Chapter 13
Awe and Wonder in Scientific Practice: Implications for the Relationship Between Science and Religion

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Abstract This paper examines the role of awe and wonder in scientific practice. Drawing on evidence from psychological research and the writings of scientists and science communicators, I argue that awe and wonder play a crucial role in scientific discovery. They focus our attention on the natural world, encourage open-mindedness, diminish the self (particularly feelings of self-importance), help to accord value to the objects that are being studied, and provide a mode of understanding in the absence of full knowledge. I will flesh out implications of the role of awe and wonder in scientific discovery for debates on the relationship between science and religion. Abraham Heschel argued that awe and wonder are religious emotions because they reduce our feelings of self-importance, and thereby help to cultivate the proper reverent attitude towards God. Yet metaphysical naturalists such as Richard Dawkins insist that awe and wonder need not lead to any theistic commitments for scientists. The awe some scientists experience can be regarded as a form of non-theistic spirituality, which is neither a reductive naturalism nor theism. I will attempt to resolve the tension between these views by identifying some common ground.

Keywords Awe · Epistemic emotions · Non-theistic spirituality · Scientific practice · Wonder

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13.1 Awe and Wonder in Scientific Practice

> The great religions have a place for awe, for ecstatic transport at the wonder and beauty of creation. And it's exactly this feeling of spine-shivering, breath-catching awe – almost worship – this flooding of the chest with epiphanic wonder, that modern science can provide. And it does so beyond the wildest dreams of saints and mystics. The fact that the supernatural has no place in our explanations, in our understanding of the universe and life, doesn't diminish the awe (Dawkins 1997: 27).

Dawkins is not atypical in having experiences of awe and wonder. Other examples of descriptions of awe from scientists who were also talented science communicators include Rachel Carson, Albert Einstein, Richard Feynman, and Carl Sagan. While awe and wonder are traditionally associated with religious attitudes, they also figure prominently in scientific practice, and as we will see, recent psychological research suggests they might even be a core element of the scientific mindset.

In autobiographical accounts of scientists, three features of awe and wonder recur. First, awe and wonder are emotions that motivate scientists to value the objects they study and that urge them to further explore. Such experiences are a driving force in the decision to become scientists and to continue scientific pursuits. For example, primatologist Jane Goodall, reflecting on her childhood experiences, writes

> When I think of my childhood I remember spring bulbs pushing up pale shoots through the dead leaves, spiders in the garden carrying tiny babies on their backs, the scent of violets and honeysuckle, and the sound of the wind rustling the leaves as I perched for hours in the branches of my beech tree. It was that magic of childhood that shaped the passion that drives me to spend my life fighting to save and protect the last wild places on the planet (Jane Goodall cited in Russell 2017: 1).

Second, scientists explicitly deny that understanding takes away the sense of awe and wonder. They do not see understanding as diametrically opposed to these emotions, but as integral to them. Here is an account from the Feynman lectures:

> Poets say that science takes away from the beauty of the stars – mere globs of gas atoms. Nothing is "mere." I too can see the stars on a desert night, and I feel them. But do I see less or more? The vastness of the heavens stretches my imagination – stuck on this carousel my little eye can catch one million year old light. A vast pattern – of which I am part – perhaps my stuff was belched from some forgotten star, as one is belching there. Or see them with the greater eye of Palomar, rushing all apart from some common starting point when they were perhaps all together. What is the pattern, the meaning or the why? It does not do harm to the mystery to know a little about it. For far more marvelous is the truth than any artist of the past imagined! (Feynman et al. 1963 [2010]: 3–11, footnote).

A third characteristic feature is the denial that these emotions of awe and wonder have any theistic content. For example, Einstein, who called himself a deeply religious nonbeliever said on several occasions.

> I do not believe in a personal God and I have never denied this but have expressed it clearly. If something is in me which can be called religious then it is the unbounded admiration for the structure of the world so far as our science can reveal it (Einstein, cited in Calaprice 2011: 341–342).

How can we make sense of the awe and wonder that scientific research engenders in its practitioners? I will examine this question, using recent psychological findings on the connection between awe, wonder and science. Section 13.2 reviews recent scientific explanations for why we sense awe and wonder. Section 13.3 outlines an account of the function of awe and wonder in scientific reasoning. I will argue that these emotions help scientists to accomplish the following three goals:

1. Accord intrinsic value to the objects they study, while diminishing self-importance and self-aggrandizement.
2. Encourage cognitive attitudes that are conducive to scientific discovery, such as open-mindedness and critical reflection, while reducing reliance on heuristics and stereotypes, and diminishing the tendency to find quick solutions.
3. Provide a mode of understanding, in the absence of a complete grasp of the topic under investigation.

A later section examines implications for the science and religion literature. Do feelings of awe and wonder for nature point to the existence of God? Can they make sense in a purely naturalistic framework? I will consider non-theistic spirituality as an alternative response. I will also identify some common ground between these positions.

13.2 Why We Feel Awe and Wonder: A Review of the Scientific Evidence

To understand what role awe and wonder might play in scientific practice, it is useful to examine the role of emotions in more general terms. What are emotions and why do we have them? Emotions are crucial in our day-to-day lives. They motivate us, give us meaning, and play a vital role in social relationships and in our personal and interpersonal wellbeing. Many philosophers, including Plato, Aristotle, Descartes, Hobbes, Hume, and James have proposed comprehensive theories of emotions, what they are and what role they play in our actions. Unfortunately, there is no definition of emotion that enjoys universal support. This lack of conceptual clarity contributed to a relative neglect of the study of emotions during most of the twentieth century.

However, in recent years philosophers and psychologists have shown a renewed interest in emotions. I will here use a common and relatively uncontroversial psychological definition of emotion as given by the American Psychological Association, namely a 'complex pattern of changes, including physiological arousal, feelings, cognitive processes, and behavioral reactions, made in response to a situation perceived to be personally significant'.[1] Emotions can be transient, such as a momentary burst of anger, or long-term, such as the love one feels for a romantic partner or

[1] http://www.apa.org/research/action/glossary.aspx, accessed April 2018.

for one's children over decades. They usually have a positive or negative valence, e.g., happiness, pride, elation, gratitude, and love usually feel good, whereas sadness, shame, disappointment, resentment, and hatred feel bad. They have physiological effects, including reducing or increasing heart rate, changing one's hormonal balance, and motivating one to engage in or refrain from action.

Charles Darwin (1871, 1872) pioneered the evolutionary study of emotions. He proposed that emotions help animals to navigate their natural and social environment. Emotions provide the appropriate motivation and drive for animals, for example, to care for their offspring, to form long-term sexual partnerships, to recognize danger, and to forge strategic alliances with others to coordinate for mutual defense. Because it is difficult to hide our emotions or to feign them (a fact that actors and poker players are acutely aware of), displaying and acting on our emotions plays a key role in social interactions. This Darwinian picture of emotions as instigators of adaptive actions, especially in social contexts, is reflected in contemporary psychological theories of emotions. For example, Keltner and Haidt (1999) have argued that emotions help us to coordinate and navigate socially complex situations. Against this theoretical backdrop of emotions as motivators for adaptive action, we can consider awe and wonder. These emotions fall into two main categories: they are both self-transcendent and epistemic. Self-transcendent emotions include gratitude, compassion, and love. They help focus us on the wider world, both the natural world and social others. They motivate us to action. For example, the emotion of compassion motivates us to altruistically help people whom we think are suffering undeservedly.

Stellar et al. (2017) provide an evolutionary-grounded theoretical account of self-transcendent emotions. They argue that these emotions evolved to solve coordination problems such as care taking, cooperative hunting, and sharing food. This is not to say that altruistic actions do not occur without self-transcendent emotions. However, they have a powerful motivating force, and thus contribute critically to them. Take, as an example, gratitude, which Stellar et al. (2017) hypothesize evolved as a way to solve problems related to resource sharing. If I receive food from a group member when I am in need, I will experience gratitude toward this person. This feeling of gratitude will motivate me to help this person in the future and thus helps to cement direct reciprocity (tit-for-tat giving), but crucially, it also makes me more generous towards others. Societies in which gratitude is a regular feature of public life thus will have higher levels of cooperation, which increases the fitness of members of such societies.

As we will see further on in this section, awe and wonder also direct attention away from the self and to the environment and to others. Awe and wonder are also epistemic emotions: they are triggered when we are confronted with gaps in our knowledge (Valdesolo et al. 2017). Other examples of epistemic emotions include surprise, curiosity, love of truth, meticulousness, and excitement. Neuropsychological evidence suggests that people who have damage to brain areas involved in emotion processing have diminished capacities for reasoning and judgment (Damasio (1994) provides a classic defense for the role of emotions in reasoning). This indicates that emotions play a key role not just in how we navigate social relationships, but also

how we learn and reason about the world. Adam Morton (2010) argues that epistemic emotions help us in forming correct beliefs and rejecting false beliefs, which is important for adaptive action (e.g., recognizing the presence of danger, finding opportunities). To see why epistemic emotions are important for scientists, imagine a scientist who is well trained in research techniques, is abreast of the cutting edge of her field, and is intelligent, but who lacks curiosity, wonder, and other epistemic emotions. Morton speculates that while we can expect this scientist to do excellent work, even become eminent in her field, she will not lead her discipline in any radical new direction, because she lacks the epistemic drive to do so. We experience epistemic emotions in a wide range of contexts. They spur on our curiosity when we read a mystery novel or explore a new domain. I will now look in more detail at awe and wonder, with most emphasis on awe as the empirical literature on this emotion is more substantial compared to wonder.

13.2.1 Awe

While eighteenth-century philosophers such as Edmund Burke and Immanuel Kant (1790 [2000]) have written about awe and its connection to the sublime, psychological research on this emotion is relatively recent. Awe tends to be elicited by the vast and expansive, it is 'in its chaos that nature most arouses our ideas of the sublime, or in its wildest and most ruleless disarray and devastation, provided it displays magnitude and might' (Kant 1790 [2000], x23, 5: 246). Vast landscapes, starry night skies, wide-scope scientific theories, mathematical theorems, and large-scale artistic productions are awe-inspiring. Awe also requires an element of incomprehension; not mere ignorance, but the sense of something beyond our epistemic grasp. Abraham Heschel anticipated the psychological literature: 'Ignorance is not the cause of reverence. The unknown as such does not fill us with awe. We have no feelings of awe for the other side of the Moon or for that which will happen tomorrow'. But completely known objects do not evoke awe either: 'the known is in our grasp, and we revere only that which surpasses us' (Heschel 1951: 26).

Keltner and Haidt's (2003) influential account of awe sparked a growing empirical literature on this emotion. They define awe as the feeling of experiencing something vast that is beyond our grasp or understanding, and that we have a desire to accommodate. Awe has two key components: a perception of vastness, which elicits a need for accommodation. The perception of vastness is not just sheer size, but has a cognitive component, the perception of something as a single, integrated whole is important, as well as some sense of what it means (Danvers et al. 2016). For example, the demolishing of the Berlin Wall was awe-inspiring for those who witnessed it, not because it was the smashing of a big wall, but because it symbolized the breaking down of barriers and the unification of Germany.

As an epistemic emotion, awe makes people more open-minded and less reliant on clichés, stereotypes, and scripts. To test whether awe reduces the tendency to rely on scripts, Danvers and Shiota (2017) elicited awe by letting participants watch a

video showing a stellar figure skater performing a complicated routine. Afterwards they asked participants to recall a story about a romantic dinner. This is a type of story where people tend to invent details that fit the scenario (reliance on script). People in the awe condition were less likely to invent details than those in a control condition. Griskevicius et al. (2010) tested whether awe increases critical thinking. They induced different positive emotions in their participants. For example, they induced awe by asking participants to think about a panoramic view they personally witnessed, such as the Grand Canyon. Participants were then presented with either a strong or a weak argument for making a comprehensive exam a requirement for graduation in a particular college. Compared to the neutral condition, participants who had positive emotions were more likely to be persuaded by either the strong or the weak argument. Awe and compassion – two self-transcendent, positive emotions – were the only emotions that reduced acceptance of the weak argument.

These psychological findings indicate why awe is a relevant emotion for scientific practice. People tend to rely on heuristics and will try to reduce novel information to stereotypes they are familiar with. Awe counteracts this tendency: people who feel awe are less likely to rely on stereotypes and heuristics to assimilate new information. The connection to scientific creativity is clear: if a scientist examines a novel phenomenon, she would close off many viable lines of inquiry if she immediately tried to accommodate the novel phenomenon in terms of cases she is familiar with. However, if a scientist experiences awe in response to a novel phenomenon, she will feel more comfortable with the uncertainty and the unknown, and more likely to be open to new explanations for it.

Keltner and Haidt (2003) hypothesize that awe has emerged in the context of social dominance relations. By feeling awe for a socially dominant other, such as an alpha male, human ancestors would experience better group coherence, which is important in complex primate groups. Awe would originate from the sense of deference subordinate primates feel towards those that are cleverer or more powerful. If correct, this would mean that socially dominant and powerful other human beings would be the prime object for which we feel awe. However, stimuli that have emerged in the literature as most reliably eliciting awe are not social others. In a sample of western Christians, Buddhists and atheists, Caldwell-Harris et al. (2011) found that nature (54%), science (30%), and art, especially music (12%) were most likely to evoke awe. Shiota et al. (2007), on the other hand, argue that the primary function of awe might be to promote some form of cognitive accommodation (understanding) when we are faced with a vast, novel stimulus that does not fit our current image of the world. It thus provides a mode of understanding in the absence of full knowledge. This might explain that while knowledge is not fatal to awe (as authors such as Feynman insisted), a bit of mystery and a lack of full grasp is nevertheless a crucial element for experiencing awe.

In agreement with the social dominance hypothesis, awe decreases feelings of self-importance and self-entitlement. Piff et al. (2015) placed participants in a grove of towering and majestic eucalyptus trees (the awe condition), or asked them to look up at a tall, plain-looking building (the control condition). Participants were subsequently tested on their prosociality and self-entitlement. The effects of awe on pro-

social behavior were only marginal, but participants who had seen the trees responded significantly less self-entitled, for instance, they were more likely to disagree with the following statement 'I honestly feel I'm just more deserving than others'. Science is of course not immune to egos and self-aggrandizement. Overinflated egos have a negative effect on scientific practice, they counteract epistemic humility, and may even encourage fraud and other dubious scientific practices. Awe is a useful emotion that shifts the focus away from the self, and thus counteracts this tendency.

13.2.2 Wonder

Wonder is closely related to awe, and not always distinguished from it in the psychological literature. In a posthumous work on the history of astronomy, Adam Smith (1795) attempted to distinguish wonder, surprise, and admiration (the latter an emotion that has close affinities to awe).

> Wonder, Surprise, and Admiration, are words which, though often confounded, denote in our language sentiments that are indeed allied, but that are in some respects different also, and distinct from one another. What is new and singular, excites that sentiment which, in strict propriety, is called Wonder; what is unexpected, Surprise; and what is great or beautiful, admiration (Smith 1795: 3).

Smith (1795) sees as primary objects of wonder unusual phenomena (comets, meteors, eclipses) but also things we are little acquainted with, including single animals and plants. While it is less intense in its phenomenology than awe, it nevertheless has a few distinct traits. Research into wonder is at an even less developed stage compared to research into awe, but preliminary work suggests that wonder is associated with curiosity, and prompts people to contemplate. In his seminal study on the emotions, Frijda (1986: 18) links wonder to surprise and amazement, and describes it as a passive, receptive form of attention that we have when we experience something unexpected.

Wonder is phenomenologically distinct from surprise. Take magic tricks, a situation where we tend to feel wonder, but not surprise (Lamont 2017). Magic tricks evoke wonder because they show events we know are impossible, such as people being sawed in half and emerging unharmed, or live elephants disappearing from the stage. We expect the magic to happen: a failed magic trick, where the elephant would still be standing on the stage, would elicit surprise but not wonder: a successful magic trick, where the elephant is effectively gone, evokes wonder but not surprise. This is because we expect the elephant to disappear (being in a magic show after all), but can still marvel at how the trick was done.

We associate wonder with children and child-like inquiry, but the emotion is not absent in adults. Whereas awe is an emotion that engulfs us through vast and sweeping landscapes or stunning works of art, wonder is a quieter, less spectacular emotion that in part comes about due to our own receptivity and focus. As Heschel (1955

[2009]: 39) put it: wonder 'may be sensed in every grain of sand, in every drop of water. Every flower in the summer, every snow flake in the winter, may arouse in us the sense of wonder'. Dawkins, likewise, thinks that wonder is primarily a matter of focus and attitude:

> We can recapture that sense of having just tumbled out to life on a new world by looking at our own world in unfamiliar ways. It's tempting to use an easy example like a rose or a butterfly, but let's go straight for the alien deep end. I remember attending a lecture, years ago, by a biologist working on octopuses, and their relatives the squids and cuttlefish. He began by explaining his fascination with these animals. 'You see,' he said, 'they are the Martians.' Have you ever watched a squid change colour? (Dawkins 1998: 6–7).

A free word association task asked participants to describe an event where they felt a distinct positive emotion (awe, wonder, happiness). Compared to awe and happiness, the emotion of wonder elicited more present-tense descriptions, more words suggesting looking for causation and for insight (such as 'think', 'because', 'cause') (Darbor et al. 2016). Wonder also encourages humans to think abstractly; to look for deeper meaning, and to question why things are the way they are, even if it is elicited by very concrete stimuli, such as snowflakes, spider webs, an unusually-shaped leaf, or a single candle flame. So as a general rule of thumb, awe is elicited by the vast and spectacular, whereas wonder is elicited by smaller and unusual (although large stimuli might also elicit wonder, as long as they are not overpowering).

Kevin Tobia (2015: 5) develops a core account of wonder, according to which four conditions need to be met for someone to experience wonder at something else:

> A person, p, feels wonder at object x if and only if: [ATTENTION] p is attending to x; [INTEREST] p is interested in x; p is disposed to continue engaging with x; [VALUE] it seems to p that x is important or valuable as an end; x seems to p to have final value; [POSITIVITY] p's experience includes positively valenced affect.

The value condition is perhaps the most controversial of this account, and has not (to my knowledge) been subject to empirical test. Tobia uses thought experiments to make us think that wonder does require that we need to value objects we wonder at. It would be strange, for instance, to say, 'I wonder at this artifact, and it does not seem valuable'. Just like awe, wonder has the propensity to open our hearts and minds. It is, fundamentally, an emotion that transports our focus away from ourselves to the objects we wonder about. Wonder makes things seem intrinsically valuable, but as Tobia (2015) points out, this does not mean that they are valuable.

Still, wonder encourages receptivity to the world, which is a key emotion for scientific discovery. Smith (1795) argued that wonder plays a crucial role in scientific practice. It motivates us to study scientific phenomena for its own sake, deepens our understanding, and plays a role in our evaluation of scientific evidence. Since science is an open-ended endeavour, this role of wonder continues as new scientific findings open up new areas of research (Schliesser 2005).

13.3 Awe, Wonder, and Scientific Practice

We are now in a position to consider why scientists such as Dawkins, Goodall, and Feynman stress the importance of awe and wonder for their work. Awe and wonder fulfill three key roles in scientific practice. The first role relates to focus: both emotions diminish our sense of self-importance and accord value to the objects we study. The second role relates to cognitive attitude: awe and wonder encourage a receptivity to the unusual and the novel, reduce reliance on stereotypes and scripts, and increase critical thinking. Given universal human biases to rely on clichés and stereotypes, it provides scientists a way to overcome this tendency. Heschel already argued that wonder and awe diminish reliance on the conventional:

> The greatest hindrance to knowledge is our adjustment to conventional notions, to mental clichés. Wonder or radical amazement, the state of maladjustment to words and notions, is therefore a prerequisite for an authentic awareness of that which is (Heschel 1951: 11).

Note that Heschel conflates awe, wonder, admiration, and radical amazement (emotions that contemporary psychologists tend to distinguish). Nevertheless, Heschel correctly identifies the epistemic role of wonder and awe, and sees it as resulting from a state of maladjustment. Awe and wonder draw us out of our comfort zone, and help us to be creative.

The third and final role is perhaps the most elusive: awe and wonder provide a mode of understanding, which paradoxically helps us to perceive a gap in our knowledge. Seeking to understand the world one lives in clearly is a good incentive for an investigator, regardless of whether they inhabit a prescientific world or a highly scientific one. Recent psychological studies have looked more closely at the role of awe in scientific practice. Gottlieb et al. (2018) call awe a scientific emotion, by which they mean that it motivates scientists to answer questions about the natural world. Across six studies, they find that a psychological disposition to experience awe is associated with psychological characteristics of a scientific mindset. These include a more accurate understanding of how science works, rejection of creationism, and rejection of unwarranted teleological explanations more broadly. This is particularly interesting, as teleology and creationism have traditionally been associated with religion, explicitly with natural theological arguments for the existence of God.

Valdesolo et al. (2017) argue that awe and wonder play a key role in scientific transformations, particularly in precipitating paradigm shifts. As sociologists and philosophers of science have recognized since Kuhn (1962), scientists do aim to find new results, but they don't want to stray too far from the bounds of what is generally accepted in their discipline. Kuhn called this state of affairs 'normal science'. He speculated that paradigms eventually fall because of the accumulation of anomalies, pesky data that don't fit established theories. Ultimately, scientists need to be open to anomalies to try to change their viewpoint, or to use unusual approaches to look at familiar domains. Major scientific discoveries resulted from scientists surveying familiar territory with fresh eyes, such as Harvey who conceptualized the heart having two clackes (pumps with one-way valves), ibn al-Haytham (aka

Alhazen) who applied geometrical insights to human vision, or Kepler who used an analogy with light to understand how gravity operated in the solar system (De Cruz and De Smedt 2010). As we have seen, wonder helps us to see the world in fresh ways, and awe helps us to reduce reliance on stereotypes, scripts and heuristics. These emotions reduce both the need to overlook anomalies or to look at the world using the same familiar ways of thinking, thus paving the way for paradigm shifts and other deep conceptual changes. Valdesolo et al. (2017) recommend that awe be elicited in science education, and predict that it would lead to more effective learning.

13.4 Awe and Wonder in Science: Theism or Non-theistic Spirituality?

The phenomenological character of awe and wonder, and the crucial role they play in science (as uncovered by recent research in cognitive science) has potential implications for the relationship between science and religion. I will explore two lines of thought on what this relationship might be. The first, defended by Heschel (1951, 1955 [2009]), holds that awe and wonder in science point to God's existence. The second holds that these emotions are part of a non-religious spirituality, a position explored in autobiographical accounts of scientists such as Dawkins (2017).

Abraham Heschel examined the role of awe and wonder in science and religion, focusing on how awe functions in Judaism. He did not argue that God exists because humans feel awe and wonder. Rather, he took the existence of God as a given and then examined what role awe and wonder might play, as a way to understand the divine aspect of the universe. To Heschel awe precedes faith, and lies at the root of it. Long before we have any propositional knowledge of God, we 'possess an intuition of a divine presence' (Heschel 1951: 67). Being religious (Jewish) means to be in awe of God. Foreshadowing the empirical literature, he saw the ability of awe to reduce our feelings of self-importance as a key element in cultivating a religious mindset. Under ordinary circumstances 'we are so impressed by our intellectual power that we deny any presence beyond our power' (Heschel 1965: 76). Awe is a necessary precondition for religious deference, which is important for Jewish religiosity, where being a religious person is almost synonymous for being in awe of God – a religious believer, *yare hashem*, is literally one who stands in awe of God.

Heschel believed that religion could play a key role in scientific knowledge acquisition by offering what he termed 'a legacy of wonder.' Wonder is the 'semen scientiae', the seed of knowledge. Not only does scripture exhort us to wonder and awe, Heschel also believed that religious rituals – in particular, Jewish rituals – help us to cultivate a sense of awe and wonder. Daily rituals such as blessings do not make sense in a purely scientific picture of the world, because once you know some scientific fact, there is no reason to be reminded of it daily. But ritual blessings make sense as a form of training to keep our ability for awe and wonder sharp. As Heschel

(1955 [2009]: 49) writes, 'We are trained in maintaining our sense of wonder by uttering a prayer before the enjoyment of food. Each time we are about to drink a glass of water, we remind ourselves of the eternal mystery of creation, "Blessed be Thou ... by Whose word all things come into being."'

Building on this account, Wettstein (2012) argues that it makes sense for a metaphysical naturalist to cultivate religious practices, as they might help her to cultivate the sense of awe. It would be very difficult and require a large transformation of one's character to become more receptive to awe and wonder purely by willpower alone, but Jewish practices are carefully calibrated to help habituate one's mindset. Judaism has blessings for many different occasions: on seeing the first blossoms of the year, on eating and drinking, or smelling fragrant spices, on receiving good news, on receiving bad news. Such blessings help one to maintain a reverent focus. Wettstein accords a similar role to the practice of praying three times a day, in ritualized and standardized form, which allow one to engage with enduring literature of great emotional scope, such as the psalms. The proper target of such practices, for Heschel, is God. Nature worship does not work because Heschel did not see why would anything be worthy of worship in a naturalistic worldview. Nature is surely beautiful, vast and wondrous, but it does not make sense to worship or revere a non-sentient entity. Heschel believed that nature worshippers have the right attitude but draw the wrong conclusions.

Wettstein and Heschel argued that religion allows one to cultivate habits that afford a space for awe and wonder. However, Heschel overlooked the possibility for the naturalist to be in awe of nature, to be moved by nature, for nature's sake. As Carroll (1993) has argued, naturalists can be moved by nature, they can have a visceral form of appreciating nature for what it is. This is not some ersatz religious sentiment (see also De Cruz and De Smedt, 2015, Chap. 7). The current empirical evidence suggests that awe and wonder are not exclusively religious sentiments, and that atheists and agnostics are capable of experiencing them (Caldwell-Harris et al., 2011). There has been a long-standing debate on whether emotions that are often experienced in religious contexts, such as awe, are specifically religious, or if they are byproducts of more general emotions. Authors such as Otto have argued that awe is a specifically religious emotion. The concept of *mysterium tremendum* in Otto (1923) is closely linked to the idea of numinous dread, or awe, which he links to the earliest religious beliefs in ancestral humans, and which he still thinks plays a role in people's attraction the to uncanny. By contrast, authors such as William James (1902: 27) argued there are no specific religious emotions. Rather, awe, wonder, love, joy, fear and a wide range of other emotions can be experienced in a religious as well as non-religious context: 'religious awe is the same organic thrill which we feel in a forest at twilight, or in a mountain gorge; only this time it comes over us at the thought of our supernatural relations'. The current empirical literature vindicates James (1902). Emotions frequently experienced in religious contexts are not exclusively religious. This does not disprove Heschel's view that awe connects to a religious mindset, but it does open up the possibility for non-theistic spirituality.

As we have seen, some scientists have explicitly rejected claims that the awe and wonder they experience are religious. If we take the writings of these atheist and agnostic scientists at face value, the wonder and awe they feel is a form of non-theistic spirituality. It is tempting for the theist (Bacon, for instance, defended this position) to see atheism as shallow and devoid from any form of spirituality. However, in recent decades, non-theistic spirituality has become more philosophically respectable, as well as a more psychologically viable option (McGhee 2011). The decline of traditional theistic religions in western culture does not mean people have become reductive naturalists, as is attested by a wide variety of nontheistic spiritual practices, such as the Burning Man festival, with their own rituals, foci of beauty, and moral ideals (e.g., the burning of the wicker man, the gift economy, and the focus on self-reliance in the Burning Man festival). Steinhart (2018) sees religions as technologies that are ultimately aimed at human ends. In the case of science and its relationship with awe and wonder, one could argue that science is a cognitive technology for cultivating awe and wonder (similar to what Heschel and Wettstein have claimed for theistic religion).

By sheer willpower alone, we cannot change our habits, but practices can help us accomplish this goal. Heschel was skeptical that science could engender a sense of awe and wonder, because there would be little point in being reminded daily of scientific facts one already knows. But scientific practice is not about rehearsal, but about exploration into the unknown. Venturing into what we don't know on a regular basis can help to instil an attitude that is receptive to awe and wonder.

Speculatively, the relationship between science and awe and wonder is not a one-way street (as cognitive scientists have claimed, by showing the salutary effects of awe and wonder on scientific practice); perhaps they reinforce each other. As self-transcendent and epistemic emotions, awe and wonder focus scientists on nature, help them to value it, and provide a mode of understanding. But regularly engaging in the pursuit of knowledge may also help scientists to cultivate awe and wonder, in a way not dissimilar to the Jewish blessings cited by Heschel.

Whatever their object – God, nature, or even scientific theories – awe and wonder are the result of cognitive adaptations. They help us to step outside of concern for ourselves, accord value to things outside of us. Such concern for the wider environment is important, a point emphasized by Goodall, who, as we have seen, feels compelled by her sense of wonder to fight to save the last wild places on the planet. Rachel Carson (1956) argued that we need to help cultivate awe and wonder in children. Her motivations for why it is important to keep a wondering mindset, something she regrets many people lose even before they become adults, are as follows:

> What is the value of preserving and strengthening this sense of awe and wonder, this recognition of something beyond the boundaries of human existence? ... Those who dwell, as scientists or laymen, among the beauties and mysteries of the earth, are never alone or weary of life. Whatever the vexations or concerns of their personal lives, their thoughts can find paths that lead to inner contentment and to renewed excitement in living. Those who contemplate the beauty of the earth find reserves of strength that will endure as long as life lasts (Carson 1956: 48).

By way of conclusion, regarded in this light, the gap between theistic awe and wonder and the non-theistic spirituality of scientists is perhaps not as large as initially appraised. Both religious practices and scientific practices are cognitive technologies that help us to transcend the self, and to find out about the world around us.

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