019). Deidealization: No Easy Reversals. *Philosophy of Science*, 86(4), 641–661. https://doi.org/10.1086/704975

Lange, M. (1993). Natural Laws and the Problem of Provisoes. *Erkenntnis*, 38, 233–248. https://doi.org/10.1007/BF01128982

Levi, I. (2010). Dewey's Logic of Inquiry. In M. Cochran (Ed.), *The Cambridge Companion to Dewey* (pp. 80–100). Cambridge University Press

Lipton, P. (1999). All Else Being Equal. *Philosophy*, 74, 155–168. https://doi.org/10.1017/S0031819199000236

Pieke, R. A. (2007). *The Honest Broker. Making Sense of Science in Policy and Politics*. Cambridge University Press

Pitt, J. (2011). *Doing Philosophy of Technology: Essays in a Pragmatist Spirit*. Springer

Putnam, H. (2002). *The Collapse of the Fact/Value Dichotomy and Other Essays*. Harvard University Press

Rhodes, R. (1986). *The Making of Atomic Bomb*. Touchstone Books

Richardson, H. S. (1994). *Practical Reasoning about Final Ends*. Cambridge University Press

Schiffer, S. (1991). Ceteris Paribus. *Mind*, 100, 1–17. https://doi.org/10.1093/mind/C.397.1

Selinger, E., & Crease, R. P. (2006). Dreyfus on Expertise. In E. Selinger, & R. P. Crease (Eds.), *The Philosophy of Expertise* (pp. 213–245). Columbia University Press

Solomon, M. (2015). *Making Medical Knowledge*. Oxford University Press

Stichter, M. (2015). Philosophical and Psychological Accounts of Expertise and Experts. *Humana.Mente Journal of Philosophical Studies*, 8(28), 105–128

Turner, S. (2014). *The Politics of Expertise*. Routledge

Watson, J. (2021). *Expertise. A Philosophical Introduction*. Bloomsbury Academic

Whyte, K., & Crease, R. P. (2010). Trust, Expertise, and the Philosophy of Science. *Synthese*, 177(3), 411–425. https://doi.org/10.1007/s11229-010-9786-3

Wynne, B. (1992). Misunderstood Misunderstanding: Social Identities and Public Uptake of Science. *Public Understanding of Science*, 1(3), 281–304. https://doi.org/10.1088/0963-6625/1/3/004

Wynne, B. (1996). May the Sheep Safely Graze? A Reflexive View of the Expert-Lay Knowledge Divide. In S. Lash, B. Szerszynski, & B. Wynne (Eds.), *Risk, Environment & Modernity* (pp. 44–83). Sage