


ARTICLE

# Scientific Disagreements, Fast Science and Higher-Order Evidence

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## Abstract

Scientific disagreements are an important catalyst for scientific progress. But what happens when scientists disagree amid times of crisis, when we need quick yet reliable policy guidance? In this article, we provide a normative account for how scientists facing disagreement in the context of “fast science” should respond and how policy makers should evaluate such disagreement. Starting from an argumentative, pragma-dialectic account of scientific controversies, we argue for the importance of higher-order evidence (HOE), and we specify desiderata for scientifically relevant HOE. We use our account to analyze the controversy about the aerosol transmission of COVID-19.

## 1. Introduction

In April 2020, an interdisciplinary group of scientists—including aerosol specialists, infectious-disease researchers, and building and ventilation engineers—alerted the World Health Organization (WHO) that the COVID-19 virus appeared to be airborne. The WHO’s reaction became a matter of controversy: while critics argued the WHO was too slow to react to the arguments presented by the proponents of the aerosol hypothesis, others maintained that the response was well paced and justified (Lewis 2022).

This case presents a puzzle for philosophers of science. We should be able to evaluate whether the fact that the WHO held firm in the face of dissent was warranted. However, accounts of peer disagreement, which provide norms for how scientists should adjust their cognitive attitudes in cases where they encounter a disagreement with their peers, fail to provide a clear answer. For one, these proposals themselves have not been univocal in articulating the rational response to peer disagreement. Whereas some have argued that disagreeing peers need to conciliate (Elga 2007; Christensen 2010; Feldman 2006, 2007), others have defended a steadfast approach (Cruz and Smedt 2013; Kelp and Douven 2012; Enoch 2010). Yet others have

suggested that different cases and contexts of disagreement may call for different verdicts (Kelly 2010; Konigsberg 2012; Christensen 2010; Douven 2010; Lackey 2013; Worsnip 2014; Borge and Guercio 2021). In addition, the bulk of this literature has focused on disagreements in the standard context of inquiry rather than inquiry in the context of “fast science” to which the current case belongs.

We use the term *fast science* to refer to application-driven research confronted with an urgent need to accept or reject a certain hypothesis for the purposes of policy guidance, aimed at addressing a significant pending social harm.<sup>1</sup> Although recent discussions of COVID-19 have emphasized the relevance of this notion in contrast to the traditional inquiry of “slow science” (Leite and Diele-Viegas 2021), fast science may be triggered by other problems as well: curbing other impactful diseases that may spread far and wide, climate-related issues, or agricultural problems requiring quick techno-scientific solutions. For any such case to count as an instance of fast science, there needs to be a scientific hypothesis that must be accepted or rejected for the purposes of immediate policy guidance (for instance, that a certain measure aimed at preventing the spread of the disease is effective and should be imposed; that the release of a certain pollutant in an ecosystem is harmful and should be stopped immediately; that a certain technological innovation could prevent a pending agricultural disaster if deployed quickly). Importantly—and in contrast to regular inquiry or slow science—postponing assessment of the hypothesis to acquire additional evidence may result in significant social harm.

Our aim in this article is to provide guidelines for how scientists and policy makers facing disagreement under such conditions should respond and, in particular, on which kind of evidence they should base their decisions. Formulating a normative account of this kind will allow us to evaluate the steadfast response by the WHO and determine whether it was warranted. As our point of departure, we will consider an argumentative, pragma-dialectic account of scientific controversies proposed by Donato Rodríguez and Zamora Bonilla (2013) (henceforth D&Z), which succinctly presents the epistemic and zetetic duties of disagreeing scientists from a diachronic, argumentative point of view.<sup>2</sup> We will argue that an epistemically adequate response to peer disagreement in the context of fast science must be based not only on first-order evidence (FOE) or object-level evidence (which refers to what is commonly considered scientific evidence) but also on higher-order evidence (HOE), which is evidence about evidence and the strength of the epistemic position one occupies. We will then take a closer look at the case of the aerosol hypothesis and examine whether the WHO took into account all the relevant FOE and HOE available at the time.

The article is structured as follows. In section 2, we provide an overview of D&Z’s account. In section 3, we supplement D&Z’s account with an explicit focus on HOE. In section 4, we examine the desiderata HOE needs to meet in order to count as scientifically relevant, and we specify the attitude of endorsement (Lacey 2015) as

<sup>1</sup> For the related notion of “urgent science” and criteria that determine if a research project is urgent, see Shaw (2022a, 2022b). As we discuss in section 6, Biddle’s (2013) cases of transient underdetermination are of a similar ilk.

<sup>2</sup> Zetetic or inquisitive duties are those pertaining to actions an inquirer should perform in their inquiry (Fleisher 2022). Usually these are performed with an eye toward securing some epistemic good, although there is much debate concerning the precise relationship between the epistemic and the zetetic (Friedman 2020; Thorstad 2022).

especially likely to depend on HOE in the context of fast science. In section 5, we describe in further detail the case study we started with and apply our account to the WHO's response. Section 6 examines potential objections to our account and the broader context of the controversy. Section 7 concludes.

## 2. An argumentative perspective on scientific disagreements

In this section, we explicate the argumentative pragma-dialectic approach to scientific disagreement developed by D&Z (2013). The spirit of the approach is to understand scientific disagreement with recourse to the tools of argumentation theory, as well as the Brandomian idea (Brandom 1994) of a game of “giving and asking for reasons.”<sup>3</sup> We will briefly sketch the account before turning to articulate where, as our case highlights, a theoretical lacuna remains.

D&Z aim to model and provide normative guidance for when scientists, already embedded in a discursive practice, disagree. Their starting point is to see scientific discourse as just another species of any rationally evaluable, normatively governed discourse (D&Z 2013, 43). Such discourse and the various speech acts that compose it can be understood in part by the broader scientific practice in which they are embedded and by examining the particular “moves” that scientists are entitled to make (i.e. the changes in deontic status they can affect). Two such examples concern “entitlement” and “commitment”:

On the one hand, a *commitment* is something that a scientist is committed to believe because it is a principle or a rule unanimously recognised as such by the community which she belongs to, or because it follows from other commitments according to the inferential rules accepted by that community. On the [other] hand, an *entitlement* is something legitimate for a scientist to be believed or claimed because she can provide good reasons (including, e.g., those provided by inductive methods, analogy or abduction and those provided by testimony and authority), although rejecting the same claim can also be legitimate for other members of the community. (D&Z 2013, 54–55; italics in original)

Conceived in this way, commitment and entitlement are deontic notions: commitment indicates one's duty to provide arguments supporting one's assertions, whereas entitlement indicates one's permission to stand behind a given assertion in view of a previously accepted set of premises or by providing arguments in support. The dynamics by which such deontic statuses change is governed by the internal normativity of the “game of science” (Zamora Bonilla 2010).

To make good on the actual role that notions like commitment and entitlement play in the progress of scientific discourse, D&Z turn to draw on the pragma-dialectical theory of argumentation proposed by Van Eemeren and Grootendorst (1984). According to pragma-dialectics, argumentation is a process aimed at resolving a difference of opinion on the merits by means of a critical exchange of argumentative moves. These moves take place between the “protagonist” of the standpoint at issue and an “antagonist” who doubts the acceptability of this standpoint or even rejects it

<sup>3</sup> For a related account of argumentation as an epistemic exchange, see Dutilh Novaes (2020).

(van Eemeren et al. 2014). Pragma-dialectics is thus a consensualist approach that sees successful exchange as requiring both the protagonist and the antagonist to agree on when the protagonist has been successful in their argumentation. Such success is determined by the rules of argumentation, which are norms that are implicit in any critical discussion guiding the participants' exchange of ideas in order to resolve differences in opinion (D&Z 2013, 60). This approach will naturally connect the deontic statuses possessed by participants in a discourse with the kinds of moves their interlocutors make by specifying when a certain move is appropriate. On this point, D&Z highlight norms for the retraction of standpoints, which allow for the initial entitlements and commitments to be defeated:

in pragma-dialectics, the protagonist is only obliged to retract the initial standpoint if the antagonist has conclusively attacked it and the antagonist is obliged to retract his or her call into question if the protagonist successfully defends his standpoint. . . . A situation of initial disagreement does not then amount to suspend[ed] belief. (D&Z 2013, 61)

To phrase these norms in the terminology of peer disagreement, a participant in disagreement must only abandon their attitude if it has been subject to conclusive attack. Further, only upon successful defense of the disputed position must the challenge to position be abandoned.

Importantly, although this position bears, on first glance, a striking similarity to steadfast approaches to peer disagreement in epistemology, it is more nuanced. Whether a protagonist is entitled to hold on to their standpoint depends on whether the antagonist has made a *legitimate conclusive attack*. Expressed this way, the norm leaves room for recognizing that what counts as a legitimate attack is judged by the standards of the given scientific practice within which a disagreement takes place, and as such, it belongs to more detailed issues than the pragma-dialectic argumentation framework aims to capture.

We find the proposal on offer a valuable contribution to characterizing disagreement within scientific discourse. First, the account is suited for the normative analysis of consensus-driven contexts, such as discussions preceding policy guidance. Second, because the primary unit of appraisal is "standpoints," the account can be adjusted to capture various cognitive attitudes that may come under dispute in scientific practice. A standpoint or a point of view is expressed with regard to a certain issue and defended by means of argumentation, with respect to someone who doubts its acceptability or has a different standpoint (van Eemeren and Grootendorst 2004, 2). A standpoint may express one's belief in a given proposition, but the degree of commitment to it "can vary from exceptionally strong, as in the case of a firm assertion, to considerably weaker, as in the case of a supposition" (van Eemeren and Grootendorst 2004, 64). This feature of pragma-dialectics is especially apt for analyzing cognitive attitudes scientists may disagree on in the context of fast science, such as endorsing a hypothesis as a suitable basis for policy guidelines.<sup>4</sup>

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<sup>4</sup> Although D&Z primarily discuss beliefs as units of appraisal, they don't address the relationship between beliefs and standpoints. The latter underlies van Eemeren and Grotendorst's pragma-dialectic approach and may differ from one's beliefs.

Although this framework provides the basis for analyzing scientific disagreements, it leaves the question of what counts as a legitimate (conclusive) attack or a legitimate (successful) defense open. We will therefore have to go beyond the pragma-dialectic theory to specify these norms. They concern common starting points that function as “substantive commitments” (in addition to the “procedural” ones) of the participants in a discussion, specifying what counts as legitimate content of an argument (van Eemeren et al. 2014, 529). As such, they are, according to the pragma-dialectic approach, a matter that is settled at the “opening stage” of the discussion. Because we are interested in scientific disagreements, we are after those norms that adequately capture the scientifically relevant exchange of reasons. But rather than leaving this issue implicit, we will propose norms that determine what kind of evidence scientists may legitimately use in a debate. In doing so, we will assume that the argumentative moves of participants—qua scientists—in scientific disputes can be evaluated according to these norms. In other words, we will take a normative angle on what counts as a substantive commitment for scientists taking part in a scientific exchange.

Although such an approach departs from the pragma-dialectic model in the strict sense, specifying these commitments is important if we want to apply the model to cases such as the controversy about the aerosol transmission of COVID-19. In particular, if the WHO found the evidence adduced at the time insufficient to warrant a change of its stance toward the aerosol hypothesis, we need to evaluate whether the WHO indeed provided a successful defense of its standpoint. This in turn requires a closer look at a specific kind of evidence—HOE—which played an important role in this debate. It is to this task that we now turn.

### 3. The role of HOE

HOE receives different treatment across epistemologies. Here are just a smattering of recent characterizations, that HOE is:

- “Evidence about evidential relations” (Christensen 2010)
- “Evidence about what your evidence supports” (Sliwa and Horowitz 2015)
- “Evidence about what you should believe” (Skipper and Steglich-Petersen 2019)
- “Evidence about one’s doxastic state” (Lasonen-Aarnio 2014)
- “Evidence that concerns how rationally one has responded to one’s first-order evidence” (Steglich-Petersen 2019)
- “Evidence which bears on a believer’s rational capacities, epistemic performance, or evidential situation” (Horowitz 2022)

For our purposes, we can consider HOE in line with the broad reading by Horowitz (2022), listed last in the previous overview. Our question in this section is how HOE, understood in this way, affects what counts as an argumentative attack and defense in scientific discourse.

The first thing to note is that peer disagreement is often taken to be a form of HOE itself (see, e.g., Christensen 2010; Kelly 2010). That is, the fact that an epistemic peer, someone equally competent and with equal access to the evidence, disagrees with one

suggests that one may have misjudged their epistemic performance or evidential situation.<sup>5</sup> Whether, and to what extent, this kind of evidence should affect one's doxastic attitude has been a matter of philosophical debate. A recent discussion by Henderson (2022) provides a helpful summary by distinguishing between "revise" and "level-splitting" views. According to the former, HOE merits a revision of both higher-order attitudes and first-order attitudes.<sup>6</sup> According to the latter, one's epistemic levels are split such that HOE affects higher-order attitudes without having evidential import for the first-order attitudes. So, depending on how one views the force of HOE, one will see its impact in cases of disagreement as calling for more or less revision about the matter at hand.

Similarly, whether HOE should play the role of defeater in scientific disagreements has also been a contested issue (see, e.g., Straßer et al. 2015; Borge and Guercio 2021). Our aim in this section is not to argue in favor of a specific weight of HOE relative to the weight of FOE. Rather, we wish to argue that HOE can *in principle* play a defeating role and serve as the basis for a legitimate move in scientific debates. We will take a closer look at the role and weight of HOE relative to other reasons in section 4.

Our thought is that HOE needs to be understood as part and parcel of what a disputant in any scientific debate to which the pragma-dialectical model applies need consider. In this way, and under specific conditions, the very fact of disagreement can serve to challenge the standing a protagonist has toward the claim they offer.<sup>7</sup> Similarly, evidence of one's track record indicating past misguided appraisals or evidence that a scientist in the debate might have a conflict of interest in the given matter can serve as the relevant HOE.<sup>8</sup> Consequently, if one party in a dispute provides arguments that amount to a "conclusive attack" in view of the FOE, HOE may challenge such conclusiveness. For instance, if a scientific community is divided on the accuracy of a certain hypothesis, where one party dismisses the opponents' arguments as too weak in view of what they consider to be relevant FOE (e.g., previous studies, experimental results), their position may be challenged by the relevant HOE (e.g., the very fact of disagreement about the strength of those results in the field). In this way, HOE may act as a defeater requiring defense that is separate from one's response to FOE.<sup>9</sup> In the next section, we discuss under which conditions HOE plays such a defeating role.

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<sup>5</sup> Note, however, that examples of HOE do not depend on the presence of disagreement; many cases discussed in the literature concern a single agent who, for instance, obtains evidence that they have consumed a substance that tends to impair one's reasoning. This information serves as HOE about their epistemic position.

<sup>6</sup> A first-order attitude is a doxastic attitude toward first-order propositions, which are those that concern ordinary subject matter in the world. In contrast, higher-order attitudes are directed toward higher-order propositions, which concern the doxastic states or attitudes of an agent, including the relationship between evidence and an agent's doxastic state (Henderson 2022, 3).

<sup>7</sup> Of course, whether the mere fact of disagreement (and the HOE it engenders) is sufficient to constitute a conclusive attack or defense will depend on features of the HOE's strength relative to the overall evidence at hand, as discussed in section 4.

<sup>8</sup> For a related notion of "meta-evidence," obtained in the field of meta-research, such as various kinds of biases endemic to certain practices, see Fuller (2018).

<sup>9</sup> The specific nature of the defeat provided by HOE—whether HOE *outweighs*, *undercuts*, or *brackets* FOE—has been a matter of philosophical discussion (Whiting 2021). Each of these notions would give rise to a specific type of argumentative attack.

Before we move on, it is helpful to express an adjusted version of the norms taken from the pragma-dialectical model by adding the substantive commitments concerning evidence that plays a relevant role in scientific debates:

**Protagonist Retraction:** A protagonist is obliged to retract her initial standpoint to the extent she has received FOE or HOE undermining her epistemic standing.

**Antagonist Retraction:** The antagonist is obligated to retract her attack to the extent the protagonist successfully defends her standpoint from both FOE and HOE.

Recall that our adjusted norms are not, strictly speaking, a part of the pragma-dialectic framework. As mentioned earlier, the pragma-dialectic approach assumes that any substantive commitments have to be agreed on at the opening stage of a discussion. In contrast, we assume that introducing HOE should indeed be agreed on as a legitimate move in a scientific debate. This allows us to formulate the norms for when the protagonist and the antagonist should retract their standpoints if their discussion is a part of the scientific discourse. Although we are therefore introducing a type of foundational norm (in the sense that these norms are a prerequisite of any scientific dispute rather than being subject to them), our norms are general, allowing for flexibility in further specifications. In particular, any details concerning the type of FOE or HOE or their relative weights are still left open, to be agreed on by the participants in a debate. Should participants in a debate disagree on the validity of these norms, any further discussion among them would be difficult if not impossible, making the pragma-dialectic model inapplicable to the analysis of such cases. Moreover, in this and the next section, we provide a meta-justification for these norms as sensible components of a scientific method broadly construed. Hence, we take our approach to be coherent with the pragma-dialectic model when the model is applied to scientific debates.<sup>10</sup>

#### 4. Scientifically relevant HOE

Not all HOE is equally valuable, for scientific disagreements or otherwise. In this section, we spell out additional features of the kind of HOE most useful to scientists disagreeing in the context of fast science. To start, consider the following case from the research on genetically modified organisms (GMOs) and their safety.

In 2015, a number of scientists affiliated with the European Network of Scientists for Social and Environmental Responsibility (ENSSER), together with coauthors from across the world, published a joint statement arguing that there is no scientific consensus on the safety of genetically modified crops and foods produced with them and that more research needs to be done to establish the safety of GMOs (Hilbeck et al. 2015). The authors wrote that the joint statement was “developed and signed by over 300 independent researchers” (1), that is, “by scientists from around the world in their personal (rather than institutional) capacities reflecting their personal views

<sup>10</sup> Clearly, scientists need not conceptualize these norms as such but need merely to have an implicit understanding, one acquired by education and participation in scientific practice, of appropriate ways of engaging in scientific discourse, which we claim will be along these lines.



and based on their personal expertise” (4). This seems to indicate that the list of signatories of the joint statement provides evidence of expert disagreement and, consequently, HOE undermining claims of GMO safety. Nevertheless, as criteria for expertise (and thus inclusion on the list), the authors write the following:

Qualifying criteria for signing the statement were deliberately selected to include scientists, physicians, social scientists, academics, and specialists in legal aspects and risk assessment of GM crops and foods. Scientist and academic signatories were requested to have qualifications from accredited institutions at the level of PhD or equivalent. Legal experts were requested to have at least a JD or equivalent. By December 2013, more than 300 people who met the strict qualification requirements had signed the statement. (Hilbeck et al. 2015, 5)

This means that among the signatories were indeed some experts on GMOs but also members of the broader scientific community who might not have expertise in biomedical sciences, let alone regarding GMOs and food safety. The opinion of scientists with no expertise in the given matter fails to constitute relevant evidence. Any higher-order evidential force this letter might possess as an attestation of expert opinion is thus significantly diminished. Accordingly, this case illustrates a failed attempt at acquiring scientifically relevant HOE by means of expert endorsement.

Note that we do not suggest that this statement as such fails to provide evidence of scientific disagreement. As Lacey (2017) has argued, the letter indeed provides such evidence to the extent that its signatories are experts on the matter. In other words, the strength of the HOE is here restricted to the experts in this domain. What we wish to emphasize is that by acquiring signatures from scholars lacking adequate knowledge of GMO safety, the HOE is not strengthened in an additional way.

Are these desiderata for expertise perhaps too demanding? After all, it would be a tall task to ask that every expert signatory to a letter like the ENSSER letter have expertise relevant to each domain of the letter’s claims. In the case of ENSSER, however, the main thrust of the letter is to dispute the idea that there is “scientific consensus” with respect to GMO food safety. Accordingly, the expertise relevant to addressing whether there is scientific consensus is appropriately delimited. It is unclear how legal academics or advanced degree holders from unrelated fields are in a position to adjudge whether there is scientific consensus on the relevant debate or, moreover, to contribute to the various pieces of evidence adduced in the letter—which deal with the interpretation of and judgments about specific scientific studies concerning GMO food safety. Moreover, discussions that subsequently addressed the ENSSER letter pointed out that its force was diminished as a result of overinclusion of irrelevant expertise (Landrum et al. 2019; Sánchez and Parrott 2017).<sup>11</sup> All in all, this case raises the question: What constitutes scientifically relevant HOE? We now turn to this question and specify a set of desiderata for scientifically relevant HOE.

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<sup>11</sup> We thank an anonymous reviewer for raising this helpful objection.



#### 4.1. *Desiderata for scientifically relevant HOE*

We now specify some of the central criteria for assessing the strength of HOE in the context of scientific discourse. We paradigmatically focus on scientific disagreements as a type of HOE, but similar criteria will also hold for other kinds of HOE (mentioned earlier in section 3).

First, HOE worth its salt will be garnered from epistemically respectable sources. Let us call this the *relevant expertise criterion*. For instance, the testimony of an expert on a certain gene-sequencing technique is, other things equal, of more pertinent relevance than that of a newcomer to the relevant debates. Assessing the relevant track records of possible sources is no easy task but is a matter that science as an institution has, in principle, ways of highlighting and with which practicing scientists are certainly familiar. If all the signatories in the ENSSER letter had been experts on GMOs and food safety, the letter would have provided stronger HOE in the context of disagreement.

Furthermore, the method of acquiring HOE needs itself to have meritorious epistemic credentials. Call this the *good acquisition criterion*. Taking just as seriously the testimony of scientists as offered in a short press release by a pharmaceutical company versus testimony acquired from an open letter signed by scientists in *Nature* would be a dangerous game. For a more realistic example, the testimony of well-placed peers as reported in generalist venues or popular science communications would offer weaker HOE than if the same testimony were acquired firsthand, for instance, from a specialist article authored by the given scientists. So good HOE in these contexts will be obtained via epistemically respectable methods.

Good HOE will also fail to possess any indication that its formation is the result of epistemically deleterious groupthink, or conformity bias (Solomon 2006). At best, HOE will possess indication that it has been produced in the opposite way, that is, by a group whose deliberations promote and preserve opportunities for dissent (e.g., by being produced within a group that employs experts of diverse and relevant backgrounds, having no known conflicts of interest, and who have varied research experience). Similarly, ensuring diverse opinions are appropriately addressed will also be another relevant factor that increases the quality of scientifically relevant HOE. Call this the *diversity criterion*.<sup>12</sup>

Finally, the more experts in support of the given standpoint there are, the stronger the HOE is. Call this criterion the *scope* of the HOE.<sup>13</sup>

<sup>12</sup> This criterion is closely related to the principle of independence, often discussed in the literature on peer disagreement; for example, Christensen (2009) notes: "In evaluating the epistemic credentials of another person's belief about P, to determine how (if at all) to modify one's own belief about P, one should do so in a way that is independent of the reasoning behind one's own initial belief about P" (758).

<sup>13</sup> The extent to which additional disagreement offers rational force is a contested issue in the peer-disagreement literature (Lackey 2013; Elga 2007). Most theorists agree that, at least, to the extent additional disagreement is independent, it has additional force. For our purposes, we can view the diversity criterion as constraining the scope criterion, such that the more experts from diverse approaches and groups in support of the given standpoint, the stronger it is.

#### 4.2. *The weight of HOE and scientific endorsement*

The previous list of desiderata should not be understood as necessary conditions for scientifically relevant HOE. Rather, they provide the basis for assessing the strength of the given HOE and the degree to which it is scientifically relevant. So what does this mean for the role of HOE in scientific disagreements? Our take is that HOE should affect one's first-order attitudes depending on its relative strength in the context of other epistemic reasons. In some situations, such as regular inquiry (or slow science), HOE may be outweighed by much stronger first-order considerations. Moreover, because scientists are not pressed to accept or reject hypotheses, they may also suspend their judgment until they acquire sufficiently strong FOE. As a result, scientists may postpone making assessments that underlie certain cognitive attitudes, such as accepting or rejecting a hypothesis for purposes of policy guidance.

The context of fast science is, however, such that scientists do not have the luxury of waiting for additional evidence before deciding to accept a certain hypothesis or not. In particular, fast science comes with pressure on scientists to make assessments that involve the attitude Lacey 2015 has called "endorsement":

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

We claim that given the contours of the context of fast science, endorsement will be a natural attitude at issue in scientific judgments and discourse. This context often requires endorsement even in the face of lacking or weak FOE. In such situations, HOE may provide a valuable source of additional epistemic reasons. For example, it may indicate that the space of potential defeaters of a hypothesis that is best supported by FOE is still open (e.g., because of an ongoing inquiry). This may suggest that the hypothesis shouldn't be endorsed because the policies based on it could soon end up being challenged on empirical grounds (once the additional evidence is available). As Lacey argues, a responsible endorsement of a hypothesis will ultimately be a matter of both epistemic and nonepistemic reasons, where the epistemic uncertainty has to be weighed against the nonepistemic consequences of error. What we wish to emphasize is that during times of fast science, epistemic reasons may be hard to come by, which is why scientifically relevant HOE should inform attitudes of endorsement in accordance with its relative strength.

What about the role of HOE in other contexts and with respect to other doxastic attitudes? In line with our elaboration of the pragma-dialectic account of disagreements, there is no reason why other doxastic attitudes (expressing one's standpoint in a debate) should not be informed by HOE, although its impact should depend on its relative strength in the overall space of epistemic reasons. Hence, whether HOE will result in protagonist or antagonist retraction will depend on the specifics of the case. What makes the context of fast science and the attitudes of endorsement particularly interesting is that they are likely to be accompanied by

relatively weak FOE. As a result, the role of HOE becomes especially relevant in situations that involve these constraints.

This leaves us with a question, however. Aren't considerations based on HOE already part of scientific deliberation and decision making? In the next section, we return to our case from earlier, the disagreement over aerosol transmission of COVID-19. With the fully elucidated pragma-dialectic framework and an account of scientifically relevant HOE on the table, we are now in a position to diagnose where scientists involved in this dispute went wrong and answer this question.

## 5. Aerosol transmission of COVID-19 redux

Before we evaluate the stance of the WHO on the hypothesis of aerosol transmission, we flesh out the background of the debate in further detail.

### 5.1. The controversy

At the time of controversy over the transmission of the COVID-19 virus, three broad models of viral transmission were discussed: droplet transmission, fomite transmission, and airborne transmission (WHO 2020a).

In the first model of transmission, droplets are expelled from infected individuals and enter the respiratory systems of others. Droplet transmission occurs primarily within close contact, and much of the strategy for fighting the pandemic turned on reducing the conditions ripe for droplet transmission via masks and social distancing.

In the second model of transmission, noninfected persons come into direct contact with infectious persons or contaminated surfaces. Strategies to avoid fomite transmission in the early pandemic involved wiping down potentially contaminated surfaces and avoiding close contact.

The third model of transmission, however, was seen as less of a genuinely prominent modality of transmission in everyday nonmedical contexts in which social distancing was possible. In this model, viral particles are transmitted in airborne fashion and may linger for long periods of time. What was pertinent for the WHO's deliberations was that no studies had been able to culture the virus from contaminated air particles (Wilson et al. 2020). This, in turn, suggested to the WHO that the airborne path was not a viable modality of transmission, especially in everyday contexts.

Expressed in terms of the previously introduced attitude of endorsement, we can say that the WHO treated the claim that aerosol transmission was a likely mode of transmission of COVID-19 as *not* being supported by evidence that was sufficiently strong to warrant the legitimacy of policy making informed by this claim.

A number of scientists found this response problematic, not least because culturing the virus from contaminated air particles was not expected to be quick and easy (Lewis 2022; Jimenez et al. 2022; Randall et al. 2021) In light of these concerns, an international, interdisciplinary group of scientists started to communicate and share their views.<sup>14</sup> Subsequently, a joint commentary signed by 239 "infectious-disease physicians, epidemiologists, engineers and aerosol scientists" (Lewis 2020) was published on July

<sup>14</sup> For a personal account of Linsey Marr, an aerosol scientist at Virginia Tech who was one of the central contributors to the discussion, see Molteni (2021).

6, 2020 (Morawska and Milton 2020). The commentary argued for a main claim: that aerosol transmission was likely a viable mode of transmission. It provided various reasons why this claim was worthy of further pursuit, including both positive (albeit preliminary) evidence in favor of the hypothesis as well as debunking explanations of why reasons to doubt the hypothesis weren't as strong as they initially seemed. This claim, then, alongside standard reasoning on the basis of the precautionary principle, suggested the WHO could stand to introduce precautionary measures based on this path of transmission. The broad thrust of the response was the following:

- Previous studies have shown that “viruses are released during exhalation, talking, and coughing in microdroplets small enough to remain aloft in air and pose a risk of exposure at distances beyond 1–2 m from an infected individual” (Morawska and Milton 2020, 2311).
- Previous studies of SARS-CoV-1, a predecessor of COVID-19, “demonstrated that airborne transmission was the most likely mechanism explaining the spatial pattern of infections” (2311).
- Studies of particular instances of the spread of COVID-19 (e.g., based on the analysis of video records from a restaurant) support the hypothesis of aerosol transmission of COVID-19 (Morawska and Milton 2020, 2311).
- The evidence for the aerosol transmission of COVID-19 is incomplete, but the evidential status of the other two modes of transmission—the large-droplet and fomite modes—is similar (Morawska and Milton 2020, 2311).
- In light of this evidence, public guidance governed by precautionary reasoning should be suitably informed—measures like effective ventilation, avoiding overcrowding, and so forth would be pertinent for combating this modality of transmission (Morawska and Milton 2020, 2312).

Expressed in terms of the attitude of endorsement, the open letter endorsed the claim that aerosol transmission was likely a viable mode of transmission of COVID-19; that is, the claim was treated as being supported by evidence that was sufficiently strong to warrant the legitimacy of policy making informed by this claim.

The WHO responded by acknowledging that aerosols couldn't be ruled out, especially in poorly ventilated places. In the updated brief from July 2020, the WHO stated that “SARS-CoV-2 is primarily transmitted between people via respiratory droplets and contact routes—although aerosolization in medical settings where aerosol generating procedures are used is also another possible mode of transmission” (WHO 2020b, 4). However, it retained the recommendation that keeping physical distance is the main preventive measure in public places, advising people to wear fabric face masks “where there is community transmission . . . and where other prevention measures, such as physical distancing, are not possible” (WHO 2020b, 4). By not including measures based on the aerosol hypothesis (e.g., effective ventilation in public buildings, based on airborne infection controls, or N95 face masks), the WHO refused to endorse it as the basis for policy guidance, even though many of the suggested measures were easy to implement and not particularly costly.<sup>15</sup>

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<sup>15</sup> As Lacey's definition of endorsement indicates, the nonepistemic consequences of accepting a hypothesis play an important role in the evaluation of its endorsement. Therefore, that measures

In sum, the disagreement between the WHO and the proponents of the aerosol hypothesis concerned the endorsement of the hypothesis for the purposes of policy guidance. Importantly, the debate was primarily about a question of the viability of a mode of transmission of a virus and the strength of evidence in its support. Subsequent policy decisions were to be informed by answers to this question, which proceeded in large part by an assumption that all parties to the debate reasoned in accordance with the precautionary principle.

It is with this backdrop that we are finally in a position to assess whether the WHO responded appropriately in this disagreement.

## 5.2. Our assessment of the WHO's standpoint

We can reconstruct the debate in terms of the previously described pragma-dialectic account, where the WHO plays the role of the protagonist, and the proponents of the aerosol hypothesis play the role of the antagonist. The WHO's standpoint on the aerosol hypothesis in July 2020, after the publication of Morawska and Milton's open letter, can be characterized as a rejection of endorsement of the hypothesis with respect to COVID-19 transmission in public places. As we have seen earlier, the WHO treated the evidence supporting the aerosol hypothesis as not being sufficiently strong to warrant the legitimacy of policy making informed by it. The assessment of the strength of the evidence had to be done in view of the nonepistemic consequences of accepting the hypothesis, in case it would have turned out to be false (e.g., the costs of effective ventilation, the cost of N95 masks in contrast to fabric masks and so forth), as well as the nonepistemic consequences of rejecting the hypothesis, in case it would have turned out to be true after all (e.g., the failure to prevent the spread of the virus and possibly save lives).

Recall that according to our norm Protagonist Retraction, the protagonist is obliged to retract the initial standpoint to the extent she has received FOE or HOE undermining her epistemic standing. The WHO's policy guidelines for public spaces were based on the endorsement of the droplet and fomite modes of transmission, leaving the aerosol mode for specific medical settings. On the one hand, the WHO received FOE, summarized in Morawska and Milton's open letter. However, this evidence was considered weak (Lewis 2022). For instance, in August 2020, another commentary was published on behalf of the WHO's Infection Prevention and Control Research and Development Expert Group for COVID-19,<sup>16</sup> stating that the primary routes of COVID-19 transmission were respiratory droplets and close contact and adding that "based on the scientific evidence accumulated to date, our view is that SARS-CoV-2 is not spread by the airborne route to any significant extent" (Conly et al. 2020, 1).

However, the WHO also received HOE: Morawska and Milton's 2020 commentary. This document, signed by over 200 scientists with relevant expertise, is evidence of

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resulting from the endorsement of the aerosol hypothesis were relatively cheap while being potentially lifesaving is a relevant factor. We come back to the role of values in disagreements on endorsement in section 6.

<sup>16</sup> Among the authors of the commentary, some are also members of the Infection Prevention and Control Guidance Development Group (IPC GDG), consisting of "about 40 clinicians and researchers that advises the WHO on infection containment, especially in hospitals" (Lewis 2022).

the disagreement between a part of the scientific community and the WHO on whether the aerosol hypothesis should be endorsed for purposes of policy guidance. As such, it provides HOE challenging the stance of the latter. Based on the criteria proposed in section 4, this is scientifically relevant HOE. First, the signatories of the document are scientists with relevant expertise concerning the spread of aerosols,<sup>17</sup> satisfying the relevant expertise criterion. Second, the commentary was published in *Clinical Infectious Diseases*, which is one of the leading journals in the field of infectious diseases.<sup>18</sup> This fulfills our good acquisition criterion. Finally, the fact that the group of signatories is interdisciplinary and international strongly supports our diversity criterion, and the large number of scientists indicates that the scope of the HOE is relatively strong as well.

Whether the WHO should have revised its position already in view of FOE is a question that goes beyond the scope of this article. Our aim here is to argue that even if the FOE was insufficiently convincing to change its standpoint, there was still HOE the WHO failed to adequately take into account. Because the WHO received scientifically relevant HOE undermining its epistemic standing, which it had no reason to dismiss, it was obliged to retract its standpoint. In particular, it was obliged to revise its endorsement of the relevant transmission paths of COVID-19 in public places and, on the basis of the precautionary principle, at least mention the guidelines that would lower the risk of aerosol transmission in public settings. By not adequately revising its endorsement of the relevant modes of the virus's transmission, the WHO failed to act according to this norm.<sup>19</sup> Indeed, it was only in October 2020 that the WHO acknowledged that aerosol transmission was happening outside of medical settings and subsequently updated its policy guidelines (Lewis 2022).<sup>20</sup>

## 6. Discussion

In this section, we address potential objections to our account and consider the broader context of the controversy.

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<sup>17</sup> The affiliations of all the signatories are provided in the Supplementary Data accompanying Morawska and Milton's commentary.

<sup>18</sup> For instance, according to the 2022 *Journal Citation Reports* by Clarivate, the journal's impact factor for 2021 was 20.999, ranking it 6th out of 94 journals in the category "Infectious Diseases" (taken from About the Journal," accessed on October 2, 2022).

<sup>19</sup> Our pragma-dialectic account is also compatible with Lacey's own take on what counts as *serious endorsement*: "*p* is seriously endorsed if and only if it can plausibly be portrayed as satisfying two conditions: First, its endorsement is based on outcomes of inclusive research in which . . . the interests of all relevant parties to obtain empirical data are taken into account; and, second, the proposals (regarding *p*) of each party to the research are subject to criticism on the basis of the strongest empirical evidence that can be obtained in the context of the time frame available, and in the light of evidence considered relevant by the critics" (Lacey 2015, 93). Although Lacey doesn't mention HOE, adding it would supplement his account in a similar way as we have done with the pragma-dialectic approach. The main reason why we have employed the latter is to allow for a sufficiently broad take on disagreements during fast science, which may also include other cognitive attitudes besides the attitude of endorsement.

<sup>20</sup> For a historical explanation of the WHO's resistance to the aerosol hypothesis, see Jimenez et al. (2022) and Randall et al. (2021), who root the problem in the decades-long dismissal of the airborne transmission of diseases and a mistaken measure of aerosol particles, used to distinguish them from larger droplets, that had become entrenched in the medical community.

### 6.1. Relevant expertise

Our analysis has thus far claimed that the WHO violated the Protagonist Retraction norm with respect to the endorsement of the hypothesis concerning the aerosol transmission of COVID-19 in light of new, scientifically relevant HOE. One might object, however, that the WHO was responding to a different sort of disagreement altogether.<sup>21</sup> That is, we might differentiate two questions about which there was perhaps disagreement:

1. *Factual Claim*: Aerosol transmission is a likely modality by which SARS-CoV-2 is transmitted (outside merely medical contexts).
2. *Policy Claim*: Aerosol transmission is a likely modality by which SARS-CoV-2 is transmitted (outside merely medical contexts) such that regulatory action and guidance should address it.

As the objection goes, the signatories to the letter that played the role of HOE were only epistemically pertinent with respect to the factual claim and not the policy claim. If the disagreement between the WHO and the letter signatories was concerning the policy claim, then the WHO did not err. Moreover, the relevant kind of HOE in such a scenario would include, for instance, evidence of potential biases in the WHO's decision making, which is different from the HOE we emphasize. The challenge, then, is to show that the letter can still function as good HOE that the WHO should have taken into account under Protagonist Retraction, if the debate was mostly about the policy claim.

To this objection, we'd like to offer two points of response.

To start, note that one claim concerns whether there exists enough evidential support to think aerosol transmission occurs outside medical contexts. The other concerns whether there is enough evidential support to think that aerosol transmission occurring outside medical contexts should be addressed by regulatory action and guidance. Presumably, expertise pertinent to the first causal claim need not be germane to the second policy claim.

However, whether there is "enough evidential support" for the policy claim crucially depends on whether there is "enough evidential support" for the factual claim. Therefore, the expertise required to establish the factual claim is of direct relevance to the policy claim. Accordingly, experts claiming that inputs crucial to the policy claim were in error certainly should serve as good HOE casting doubt on the WHO's conviction concerning the policy claim. Therefore, the letter should function as important HOE for both the factual claim and the policy claim.

Furthermore, as we saw in section 5.1, the dispute first and foremost concerned the factual claim. Indeed, a large chunk of the letter's text was devoted to articulating arguments in support of this claim (see Morawska and Milton 2020, 2311).<sup>22</sup> This shows that the signatories to the open letter considered the factual claim as the issue

<sup>21</sup> We are grateful to an anonymous reviewer for bringing this objection to our attention.

<sup>22</sup> Later reporting on the letter's genesis highlights that key organizers worried that the group advising the WHO about aerosol transmission failed to possess the appropriate expertise necessary for



under dispute. But it is precisely the dispute about the factual claim that explains the dispute about the policy claim. In other words, this is not a case in which both parties agree about the factual claim but disagree on the measures that should be taken on the basis of it.<sup>23</sup> Rather, it is a disagreement about whether the factual claim is sufficiently supported by evidence to warrant policy guidance informed by it. Indeed, our construal of this debate in terms of the attitude of endorsement (sec. 4.2) aims to capture the tight connection between the two claims.

Second, the open letter also provided arguments in favor of the policy claim, offering reasoning centered around a (presumably) shared commitment to the precautionary principle. Although one may wonder whether this falls within the expertise of scientists who themselves are not policy makers, the literature on expertise has in fact emphasized such assessments as indeed falling within responsible expert advice. For instance, according to Douglas (2008):

experts are more than just purveyors of an arcane disciplinary perspective. Such disciplinary work is embedded in a broader society that cultivates expertise for useful knowledge. And we expect experts to help inform crucial decisions, decisions that will affect millions (or billions) of people. Experts cannot take on the societal perks of expertise (such as ample public funding of research and the status accorded experts in society) and not take on the responsibilities that arise from having a real impact on society. (4–5)

Douglas's take on scientific expertise highlights the fact that scientists are often in a position where they have to make an informed judgment on policy issues. This also fits the current case, where the issue under dispute was not only the factual claim but also the *endorsement* of the factual claim in the specific context of its application. The factual claim was not discussed in a social vacuum, but in the context of the pandemic and the urgent social need to respond to it. As a result, judging whether there was "enough evidential support" to warrant the factual claim also had to be informed by what Biddle (2013) calls *contextual factors*, such as social, moral, and political values. The role of these factors is to help adjudicate whether the evidential support for the given hypothesis is strong enough, where responsible assessment of the strength of the evidence includes considering nonepistemic consequences of error.

As Biddle argues, extricating contextual factors is especially difficult in cases of "transient underdetermination." These are cases at the frontiers of science in which theories are underdetermined by logic and the currently available evidence. In such cases, contextual factors come into play at all stages of scientific practice: methodological choices and hypothesis selection, gathering/characterizing data, and data analysis and interpretation, including, crucially, conceptions of evidential strength and support (see also Douglas 2000).

Clearly, the contexts of fast science are much like the cases of transient underdetermination Biddle considers, insofar as both involve current

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understanding its viability, given their backgrounds concerning transmission within hospital settings (Lewis 2022, 27–28)

<sup>23</sup> If it were, HOE concerning, for example, inappropriate bias influencing the WHO or HOE based on its track record in ignoring evidence would have been relevant in that scenario.

underdetermination by evidence, ongoing research, and often the need for some kind of judgment about how to move forward. But if contextual factors like sociopolitical values frequently inform scientific judgment (see also Hoyningen-Huene 2023), this suggests that the assessment of evidential support will frequently be informed by the regulatory context and consequences. Insofar as judgments of experts about the factual claim are already and usually informed by some familiarity with regulatory context and consequences, there is no reason to think that the expertise of signatories to the letter must fail with respect to the policy claim.

Indeed, the open letter brings up contextual factors, such as practical, low-cost measures that would save lives. Moreover, it calls on the precautionary principle as an adequate normative framework for policy guidance in the case at hand. Therefore, disagreement on the policy claim can still be understood as relevant HOE.

To sum up, we have argued that the WHO received scientifically relevant HOE concerning the expert disagreement on its rejection to endorse the factual claim, which was therefore also relevant for the policy claim.<sup>24</sup> In addition, we have suggested that scientists often have to make judgments that are pertinent to policy making, in which case their disagreement on the policy claim also provides relevant HOE.

## 6.2. WHO did better?

The previous analysis has focused on the disagreement between a part of the scientific community and the WHO. But what about other public health institutions? Did they fare any better in their update of policy guidelines? And isn't our assessment simply uncharitable—after all, the WHO did revise its guidelines in October 2020, so why should it have revised them sooner than that? We close this section by addressing these two questions.

Concerning the former issue, at the Centers for Disease Control and Prevention (CDC) in the United States, the situation was not any better. Until September 2020, the CDC maintained that COVID-19 was primarily spread through close contact, from person to person. On September 18, 2020, the CDC finally published an update on its website, for the first time mentioning aerosol transmission. Just 3 days later, this information was removed: the CDC explained that a draft version had been posted in error and that further updates would follow (see, e.g., Tanne 2020), suggesting the CDC considered the aerosol hypothesis controversial.<sup>25</sup> On October 5, 2020, an

<sup>24</sup> Of course, one way of viewing the policy claim is as amenable to political expertise, above and beyond scientific expertise. In that case, our first rejoinder still applies. It is worth mentioning, though, that the scope of our analysis is restricted to the treatment of the case as an instance of a scientific disagreement. Consequently, a reader who is unconvinced of such an interpretation (given that the WHO is a political institution, after all) may consider our case study as an idealized version of the actual controversy.

<sup>25</sup> A question one may ask at this point is: Wasn't the attitude of the CDC supporting HOE for the WHO (and the other way around)? Our answer is that such an agreement indeed plays the role of HOE. However, it doesn't undermine the force of HOE obtained by Morawska and Milton's commentary, given the number of signatories and their expertise on the matter. For HOE to be rejected, one needs reasons pertinent to it specifically rather than different HOE in support of one's view. Given the scope of the HOE in this particular case, we do not consider the stance of the CDC to play such a defeating role.

adjusted version of the information concerning the spread of the virus was published, stating that COVID-19 “can sometimes be spread by airborne transmission.”<sup>26</sup>

This indicates that the public health institutions primarily based their scientific endorsement on FOE, as is usually done in the context of slow science. Even if one disagrees with certain particularities of our assessment in this case, our main point is to draw attention to the importance of HOE in the context of fast science.

Concerning the second issue—whether the WHO (as well as the CDC) revised its standpoint quickly enough—we have to emphasize that we are analyzing the context of fast science, where policy guidelines may have to be adjusted daily, given the epidemiological circumstances and incoming scientific evidence. The fact that the WHO did provide an updated scientific brief in view of the objections raised by the aerosol scientists suggests the WHO did react to it. However, as we have argued, the WHO failed to consider HOE as a relevant type of evidence that should have further informed its revised stance. Given the stakes, a revised stance on the precautionary measures in line with the aerosol hypothesis was already required in July 2020, rather than 2 or 3 months later.

## 7. Conclusion

In this article, we have aimed to provide a normative account of scientific disagreement in the context of fast science. For this, we have used a pragma-dialectic take on scientific disagreements by D&Z (2013) and enhanced it with the notion of HOE. Furthermore, we have provided criteria for assessing whether certain HOE is scientifically relevant. By applying our account to the recent controversy concerning the aerosol hypothesis of COVID-19 transmission, we have provided an explanation of why the WHO’s stance was unwarranted and what its stance should have been instead. Although certain elements of the case may have been idealized (as in any rational reconstruction of historical episodes), we hope our model provides a good starting point for analysis and guidance concerning disagreement in fast science. Furthermore, our account may equally apply to scientific disagreements in the context of slow science, although the relevance of HOE may not be as pronounced in such cases as it can be in fast-scientific disagreements.<sup>27</sup> In any case, with this revised framework in hand, we are in a better position to analyze scientific disagreements, the bearing of relevant evidence, and the degree to which the standpoint of each party in a debate is warranted.

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<sup>26</sup> “How COVID-19 Spreads,” accessed via [web.archive.org](https://web.archive.org) for October 5, 2020 (accessed on October 2, 2022).

<sup>27</sup> See, for example, Borge and Guercio (2021).

## References

- Biddle, Justin. 2013. "State of the Field: Transient Underdetermination and Values in Science." *Studies in History and Philosophy of Science Part A* 44 (1): 124–33.
- Borge, Bruno, and Nicolás Lo Guercio. 2021. "Learning from Scientific Disagreement." *Theoria* 36 (3): 375–98.
- Brandom, Robert. 1994. *Making It Explicit: Reasoning, Representing, and Discursive Commitment*. Cambridge, MA: Harvard University Press.
- Christensen, David. 2009. "Disagreement as Evidence: The Epistemology of Controversy." *Philosophy Compass* 4 (5): 756–67.
- Christensen, David. 2010. "Higher-Order Evidence." *Philosophy and Phenomenological Research* 81 (1): 185–215.
- Conly, John, Wing Hong Seto, Didier Pittet, Alison Holmes, May Chu, and Paul R. Hunter. 2020. "Use of Medical Face Masks versus Particulate Respirators as a Component of Personal Protective Equipment for Health Care Workers in the Context of the COVID-19 Pandemic." *Antimicrobial Resistance & Infection Control* 9 (1): 1–7.
- Cruz, Helen De, and Johan De Smedt. 2013. "The Value of Epistemic Disagreement in Scientific Practice. The Case of *Homo floresiensis*." *Studies in History and Philosophy of Science Part A* 44 (2): 169–77.
- Donato Rodríguez, Xavier de, and Jesús Zamora Bonilla. 2013. "Scientific Controversies and the Ethics of Arguing and Belief in the Face of Rational Disagreement." *Argumentation* 28 (1): 39–65.
- Douglas, Heather. 2000. "Inductive Risks and Values in Science." *Philosophy of Science* 67 (4): 559–79.
- Douglas, Heather. 2008. "The Role of Values in Expert Reasoning." *Public Affairs Quarterly* 22 (1): 1–18.
- Douven, Igor. 2010. "Simulating Peer Disagreements." *Studies in History and Philosophy of Science Part A* 41 (2): 148–57.
- Dutilh Novaes, Catarina. 2020. "The Role of Trust in Argumentation." *Informal Logic* 40 (2): 205–36.
- Elga, Adam. 2007. "Reflection and Disagreement." *Noûs* 41 (3): 478–502.
- Enoch, David. 2010. "Not Just a Truthometer: Taking Oneself Seriously (but Not Too Seriously) in Cases of Peer Disagreement." *Mind* 119 (476): 953–97.
- Feldman, Richard. 2006. "Epistemological Puzzles about Disagreement." In *Epistemology Futures*, edited by Stephen Hetherington, 216–326. Oxford: Oxford University Press.
- Feldman, Richard. 2007. "Reasonable Religious Disagreements." In *Philosophers without Gods*, edited by Louise M. Antony, 194–214. Oxford: Oxford University Press.
- Fleisher, Will. 2022. "Pursuit and Inquisitive Reasons." *Studies in History and Philosophy of Science Part A* 94:17–30.
- Friedman, Jane. 2020. "The Epistemic and the Zetetic." *Philosophical Review* 129 (4): 501–36.
- Fuller, Jonathan. 2018. "Meta-Research Evidence for Evaluating Therapies." *Philosophy of Science* 85 (5): 767–80.
- Henderson, Leah. 2022. "Higher-Order Evidence and Losing One's Conviction." *Noûs* 56 (3): 513–29.
- Hilbeck, Angela, Rosa Binimelis, Nicolas Defarge, Ricarda Steinbrecher, Andras Szekacs, Fern Wickson, Michael Antoniou, Phillip L. Bereano, Ethel Ann Clark, Michael Hansen, Eva Novotny, Jack Heinemann, Hartmut Meyer, Vandana Shiva, and Brian Wynne. 2015. "No Scientific Consensus on GMO Safety." *Environmental Sciences Europe* 27:article 4.
- Horowitz, Sophie. 2022. "Higher-Order Evidence." In *The Stanford Encyclopedia of Philosophy*, fall 2022 ed., edited by Edward N. Zalta and Uri Nodelman. Stanford: Stanford University Press.
- Hoynigen-Huene, Paul. 2023. "Objectivity, Value-Free Science, and Inductive Risk." *European Journal for Philosophy of Science* 13 (1): article 14.
- Jimenez, Jose L., Linsey C. Marr, Katherine Randall, Edward Thomas Ewing, Zeynep Tufekci, Trish Greenhalgh, Raymond Tellier, Julian W. Tang, Yuguo Li, Lidia Morawska, Jonathan Mesiano-Crookston, David Fisman, Orla Hegarty, Stephanie J. Dancer, Philomena M. Bluyssen, Giorgio Buonanno, Marcel G. L. C. Loomans, William P. Bahnfleth, Maosheng Yao, Chandra Sekhar, Pawel Wargocki, Arsen K. Melikov, and Kimberly A. Prather. 2022. "What Were the Historical Reasons for the Resistance to Recognizing Airborne Transmission during the COVID-19 Pandemic?" *Indoor Air* 32 (8): e13070.
- Kelly, Thomas. 2010. "Peer Disagreement and Higher-Order Evidence." In *Disagreement*, edited by Richard Feldman and Ted A. Warfield, 111–74. Oxford: Oxford University Press.

- Kelp, Christoph, and Igor Douven. 2012. "Sustaining a Rational Disagreement." In *EPSA Philosophy of Science: Amsterdam 2009*, edited by Henk W. de Regt, Stephan Hartmann, and Samir Okasha, 101–10. Dordrecht, Netherlands: Springer.
- Konigsberg, Amir. 2012. "The Problem with Uniform Solutions to Peer Disagreement." *Theoria* 79 (2): 96–126.
- Lacey, Hugh. 2015. "'Holding' and 'Endorsing' Claims in the Course of Scientific Activities." *Studies in History and Philosophy of Science Part A* 53:89–95.
- Lacey, Hugh. 2017. "The Safety of Using Genetically Engineered Organisms: Empirical Evidence and Value Judgments." *Public Affairs Quarterly* 31 (4): 259–79.
- Lackey, Jennifer. 2013. "Disagreement and Belief Dependence: Why Numbers Matter." In *The Epistemology of Disagreement: New Essays*, edited by David Phiroze Christensen and Jennifer Lackey, 243–68. Oxford: Oxford University Press.
- Landrum, Asheley R., William K. Hallman, and Kathleen Hall Jamieson. 2019. "Examining the Impact of Expert Voices: Communicating the Scientific Consensus on Genetically-Modified Organisms." *Environmental Communication* 13 (1): 51–70.
- Lasonen-Aarnio, Maria. 2014. "Higher-Order Evidence and the Limits of Defeat." *Philosophy and Phenomenological Research* 88 (2): 314–45.
- Leite, Luciana, and Luisa Maria Diele-Viegas. 2021. "Juggling Slow and Fast Science." *Nature Human Behaviour* 5 (4): 409.
- Lewis, Dyani. 2020. "Mounting Evidence Suggests Coronavirus Is Airborne—but Health Advice Has Not Caught Up." *Nature* 583 (7817): 510–13.
- Lewis, Dyani. 2022. "Why the WHO Took Two Years to Say COVID Is Airborne." *Nature* 604 (7904): 26–31.
- Molteni, Megan. 2021. "The 60-Year-Old Scientific Screwup That Helped COVID Kill." *Wired*. May 13, 2021. <https://www.wired.com/story/the-teeny-tiny-scientific-screwup-that-helped-covid-kill/>.
- Morawska, Lidia, and Donald K. Milton. 2020. "It Is Time to Address Airborne Transmission of Coronavirus Disease 2019 (COVID-19)." *Clinical Infectious Diseases* 71 (9): 2311–13.
- Randall, Katherine, E. Thomas Ewing, Linsey C. Marr, Jose L. Jimenez, and Lydia Bourouiba. 2021. "How Did We Get Here: What Are Droplets and Aerosols and How Far Do They Go? A Historical Perspective on the Transmission of Respiratory Infectious Diseases." *Interface Focus* 11 (6): 20210049.
- Sánchez, Miguel A., and Wayne A. Parrott. 2017. "Characterization of Scientific Studies Usually Cited as Evidence of Adverse Effects of GM Food/Feed." *Plant Biotechnology Journal* 15 (10): 1227–34.
- Shaw, Jamie. 2022a. "On the Very Idea of Pursuitworthiness." *Studies in History and Philosophy of Science* 91:103–12.
- Shaw, Jamie. 2022b. "Revisiting the Basic/Applied Science Distinction: The Significance of Urgent Science for Science Funding Policy." *Journal for General Philosophy of Science* 53:477–99.
- Skipper, Mattias, and Asbjør Steglich-Petersen. 2019. *Higher-Order Evidence: New Essays*. Oxford: Oxford University Press.
- Sliwa, Paulina, and Sophie Horowitz. 2015. "Respecting All the Evidence." *Philosophical Studies* 172 (11): 2835–58.
- Solomon, Miriam. 2006. "Groupthink versus the Wisdom of Crowds: The Social Epistemology of Deliberation and Dissent." *Southern Journal of Philosophy* 44 (S1): 28–42.
- Steglich-Petersen, Asbjørn. 2019. "Higher-Order Defeat and Doxastic Resilience." In *Higher-Order Evidence: New Essays*, edited by Mattias Skipper and Asbjørn Steglich-Petersen, 209–25. Oxford: Oxford University Press.
- Straßer, Christian, Dunja Šešelja, and Jan Willem Wieland. 2015. "Withstanding Tensions: Scientific Disagreement and Epistemic Tolerance." In *Heuristic Reasoning*, edited by Emiliano Ippoliti, 113–46. Cham, Switzerland: Springer.
- Tanne, Janice Hopkins. 2020. "Covid-19: CDC Publishes Then Withdraws Information on Aerosol Transmission." *BMJ* 370:m3739.
- Thorstad, David. 2022. "There Are No Epistemic Norms of Inquiry." *Synthese* 200 (5): 1–24.
- van Eemeren, Frans H., Bart Garssen, Bart Verheij, Erik C. W. Krabbe, A. Francisca Snoeck Henkemans, and Jean H. M. Wagemans. 2014. "The Pragma-Dialectical Theory of Argumentation." In *Handbook of Argumentation Theory*, edited by Frans H. van Eemeren, Bart Garssen, Bart Verheij, Erik C. W. Krabbe, A. Francisca Snoeck Henkemans, and Jean H. M. Wagemans, 517–613. Dordrecht, Netherlands: Springer.

- van Eemeren, Frans H., and Rob Grootendorst. 1984. *Speech Acts in Argumentative Discussions*. Berlin: De Gruyter Mouton.
- van Eemeren, Frans H., and Rob Grootendorst. 2004. *A Systematic Theory of Argumentation: The Pragmatic-Dialectical Approach*. Vol. 14. Cambridge: Cambridge University Press.
- Whiting, Daniel. 2021. "Higher-Order Evidence." *Analysis* 80 (4): 789–807.
- Wilson, Nick, Stephen Corbett, and Euan Tovey. 2020. "Airborne Transmission of Covid-19." *BMJ* 370: m3206.
- World Health Organization. 2020a. "Modes of Transmission of Virus Causing COVID-19: Implications for IPC Precaution Recommendations." Scientific Brief. March 27. <https://apps.who.int/iris/handle/10665/331601>.
- World Health Organization. 2020b. "Transmission of SARS-CoV-2: Implications for Infection Prevention Precautions." Scientific Brief. July 9. <https://apps.who.int/iris/handle/10665/333114>.
- Worsnip, Alex. 2014. "Disagreement about Disagreement? What Disagreement about Disagreement?" *Philosophers' Imprint* 14 (18): 1–20.
- Zamora Bonilla, Jesús. 2010. "What Games Do Scientists Play? Rationality and Objectivity in a Game-Theoretic Approach to the Social Construction of Scientific Knowledge." In *EPSA Epistemology and Methodology of Science*, edited by Mauricio Suárez, Mauro Dorato, and Miklós Rédei, 323–32. Dordrecht, Netherlands: Springer.

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