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Evoking, Grounding, and Defining: How Contemporary Scientists Connect Religion, Spirituality, and Aesthetics

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Abstract: Social scientific research challenges stereotypes of scientists as irreligious, on the one hand, and lacking aesthetic sensitivity, on the other. Yet, while some research suggests connections between these domains, the question remains as to whether and how scientists themselves connect their religion or spirituality with their aesthetic experiences in science. Drawing on interviews with 71 biologists and physicists in India, Italy, the United Kingdom, and the United States, we find three distinct logics by which scientists connect these experiences, which we call "evoking", "grounding", and "defining". We also find some scientists assume a modernist logic on which religion or spirituality and science are seen as separate to explain why they do not experience their religion or spirituality and aesthetic experiences as connected. Our findings enhance our understanding of how personal beliefs can shape and be shaped by professional experiences and suggest opportunities for dialogue between scientists and communities of faith centering aesthetic experience.

Keywords: religion; spirituality; aesthetics; science; qualitative methodology

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1. Introduction

The cultural authority of science and scientists has grown significantly in recent years (Gauchat 2011), yet public perceptions of scientists frequently remain anchored in stereotypes (Culliton 1990). Scientists are often depicted, for instance, as excessively analytical, entirely rational, and devoid of aesthetic experiences (Orzel 2015; Zahry and Besley 2021). Often, they are portrayed as "new atheists" opposed to religion as conflicting with scientific reasoning (Johnson et al. 2016). For many scientists, however, neither of these cultural images aligns with their own experiences.

American physicist and Nobel laureate Richard Feynman, for example, describes having a profound experience of beauty when scientifically understanding the inner workings of a flower. "I can appreciate the beauty of the flower", Feynman (1999, p. 1) writes. "At the same time [. . .] I can imagine the cells in there, the complicated actions inside which also have a beauty". For Feynman, experiencing the beauty of a flower generates a sense of excitement, mystery, and awe. Such aesthetic experiences in science are not restricted to an elite few. They are common among physicists and biologists alike. Biologists, for instance, find beauty in understanding the inner processes of systems, identifying hidden patterns, and appreciating the complexity, elegance, and simplicity of organisms (Vaidyanathan et al. 2023). Scientists of both disciplines also experience understanding itself aesthetically, finding pleasure and satisfaction in new scientific insight (Ritz and Vaidyanathan 2023). Research also highlights the relationship between aesthetic experience and well-being among scientists (Jacobi et al. 2022).

The stereotype of scientists as irreligious is similarly complicated by research showing a variety of ways scientists engage matters of faith (Ecklund 2010; Ecklund et al. 2019). Interviews with academic scientists in various social contexts suggest scientists can indeed

be religious and possess a sense of spirituality outside traditional religious frameworks by, for example, disconnecting it from theism and connecting with nature (Di and Ecklund 2017; Ecklund et al. 2019; Ecklund and Long 2011). They may even integrate their religion and spirituality into their work, such as in teaching and research ethics by, for instance, referring to religious teachings in one-on-one mentoring conversations with students (Di and Ecklund 2017; Ecklund et al. 2019).

Social scientific research thus challenges the prevailing stereotypes about scientists in regard to their aesthetic experiences, on the one hand, and religiosity/spirituality, on the other. These two literatures, however, tend to run on parallel tracks with little investigation into how scientists' religiosity/spirituality might connect with their aesthetic experiences in science. Scholarly examinations of scientists' religiosity and spirituality (R/S) typically focus on scientists' involvement in religious services or experiences of transcendence outside their scientific pursuits—with some exceptions for those who integrate religion and spirituality into their ethical considerations in science (Ecklund et al. 2019). Yet, the broader literature on aesthetic experiences suggests a close connection between religion, spirituality, and aesthetic encounters (Świątek et al. 2023; Van Cappellen and Saroglou 2012). In a recent study, Preston et al. (2023) examine whether scientists' aesthetic experiences yield comparable psychological benefits to those derived from their religiosity and spirituality. Even so, little work specifically examines the possibility of a connection between scientists' aesthetic experiences in their work and religiosity/spirituality as meaning-making systems. We expect that academic scientists do experience connections between their religion or spirituality and aesthetic experiences. But whether, how, and to what extent academic scientists connect R/S with their aesthetic experiences in scientific research remains unclear.

To answer this question, we analysed data from interviews with 71 scientists in India, Italy, the UK, and the US. Our findings reveal three distinct logics with which scientists connect their R/S and their aesthetic experiences: *evoking*, *grounding*, and *defining*.[1] Identifying and describing these logics contributes to the literature on science, religion, and spirituality by illuminating how scientists themselves experience connections between these domains. Our findings also enrich knowledge of scientists' aesthetic experiences, providing insights into when academic scientists have them and how they interpret them. Further, understanding how scientists link their R/S and aesthetic experiences offers new possibilities for dialogue between scientists and communities of faith, centering aesthetic experience. For the broader public, understanding whether scientists connect their R/S with aesthetic experiences may help dispel stereotypes about scientists (Gauchat 2011).

1.1. Religion, Spirituality, and Scientific Work

In modern times, science and religion generally have been perceived as being in conflict, a perception in accord with studies indicating that scientists and those with scientific knowledge were typically less religious than other people (Stark 1963; Thalheimer 1973; Tschannen 1991). Science became widely regarded as a driving force behind the decline of religious attendance and authority, a phenomenon commonly referred to as secularisation (Bruce 2002; Chaves 1994; Tschannen 1991).

Recent research, however, offers a different account. This work suggests tensions between science and religion stem primarily not from disparities in knowledge but rather from institutional boundaries and claims to authority made by individuals affiliated with science or religion (Evans and Evans 2008; Gieryn 1983). For instance, scientists may carefully differentiate evidence-based reasoning from religious reasoning as a means to establish the authority of science as a social institution (Ecklund 2010; Thomas 2021). Nevertheless, the manifestation of the institutional tension between science and religion varies based on scientists' religiosity, social locations, and the social and cultural contexts in which they work (Ecklund et al. 2019). Some religious scientists in the US, for example, conceal their religiosity in the workplace (Ecklund 2010). In Taiwan, some scientists navigate the institutional tension by avoiding discussions of religion and spirituality in

their teaching and research while addressing these topics in informal conversations (Di and Ecklund 2017).

Further, some scientists may cultivate an alternative form of spirituality, seeking a sense of sacredness outside conventional faith traditions (Di et al. 2020). Outside academic science, individuals identifying as spiritual but not religious may integrate cultural resources from various faith traditions and social institutions, creating an individualistic and arguably more authentic sense of sacredness (Bender 2010). In the context of academic science, scientists disassociate supernatural connotations from religions, secularise specific religious teachings, and uphold moral implications from religions to construct their alternative spirituality, thus addressing their tensions with conventional faith traditions (Di et al. 2020). Locating sources of tension between science and religion in the socially constructed boundaries between these domains suggests potential for those associated with science and religion to reshape norms in ways that help reconcile tensions between them (Evans and Evans 2008).

1.2. Aesthetic Experience and Spirituality

Scientists experience beauty in their work in various ways (Ritz and Vaidyanathan 2023; Vaidyanathan et al. 2023). Beauty is manifest in scientific observations, with biologists, for example, finding beauty in the elegant, simple, harmonious, symmetric, or pleasing colours and shapes they see during their scientific observations (Vaidyanathan et al. 2023). Additionally, beauty may be experienced through scientific exploration itself, as making sense of surprising findings can evoke an aesthetic sense of closure (Ritz and Vaidyanathan 2023; Vaidyanathan et al. 2023). These aesthetic experiences resonate with Feynman's perception of beauty when contemplating "the cells in there" and "the complicated actions inside" a flower (Feynman 1999, p. 1).

When academic scientists describe their aesthetic experiences in science, they sometimes draw comparisons with aesthetic experiences on the part of the faithful in their religious practices (e.g., Tinbergen [1958] 2017). For instance, Niko Tinbergen, a naturalist, likens aesthetic experiences in science to contemplative spirituality, noting that scientists "often felt that there is not less, and perhaps even more, beauty in the result of analysis than there is to be found in mere contemplation" (Tinbergen [1958] 2017, p. 154). This kind of comparison is even more pronounced in the narratives of religious scientists. Francis Collins, an American physician-geneticist and a Christian, for example, writes, "I cannot see how nature could have created itself. Only a supernatural force that is outside of space and time could have done that" (Collins 2006, p. 67).

Profound aesthetic experiences like those described by Tinbergen and Collins can evoke a sense of what psychologists call "awe", an emotional response that arises from exposure to overwhelming stimuli that exceed one's existing mental structure (Keltner and Haidt 2003). Experiences of awe may be evoked by unforgettable encounters with nature (Cohen et al. 2010) or intensely moving musicals (Gabrielsson 2011) but are also frequently tied to religion and spirituality (Keltner and Haidt 2003; Silvia et al. 2015). Some work suggests experiences of awe incline people to seek further spiritual experiences (Van Cappellen and Saroglou 2012).

The present article seeks to examine how scientists might connect the aesthetic experiences they have in their work with their religion and spirituality. While we expect scientists connect these domains, not all scientists may use spiritual or religious frameworks to make sense of their aesthetic experiences. Whether and how academic scientists link religion and spirituality to their aesthetic experiences is important to understand, considering the institutionally based tension between science and religion and reservations some academic scientists may have about incorporating religion and spirituality into their scientific work (Di and Ecklund 2017).

2. Methodology

2.1. The Study

Data for our study come from a broader mixed-methods project called "Work and Well-Being in Science".[2] The study included nationally representative surveys (N = 3442) and in-depth interviews (N = 215) with physicists and biologists working in PhD-granting institutions and research institutes in four countries: India, Italy, the United Kingdom, and the United States.

This selection of countries provides a rich diversity of cultural, historical, and institutional contexts, particularly when it comes to science, spirituality, and their interaction (Ecklund et al. 2019), affording insights into patterns a single-country study might miss. Our study's focus on both physicists and biologists also ensures diversity regarding scientists' relationships with religion and their aesthetic experiences, as research suggests the former (Ecklund et al. 2019) and the latter (Vaidyanathan and Jacobi 2022; MacArthur 2021) vary by discipline.

While the broader study was not focused on religion/spirituality, our survey provides basic demographic information regarding the religious and spiritual profiles of physicists and biologists in these four countries. We found that the vast majority of scientists identify as neither religious nor spiritual (55%), which aligns with previous research on scientists in these countries (Ecklund et al. 2019). We also found that 17% consider themselves as both religious and spiritual, 12% as religious but not spiritual, and 16% as spiritual but not religious.

Our survey also included various measures of aesthetic experience, which we find have intriguing associations with spirituality. On the whole, scientists who consider themselves spiritual (whether or not they identify as religious) score higher on survey measures of aesthetic disposition and report having aesthetic experiences more frequently at work compared to scientists who do not consider themselves spiritual. These differences, while statistically significant, are not substantial (see Appendix A). These associations further give us no insight into how scientists connect their aesthetic experience and their religiosity/spirituality. For this, we turn to our study's rich interview data.

Qualitative inquiry is an especially apt methodology for answering our research question since it allows us to understand how scientists make sense of complex phenomena such as aesthetics and spirituality, affording insight into the meanings they attach to their lived experiences. The analysis that follows thus centres on the qualitative data from our study.

2.2. Qualitative Analytic Sample

Our analytic sample comes from the broader set of 215 interviews with physicists and biologists in the four countries mentioned above, conducted between July 2021 and January 2022. We recruited the majority of these interviewees from a pool of scientists who completed our survey. The survey included a question asking whether the respondent would be willing to be contacted for a follow-up interview. From those who agreed to be re-contacted, we invited scientists to be interviewed who met our sampling criteria aimed at a diverse and balanced sample with respect to country, gender, discipline, and position. To reach a greater representation of certain characteristics of theoretical interest, including religious or spiritual identification, we recruited a subset of the 215 interviewees (n = 24) via snowballing techniques, inviting, for instance, religious or spiritual scientists acquainted with interviewees or research team members.

The interviewers used a semi-structured interview guide, which included questions about religion, spirituality, and their connection to aesthetic experiences in science, such as "Do you consider yourself religious or spiritual in any way?" and "Some people say that their faith or spirituality attunes them to beauty in science, or helps them experience awe or wonder in their scientific work. To what extent, if any, is this the case for you?" In many cases, the interviewer did not ask about such a connection because he or she knew from interviewees' responses to the survey or interview questions that they identified as

neither religious nor spiritual. In other cases, the interviewer chose to skip these questions to prioritise other topics more central to the study's main purpose, namely, to understand scientists' aesthetic experiences at work and their relation to scientists' well-being and practice of science; exploring the connection between aesthetic experiences in science and scientists' religious and spiritual identities and experiences was one among other secondary goals.

Our analytic sample thus comprises 71 respondents and excludes interviewees who identified as neither religious nor spiritual, who were not asked about the connection between religion/spirituality and their aesthetic experiences in science or were asked about this but whose responses either focused only on the relation between faith and science or were unclear.

In Table 1, we present the distribution of the key demographic characteristics among our analytic sample.

Table 1. Analytic sample characteristics.

	N	% of Analytic Sample
Country		
India	17	23
Italy	22	31
Uk	9	13
Usa	23	33
Gender		
Female	26	37
Male	44	62
Other	1	1
Discipline		
Biology	31	44
Physics	40	56
Position		
Postgraduate Student	20	28
Postdoc	16	23
Research Scientist	6	8
Junior Faculty	13	18
Mid-Level Faculty	7	10
Senior Faculty	8	11
Left Academia	1	1
Total Analytic Sample	71	100

We conducted all interviews via Zoom and in English, except for the Italian respondents, most of whom were interviewed in Italian by Italian-speaking interviewers. Italian-language interviews were translated into English by a professional translation company and then checked for quality by the interviewer. English-language interviews were transcribed by a professional transcription company and also checked for quality by research assistants. Interviews with scientists among our analytic sample lasted 74 min on average, ranging from 38 to 106 min. Interviewees each received a gift card valued at the equivalent of USD 50 in thanks for their participation. All names of interviewees in this paper are pseudonyms.

2.3. Qualitative Analytic Approach

The qualitative analysis for this paper is based on the interview data addressing the connection between scientists' religious faith or spirituality and aesthetic experiences in science. To identify these data, we read each of the interview transcripts, tagging all data relevant to religious or spiritual identification and the connection between religion or spirituality and aesthetic experience in science with relevant codes using ATLAS.ti, a software designed to assist qualitative interview analysis.

We then read and summarised all the interview passages tagged accordingly. For each interviewee, we noted whether he or she experienced a connection between his or her religion/spirituality and aesthetic experiences in science; if so, what sort of connection the interviewee expressed having experienced; and if not, what explanation the interviewee gave for experiencing no such connection. By comparing themes across cases, we inductively generated a typology of the logics of connections between religion and spirituality and aesthetic experiences in science that were evident in our data. We iteratively revised our articulation of the types as we read more data until they suited the patterns in our analytic dataset. The resulting typology is presented below.

While our sample is not meant to be exhaustive or our findings statistically generalizable, our study can lay important groundwork for future research. If scientists from diverse backgrounds and distinct scientific disciplines in various countries exhibit similarities in their connections between aesthetic experiences and spirituality, this suggests aesthetic experiences may be significant for religious and spiritual experiences more broadly.

3. Connecting Religion, Spirituality, and Aesthetics

The scientists that we interviewed who reported experiencing a connection between their religion or spirituality and aesthetic experiences in science (n = 49) expressed three main logics of connection: *evoking*, *grounding*, and *defining*. Most commonly, scientists' aesthetic experiences *evoke* their religious faith or spirituality, which tend to be transcendently oriented among scientists in our sample who experience evoking. Other scientists' religious faith or spirituality *grounds* their understanding and appreciation of the aesthetic experiences they have in science. Where evoking and grounding differ in the direction of influence between aesthetic experiences and religion/spirituality, *defining* is distinguished by the identification scientists make between the two. For many scientists who espouse an immanently oriented spirituality, experiencing awe or a sense of connection in their work *is* a spiritual experience.

We also found that many scientists (n = 22) report experiencing no connection between their religion or spirituality and aesthetic experiences in science. Most did not explain why (and interviewers rarely probed further), but those who did offered a typically *modernist* rationale (Ecklund and Johnson 2021), emphasising the idea that religion or spirituality and science are separate or distinct.

In what follows, we further describe and illustrate each of these logics by which scientists connect their religious faith or spirituality and aesthetic experiences in science.

3.1. Evoking

For some scientists with a robust religious identity, aesthetic experiences in science evoke their religious faith. As Timothy, a biologist and self-described "practicing Catholic" in the United States, puts it, "Seeing the beauty in the natural world, whether that be under the microscope or out in the woods experiencing nature, that connects me back to my faith".

Other interviewees specify what in particular about their religious faith their aesthetic experiences in science evoke. For Angela, an Italian Catholic physicist who describes religion as "an important part of my life", the beauty of nature calls to mind God the creator. "In the beauty of everyday things, even in the stars, the galaxies, the planets", Angela explains, "I see the reflection of what he created". Angela finds her scientific practice enriched by her experience of a connection between natural beauty and her religious faith since she is able to appreciate the beauty she sees not "as the work of nature only, but also as the work of a higher power that created all this beauty".

Similar to his Italian colleague, Peter, a Protestant physicist in the United Kingdom, sees the reflection of God in nature. But where Angela focuses on the beauty of God's creation, for Peter, "the vastness of what you're studying" evokes in particular "the awesomeness of God".

Traditionally religious conceptions of God, such as those espoused by Angela and Peter, do not exhaust what aesthetic experiences in science evoke for scientists. For some

scientists, such experiences evoke ideas and images more "spiritual" than religious,[3] while similarly bearing a transcendent orientation.

Mukesh, an Indian physicist who identifies as spiritual but not religious, for instance, recalls experiencing "the moment of awe" when reading about statistical physics for the first time. For him, this evoked the sense "that there is something bigger than us, our emotional, psychological—something much bigger than that, and we are just a part of it". Likewise, UK biologist Iliya, who identifies as someone who does not "fit into any of the obvious categories" when it comes to religion and spirituality, experiences the beauty of science as evoking "grander machinations". Iliya explains, "[What I see in science] is almost too beautiful to be. . .I mean, it is random, but I don't know. [. . .] It's nice to imagine there's something else going on".

The evocation of a transcendentally oriented spirituality by aesthetic experiences in science is not limited to nonreligiously affiliated scientists like Mukesh and Iliya. Even some religiously identifying scientists experience the beauty of nature as evoking "some higher entity", as Italian Catholic physicist Olivia puts it, which they do not necessarily understand in traditionally religious terms. "Everything I see looks beautiful", says Olivia. She continues:

> I see an image of a cell under a microscope and it looks beautiful to me. I see the image of a star and it seems beautiful. I see the data of an earthquake and it seems beautiful. It seems to me that everything can be traced back to some higher entity.

This "higher entity", Olivia goes on, is maybe "represented through religiosity", or perhaps, she wonders, it may be "the Earth itself, which is such a strong entity that it is a step above man". Olivia does not commit to either interpretation: "whether beauty is related to the Earth system itself or to some higher form of spirituality, I cannot say".

Likewise, in response to our question about whether she experiences a connection between her faith or spirituality and beauty in science, Margaret, a Methodist and biologist in the UK who rates religion as "moderately important" in her life, replies she "can't help but link the two" when "I stand in the mountains of Mongolia and look out". Margaret clarifies she does not necessarily mean "a Divine being" in a traditionally religious sense. She is not sure she even believes in that. "I am more thinking of divineness being broader than that, I guess. And I can't help but evoke that feeling of grandeur and awe when I'm working in nature". Similar to Olivia, Margaret leaves open the possibility that the transcendent evoked by natural beauty is something like the traditional conception of God without embracing that interpretation. With a laugh, she says, "if there is a God, I guess, I feel closer to God when I'm out there".

3.2. Grounding

For some scientists, the direction of influence between their aesthetic experiences in science and their religious faith or spirituality runs opposite from that for whom the former evokes the latter. These scientists' religious faith or spirituality grounds their understanding and appreciation of the aesthetic experiences science affords.

For scientists like Samu, an Italian physicist whose Catholic faith is "moderately important", their religious faith offers a framework for understanding why science offers aesthetic experiences in the first place. "If we didn't believe in the existence of a higher reality", says Samu, "we probably wouldn't be able to explain why reality presents itself as it is". Samu takes symmetry as an example, which he referenced earlier in our interview as an instance of beauty in science:

> I was talking earlier about symmetry. There is no motivation for reality to be symmetrical and yet it is symmetrical and this makes it beautiful. The reason why physics can't explain it, the only reason that one can think of, is that someone, something has decided that reality is as it is.

Samu's faith in a transcendent "someone, something" as the ultimate cause of natural symmetry allows him to make sense of the beauty he sees in it.

Likewise, religious faith grounds US biologist Daniel's understanding and appreciation of what he finds "amazing" in science. A Catholic for whom religion is "very important", Daniel agrees with a point he attributes to Einstein:

> I guess I kind of take the—there's a quote that I'm paraphrasing, I probably don't have it exactly right, from Einstein, who said that, 'Maybe the most amazing thing about knowing about our universe is that it's knowable,' you know what I mean?[4]

"I find that to be kind of interesting", Daniel comments. "It's almost as if", he muses quizzically, "God *wants* us to know about it?" He continues: "I kind of feel in a certain sense that by practicing science, if I know more about myself and I know more about the world, I can know a little bit more about this universe that God created". Daniel's belief in God the creator helps him make sense of the intelligibility of the universe—the most "amazing" thing about science—as perhaps intentionally designed to be so. Moreover, this understanding allows him to appreciate his work as bearing religious significance in that the knowledge it generates is a window into God's creation.

Fellow US biologist Jay's appreciation of his aesthetic experiences in science also stems from his religious faith. "I think there's a real sense", says Jay, an Episcopalian, "in which, when we take time to pray and to give thanks to God for the blessings of this life, it does remind me to have my eyes open to what's beautiful and good in the world".

Samu, Daniel, and Jay each espouse a traditionally religious identity and ground their aesthetic experiences in science in a traditional conception of God. But, the grounding logic they express is not restricted to scientists with a religious identity and faith. Indeed, some scientists who identify as spiritual but not religious operate with a similar logic.

Hili, for instance, sounds a lot like Jay, except it is her nonreligious spirituality that grounds her appreciation of the beauty she sees in her scientific work. A biologist working in the United Kingdom, Hili identifies as spiritual but not religious. Her spirituality centres on appreciating "more traditional ways of dealing with stuff like anxiety, but even health related issues", and she practices meditation on a daily basis. "When you do something like mindfulness", she explains, "you take a step back and you're more likely to appreciate the beauty around you, which sometimes you forget when you're rushing and you're after some details or whatever". Hili's spiritual practices of meditation and mindfulness ground her appreciation of beauty in science.

3.3. Defining

While some scientists' aesthetic experiences in science evoke the transcendent, whether understood in traditionally religious terms or otherwise, or their religious faith or spirituality grounds their understanding and appreciation of these experiences, others' aesthetic experiences help define a more immanently oriented spirituality. These scientists tend to be nonreligious. For them, aesthetic experiences at least partially comprise their spirituality outside conventional religions.

Similar to Peter, Veer, an Indian biologist working in the United States, experiences nature's "vastness" aesthetically. But whereas Peter links this to the "awesomeness" of God, for Veer, admiring nature's vastness is a spiritual experience in its own right.

In our interview, Veer describes himself as "not religious at all" (while identifying as Hindu on our survey). After gradually falling out of religious practice, Veer tells us that he continued believing in God for several years but is now an atheist. As to "spiritual", he is not quite sure how others might define that but reckons he is "a little spiritual". Veer explains: "I believe that there is something after death, but, no, I'm not religious. I'm also an atheist, but a little spiritual. I admire the glory of this vastness around us". Veer identifies as spiritual in part precisely because he feels awe when admiring nature.

Similar to Veer, scientists whose immanently oriented spirituality is, in part, defined by their aesthetic experiences in science tend to identify as spiritual but not religious. US

biologist Javier, for instance, says, "I'm definitely not religious. I think I'm spiritual". He continues:

> But I think a lot of the way I'm spiritual is through science in a way, like the natural world, how it really triggers a spiritual sense to me. Like makes me tingle, I guess, to think about things we know and things we don't know, and how much we don't know, and the mystery and craziness of life, and the diversity of life.

Javier identifies his spirituality with the "tingle" (said with a self-conscious laugh) he feels when contemplating the horizons of human understanding, as well as with the sense of "the connectedness of all things" he derives from knowledge of such facts as that "we share DNA with a fruit fly".

Javier's understanding of his sense of connection as a spiritual experience accords with UK physicist Jade's articulation of the way in which the aesthetic emotions she experiences working with uranium evoke her spirituality. "It's really hard to use language that isn't inherently spiritual to describe these kinds of feelings [about aesthetics]", Jade begins.

> Because it is that feeling of like that connection, that connection with the universe around you that you're like, 'Yes, I understand why this is happening and I understand what is happening, and I can see it reliably and predictably every single time occurring in the same way.' [...] So, there is always that wonder, which is playful and a bit spiritual and like that, that childlike curiosity and an intrigue.

"So", Jade continues, "it probably sounds strange to say that working with uranium and nuclear waste is directly connected to my understanding of my own spirituality. But they are intertwined". She explains:

> The deeper your understanding of the universe, the deeper your understanding of yourself and your place in the universe, and why you're here, and what you're doing. Those connections, to me, when I feel those physical and mental reactions to the joy and that thrill of understanding something in my data, that does make me feel that feeling of connection. That's a spiritual thing for me.

The joy and thrill Jade feels in moments of understanding conjure a sense of connection with the universe, which, for her, is "a spiritual thing".

3.4. No Connection

While the majority of religious or spiritual scientists we interviewed who have aesthetic experiences in their work connect these experiences with their faith or spirituality on the logic of evoking, grounding, or defining, some do *not* experience them as connected.

Italian Catholic physicist Massimo puts it this way:

> So then, as a person of faith, let's say that as far as I'm concerned, I don't have a direct link between faith and science, that is, when I see something beautiful, I don't feel like saying that this is an expression of God in my life, or at least something with which I connect my spirituality.

Scientists we interviewed who, like Massimo, see no connection between their religious faith or spirituality and aesthetic experiences in science, typically did not offer an explanation as to why not. Those who did, however, tend to view religion or spirituality and science as separate.

For instance, Josephine, a biologist in the United States whose Protestant faith is of "neutral" importance and who does not identify as spiritual, sees religion and science as separate "ways of knowing". "I think that science is a way of knowing, religion is a way of knowing", she says. "There's ways of experiencing awe and beauty that I find in the sciences and things. Somebody else [may] see that as like a religious experience. And both of them are valid, but that's mixing the two of them".

Tia, an Indian physicist who identifies as "a little spiritual" as she believes in "manifesting", expresses a similar sentiment. "I don't relate spirituality and having faith to

science, because it's science, it has to be logical", she states. "And faith and spirituality are not about logic. It's about having faith. It's about believing in something, right. And science is about facts".

Scientists like Josephine and Tia, who draw a categorical distinction between religion/spirituality and science, personally do not see how aesthetic experiences in science might bridge the two.

4. Discussion

Our survey results suggest a relationship between aesthetics and spirituality in science, which our interviews with scientists helped us better understand. We learned from interviews with an international group of physicists and biologists that their aesthetic experiences encompass appreciating nature's beauty to feeling awe at its vastness or a sense of connection deriving from scientific knowledge and understanding. Our interviews also allowed us to identify and illustrate three distinct logics by which scientists connect their religious faith or spirituality and aesthetic experiences in science. These we call *evoking*, *grounding*, and *defining*.

Where some scientists' experiences of beauty or awe evoke the transcendent—understood as God the creator or in non-traditionally religious terms—other scientists' faith or spirituality grounds their understanding and appreciation of their aesthetic experiences in science. The evoking and grounding logics are not incompatible; indeed, some religious scientists we interviewed combine both logics in connecting their faith and aesthetic experiences in their work. Yet they are distinct in the direction of influence between religion/spirituality and aesthetic experiences in science. Still other scientists embrace an immanently oriented spirituality defined, at least in part, in aesthetic terms. For these scientists, their experiences of awe or connection constitute spiritual experiences in their own right.

The phenomenon of "evoking", where scientists' experiences stir their religious or spiritual beliefs, aligns with the psychological understanding of awe as an emotion that connects the spiritual and the aesthetic (Keltner and Haidt 2003). This indicates that, for many, science is not a mere academic pursuit but a space where profound encounters can awaken or rekindle religious or spiritual beliefs. For those scientists who are more conventionally religious, evoking entails an experience of transcendence; these scientists become what Taylor (2007) calls "porous selves", open to engaging with transcendent entities such as God or a higher power.

In the "grounding" pattern, scientists' religiosity or spirituality serves as a framework that contextualises their scientific experiences, affording a particular flavour of interpretation of beauty and wonder in science. For religious scientists, aesthetic experiences in science may serve as signs that further confirm their religious beliefs, enabling them to better connect science and religion and their professional and personal lives.

The "defining" category, where the very act of scientific discovery becomes a spiritual experience, resonates intriguingly with alternative spiritualities that are lately on the rise (Ammerman 2013; Bender 2010). For this logic, the aesthetic experience is not an adjunct to scientists' spiritual beliefs but is intrinsically spiritual. This squares with Taylor's (2007) notion of the "immanent frame", suggesting that for many scientists, the numinous is found in the tangible, the earthly, and the empirical. Individuals who identify as spiritual but not religious often leverage resources from diverse social institutions, including religions, to construct their alternative spirituality (Bender 2010). Narratives provided by scientists in the "defining" category suggest that aesthetic experiences in scientific research could serve as a cultural resource for constructing their alternative spirituality. That said, we are not able, nor do we intend, to intervene in discussions on conceptual distinctions between religiosity and spirituality. We invite scholars to further explore the construction of alternative spirituality within the context of academic science. However, the cohort of scientists maintaining a stark separation between their scientific and spiritual experiences underscores the enduring influence of modernist perspectives (Ecklund and Johnson 2021)—and our research suggests that even scientists who identify as religious may adopt

such a perspective in being unable to see connections between aesthetic experience and their religiosity.

This research sheds light on the various ways in which scientists incorporate religion and spirituality into their aesthetic encounters and thereby contributes to the fields of the sociology of science and the sociology of religion. While the institutional boundaries between science and religion may become more rigid when scientists engage in scientific research and teaching (Di and Ecklund 2017), aesthetic experience can potentially serve as another point of convergence for religious and spiritual scientists to integrate their faith and spirituality with their scientific endeavours. By invoking religious and spiritual elements in aesthetic experiences, anchoring these experiences in religious and spiritual frameworks, and experiencing aesthetic encounters as spiritual experiences, academic scientists may find ways to navigate the rigid institutional boundaries between science and religion in their professional contexts.

Overall, our findings suggest a variety of ways in which scientists connect their professional and religious/spiritual lives despite the limitations of our study. The broader project from which the present article derives was not primarily aimed at studying religion or spirituality. As a result, only a limited number of interview questions were asked about the topic of a limited set of interview respondents. We do not have sufficient sample sizes from each country for adequate saturation to understand differences by country or by religious tradition (e.g., most of our scientists who identified as Hindu said they were nonreligious, limiting our ability to understand the experience of religious Hindu scientists). Future research is needed to more systematically examine whether different religious traditions or national contexts afford different interpretations of the relationship between aesthetic experience and religiosity/spirituality in science.

5. Conclusions

Our analysis of qualitative interviews with scientists illuminates ways in which religion, spirituality, and aesthetic experiences intertwine in the scientific domain. These findings challenge binaries between science and religious or spiritual experiences and underscore the complex, diverse ways in which scientists relate to their work. Crucially, this study contributes to understanding how personal beliefs can shape and be shaped by professional experiences. Accordingly, it invites academic and scientific institutions to recognise and value the deeply personal and spiritual dimensions scientists bring to their work. Understanding these dynamics is no mere academic exercise but holds profound implications for fostering well-being at work, promoting creativity, and cultivating an inclusive, empathetic scientific community that values the fullness of human experience. Future research should delve deeper into these intersections, examining in more detail the differences across countries and religious/spiritual traditions, how the relationship between aesthetics and spirituality may evolve over a scientist's career, and the implications of this relationship for pedagogical strategies, mentorship, and scientific collaboration. Such analyses should not be restricted to scientists but are also needed in other domains of work to better understand the richness of religious or spiritual experiences and their relevance to our lives.

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Data Availability Statement: The interview data are not available per institutional review board protocols, as participants did not consent to the public availability of their full interview transcripts.

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Appendix A

We measured aesthetic disposition using the Dispositional Positive Emotions Scale (DPES) (Shiota et al. 2006). This is an additive scale comprising six items, each of which is coded on a 5-point Likert scale from 1 = Disagree Strongly to 5 = Agree Strongly: "I often feel awe", "I see beauty all around me", "I feel wonder almost every day", "I often look for patterns in the objects around me", "I have many opportunities to see the beauty of nature", and "I seek out experiences that challenge my understanding of the world". We developed an additive measure of aesthetic disposition using these indicators (1–30) and found that scientists who identify as spiritual (regardless of their religiosity) report significantly higher aesthetic dispositions than those who do not (Figure A1).

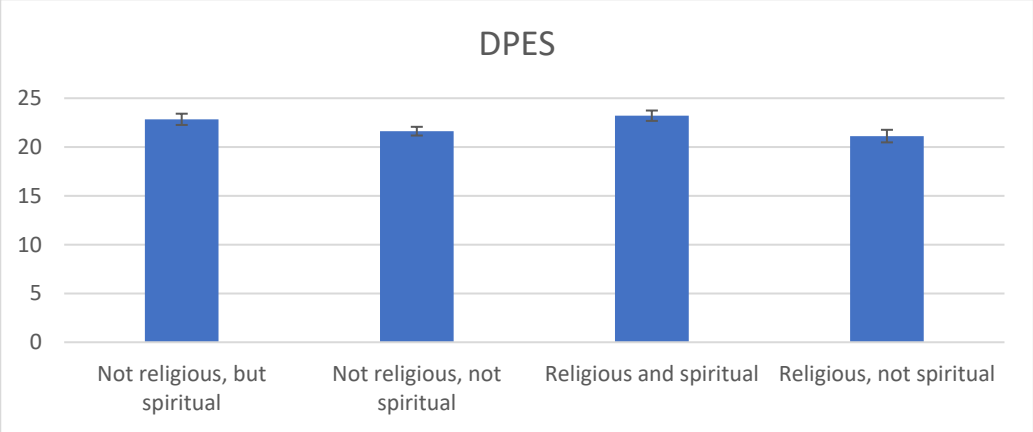
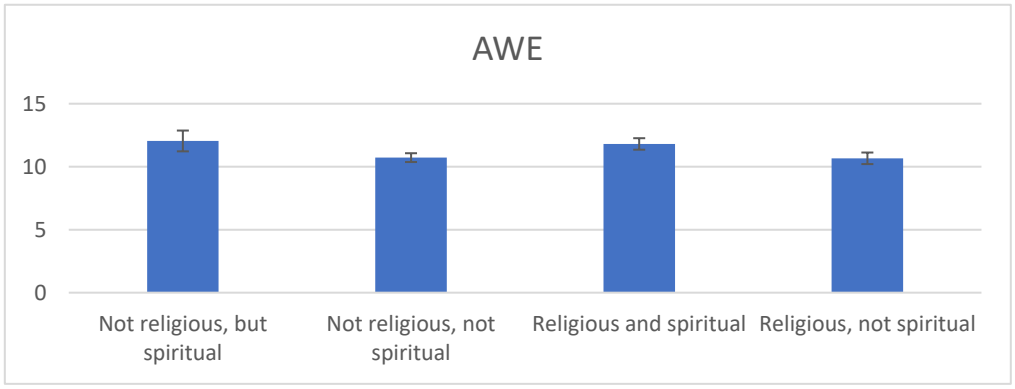
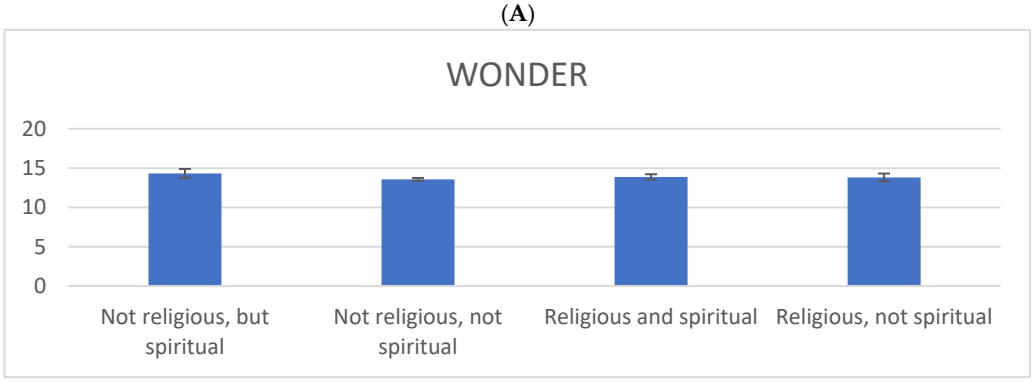


Figure A1. Differences in aesthetic disposition by religious/spiritual identity.

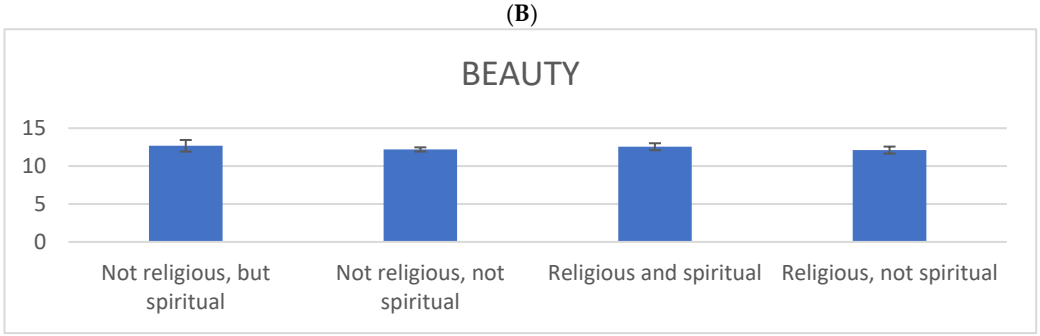
In addition to the above aesthetic trait measure, we also developed aesthetic state measures by calculating the frequencies of encountering awe, wonder, and beauty in scientific work. We measured awe using four indicators ("I felt my sense of self become somehow smaller in the face of what I was researching", "I felt that I was in the presence of something grand", "I felt a sense of reverence or respect about the things I was discovering", and "I was thrilled by a new insight"); wonder using four indicators ("Thinking about a scientific problem kept me awake at night", "I felt my research opened up new mysteries for me to explore", "I felt a sense of almost childlike delight or joy during my work", and "I felt grateful for learning something new"; and beauty using four indicators ("I felt my sense of self become somehow smaller in the face of what I was researching", "I felt that I was in the presence of something grand", "I felt a sense of reverence or respect about the things I was discovering", and "I was thrilled by a new insight".) Each of these 12 indicators was measured on a 5-point frequency scale (Never, Rarely, A few times a year, A few times a month, and Weekly or more). Using these variables, we then created additive scales of awe, wonder, and beauty, ranging from 0–20 each. Here we found that spirituality is significantly associated with higher frequencies of encountering awe but not beauty or wonder (Figure A2A–C).



(**A**)



(**B**)



(**C**)

Figure A2. (**A**). Differences in frequency of experiencing awe by religious/spiritual identity. (**B**). Differences in frequency of experiencing wonder by religious/spiritual identity. (**C**). Differences in frequency of experiencing beauty by religious/spiritual identity.

Notes

1 We use the term 'logic' in the sense in which it is commonly used in sociology and organizational studies to distinguish between modalities of thought or action that have an internal consistency (e.g., Swidler 2013; Thornton et al. 2012; Ebrahim 2009; Bacharach et al. 1996). Specifically, we use the term to point to distinct modes of reasoning by which scientists connect aesthetics and religion/spirituality.

2 For more information about and results from the broader study, see Jacobi et al. (2022), and Vaidyanathan et al. (2023).

3 As Watts (2020) observes, uniting the scholarly disagreement regarding emic variety in the meaning of the term "spiritual" is the idea that the terms "spiritual" and "religious" denote distinct things and carry positive and negative connotations, respectively.

4 Einstein (1936, p. 351) wrote, "the eternal mystery of the world is its comprehensibility".

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