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ORIGINAL RESEARCH/SCHOLARSHIP

Facing the Pariah of Science: The Frankenstein Myth as a Social and Ethical Reference for Scientists

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Abstract

Since its first publication in 1818, Mary Shelley's *Frankenstein*; *or*, *The Modern Prometheus* has transcended genres and cultures to become a foundational myth about science and technology across a multitude of media forms and adaptations. Following in the footsteps of the brilliant yet troubled Victor Frankenstein, professionals and practitioners have been debating the scientific ethics of creating life for decades, never before have powerful tools for doing so been so widely available. This paper investigates how engaging with the Frankenstein myth may help scientists gain a more accurate understanding of their own beliefs and opinions about the social and ethical aspects of their profession and their work. The paper presents findings from phenomenological interviews with twelve scientists working on biotechnology, robotics, or artificial intelligence projects. The results suggest that the Frankenstein myth, and the figure of Victor Frankenstein in particular, establishes norms for scientists about what is considered unethical and dangerous in scientific work. The Frankenstein myth both serves as a social and ethical reference for scientists and a mediator between scientists and the society. Grappling with the cultural ubiquity of the Frankenstein myth prepares scientists to face their ethical dilemmas and create a more transparent research agenda. Meanwhile, by focusing on the differences between real scientists and the imaginary figure of Victor Frankenstein, scientists may avoid being labeled as dangerous individuals, and could better conceptualize the potential societal and ethical perceptions and implications of their research.

Keywords Responsibility · Science ethics · Scientist identity · Frankenstein myth · Science communication

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Introduction

> Learn from me, if not by my precepts, at least by my example, how dangerous is the acquirement of knowledge and how much happier that man is who believes his native town to be the world, than he who aspires to become greater than his nature will allow.
> (Victor Frankenstein, in Mary Shelley's *Frankenstein*; *or*, *The Modern Prometheus*)

Myths are cultural artifacts used to make sense of real or imaginary phenomena, to find meaning and significance in people's lives (Stein 2005). Myths are deeply entangled with society and culture; they define customs and answer fundamental questions by expressing existential and archetypal truths about human history (Diamond 1996). Myths are highly enjoyable because they convey stories that are compelling, surprising, and easy to understand. According to the French literary theorist and philosopher Barthes (1972), myth "abolishes the complexity of human acts, it gives them the simplicity of essences" (p. 143). Myths offer straightforward solutions to both mundane and supernatural problems (Lévi-Strauss 1955), dramatize the consequences of human frailties, such as pride and arrogance, and warn people about the dangers of pursuing forbidden knowledge (McComas 1996).

Published 200 years ago, Mary Shelley's *Frankenstein*; *or*, *The Modern Prometheus* has become, in Anglophone western cultures, an enduring and pervasive myth of radical scientific intervention and the consequences of irresponsible and transgressive research practices (Vacquin 2002). Witnessing the rapid growth of new technologies, the literature and culture of the Romantic Era presented scientists, and science more generally, as harbingers of world-reshaping industrialism (Turney 1998). Shelley's novel reinvents the ancient myth of Prometheus, the titan who defied the gods by giving fire to humankind and was severely punished for his transgression. Shelley's adaptation of that narrative for the Romantic era allowed for the creation of a compelling new myth, one that continues to speak to people's ambivalent feelings about how science can upend and reconfigure society. The story has become a shorthand for unchecked ambition and humanity's tendency to play with forces beyond our control. The Frankenstein myth is so deeply embedded in Western culture that it appears almost ubiquitous, bringing its embedded questions about science and technology to a wide range of popular art forms and discourses. As science writer Jon Turney (1998) puts it:

> we are never going to be rid of Frankenstein even if we want to be. The story is too deeply embedded in our culture now not to leave its traces or raise echoes whenever we discuss our attitude to science and scientists (p. 220).

The Frankenstein myth concerns an important paradox of modern science: how can societies regulate science that is capable of creating and manipulating human and artificial life (Cartwright 2007)? This question feels especially relevant today, given rapid progress in applied sciences working towards the production and modification of biological and artificial organisms, such as robotics,

genetic engineering, and nanotechnology (McCauley 2007). In the context of these emerging means of fabricating life, the Frankenstein myth suggests that the boundaries between life and matter, human and nonhuman, living and machine are not easily defined (Guerrini 2008).

This paper uses the concept of the "Frankenstein myth" to refer to the popular understanding of *Frankenstein*, combining multiple literary and cinematic adaptations of the original story into a simplified narrative about a mad scientist who "plays God" and unleashes a horrifying monster on the world. The "playing God" argument is a central theme of the Frankenstein myth, serving as a convenient framework for people or groups wishing to question the activities of scientists and anticipate disastrous outcomes of scientific exploration (van den Belt 2009). For instance, concepts such as "Frankenstein Factor," "Frankenstein Science," and "Frankenfood" have become increasingly popular and heavily used, especially in media coverage of emerging scientific practices and individual scientists described as suffering from a God complex (Meyer et al. 2013). Approaching Frankenstein as a myth that continues to shadow the scientist as a cultural figure, this paper aims to map scientists' interpretations about and attitudes towards the Frankenstein myth. The Frankenstein myth could serve as a lens for scientists and engineers to gain a more concrete understanding of the social and ethical principles underlying their research agenda. A large body of research has already documented that science stories and case studies can inspire people to develop more elaborate ethical beliefs and reasoning skills (Zeidler et al. 2005; Sadler et al. 2006; Han and Jeong 2014). Such science ethics exemplars may provide important opportunities for students to explore science ethics more fully and effectively when compared to reading more abstract textbook accounts of moral philosophy theories and concepts (Han 2015; Han et al. 2017). In education and training settings, the Frankenstein myth could serve as a relevant exemplar to facilitate more constructive discussions about the responsibilities of scientists and engineers in society.

The Frankenstein myth could be helpful framing for scientists and engineers to learn more about the consequences of scientific misconduct and failures, as well as fundamental debates about what "counts" as science, which in turn could provide opportunities for them to deepen their knowledge of science ethics (Athanassoulis 2017). As the science and technology scholar Milburn (2010) noted, scholars should invest more effort in studying how science fiction stories influence scientific actors and their research agendas. Although *Frankenstein* is deeply embedded in Anglophone western cultures, people rarely talk about its enduring social and ethical impact on science and scientists. As the philosopher Morton (2016) has argued,

> The very "universality" of this impact – the way in which the novel has become something like what Richard Dawkins calls a *meme* – a virus-like string of code that can easily be reproduced and circulated – mitigates against the specific, explicit study. Everyone wants to talk about *Frankenstein* – so no one talks directly about *Frankenstein*. (p. 128)

In fact, while several studies have investigated how the Frankenstein myth shapes public perceptions of science (e.g., Mulkay 1996; Swart 2014), no research has

yet been done to explore how scientists and/or engineers approach and interpret the Frankenstein myth (see also Nagy et al. 2018). The current paper sets out to address this silence about *Frankenstein*'s impact on scientists by exploring how scientists approach, interpret, and use the Frankenstein myth and other popular science narratives to frame their work and conceptualize the proper relationship between the scientist and the public. This research will explore the influence of the Frankenstein myth and the figure of Victor Frankenstein on scientists by building on the concept of *possible selves*, referring to how people think about their future and potential (Markus and Nurius 1986). The concept of possible selves has been widely used in psychology and social science studies to investigate how people regulate motivations, behaviors and future plans (e.g., Cross and Markus 1991; Sheldon and Lyubomirsky 2006; Oyserman et al. 2015). Serving as behavioral standards for achieving desired selves and avoiding feared selves, possible selves enable individuals to evaluate their current as well as future behaviors (van Dellen and Hoyle 2008). These studies show that positive possible selves can be important incentives for desired future behaviors (Oyserman and Markus 1990), while feared or unwanted selves help individuals protect their self-image, cope with their anxieties, and avoid undesirable future events (Ogilvie 1987). Personality psychologists (e.g., Carver et al. 1999) argue that "the feared self is a point of comparison that is undesired and punishing, leading to efforts to escape from or avoid it" (p. 785). The present paper suggests that scientists may view Victor Frankenstein as a paradoxical possible self because while he makes a miraculous breakthrough, he behaves irresponsibly in both the pursuit and the aftermath of his discovery, and because his values and ethical principles clash with the commonly accepted and preferred standards of contemporary science. Frankenstein's character encapsulates a host of human frailties, such as arrogance and irresponsibility, which are often considered particularly negative or even toxic attributes among scientists (Rotblat 1999).

The Mythical Character of the Scientist: Frankenstein's Tainted Legacy

While the professional obligations and intellectual frameworks of scientists have changed significantly over the past 200 years, the popular myths of science have changed remarkably little. In order to better capture the social and technological implications of science, science studies have increasingly focused on what kinds of people scientists are, and how the public perceives scientists and science. Scientists lead complex professional lives—they are charged with designing and conducting research projects, evaluating findings, and, increasingly, with communicating their results with their peers and the public. Their work and identities as scientists also reflect their personal, social and cultural values and beliefs along with the ethical principles and guidelines they follow as professionals (Osbeck et al. 2011).

The scientific community, however, often has a rather ambivalent relationship with the public (Rutjens et al. 2018). While some people trust and respect scientists, others are skeptical of them and their work. Science is popularly thought to

embody the spirit of progress—a field with a unique capacity to improve as well as extend people's lives; yet a growing number of individuals express suspicion and fear, claiming that science has the potential to seed devastation and calamity (e.g., Koren and Bar 2009; Gauchat 2012; Pittinsky 2015). A recent study showed that people tend to think that scientists are at constant risk of becoming immoral individuals because of their curiosity and tendency for transgression (Rutjens and Heine 2016). Also, when it comes to controversial issues such as vaccination, genetic research, artificial intelligence, and robotics, members of the public are likely to form detailed conspiracy theories about scientists, imagining them as immoral, selfish, and malevolent individuals who are willing to endanger others' health and lives to accomplish their goals (Douglas et al. 2017). For instance, some people think that scientists working on genetically modified organism (GMO) projects are dangerous individuals who deceive the public about the potential harmful effects of engineered food and animals (Hielscher et al. 2016).

In order to gain a better understanding of how people get these ideas, some scholars started studying how science fiction stories (e.g., Milburn 2010) and popular narratives and storytelling practices (e.g., Dahlstrom 2014) shape the public's imagination of science and scientists. Fictional sources, especially science fiction novels and movies, serve as convenient and powerful resources for people to understand and imagine technological and scientific work (Marsh et al. 2003). Popular science fiction movies and novels give form to the fears about and expectations for science. Tropes such as the creation and manipulation of life are also heavily used in various science fiction movies and novels, such as *Ex Machina*, *Blade Runner*, and *Gattaca*. Interestingly, even when people know that these stories are likely to invent and fabricate facts in service of a more interesting and exciting storyline, these narratives have a remarkably strong effect on the public's judgements and attitudes (Marsh and Fazio 2006).

As a popular and ubiquitous story about irresponsible science and scientists, *Frankenstein* has become a preeminent myth for imagining the dangers of science in Anglophone western cultures (Allen 2009). According to this myth, science often produces dangerous side effects, leading to catastrophes from which there is no turning back (Nisbet 2010). The Frankenstein myth suggests that scientists' inventions, whether they are biological, artificial or both, can become dangerous, disrupt existing social order, transform human life into something beyond people's comprehension, or even turn against humankind (Dourish and Bell 2014). In this sense, the myth serves as an important ethical reference point for the scientist by showing that science is a deeply social endeavor with potential positive and negative outcomes; therefore, it requires continuous and close scrutiny as well as subsequent adherence to ethical principles (Davis 2004).

The myth suggests that scientists can? Clone human beings, create genetically enhanced humans and human-animal hybrids, or engineer lethal viruses or bacteria that can be used as biological weapons if they fall into the hands of the wrong people (Anthes 2013). Similarly, robots and AI technologies can already outperform people in certain domains, further fueling societal anxieties about a future where machines take people's jobs or develop superintelligence and take control

over their lives. Studying technological development from a historic perspective, Harari (2014) envisions the following scenario:

> The Frankenstein myth confronts Homo sapiens with the fact that the last days are fast approaching. Unless some nuclear or ecological catastrophe intervenes, so goes the story, the pace of technological development will soon lead to the replacement of Homo sapiens by completely different beings who possess not only different physiques, but also very different cognitive and emotional worlds. (p. 349)

Harari's prediction resonates with how posthumanists imagine the impact of emerging technologies on humanity (e.g., Pepperell 1995; Hayles 1999). Ranging from biological to artificial modifications, novel scientific advancements have the potential to augment, change, and even transform humankind on an unprecedented scale. These changes, however, can often lead to unintended consequences. For example, while scientists can genetically enhance humans to better fight off diseases, these genetic modifications may also leave them more vulnerable to certain infections.

Similarly, scientists' and technologists' work within the fields of robotics and AI are sometimes conceptualized and understood by the media and the public as "irresponsible" and "transgression" (Gunkel 2012). Entrepreneur Elon Musk considers AI one of the most dangerous challenges humanity has faced in history (Gibbs 2014). Drawing a comparison between emerging technologies and Victor Frankenstein's "monster," he has suggested that AI advancements can easily become "godlike entities" and take over the world. Scientists and engineers, consequently, have a responsibility to minimize the risks of misuse. These examples show that the Frankenstein myth can be easily used to succinctly and comprehensibly raise doubts around the work of researchers focusing on biological or artificial life (Nordmann 2017). The Frankenstein myth dramatizes the dangers of scientific obsession and egoism, evoking strong images of the mad genius who does not care about the dire consequences of his scientific enterprise (Smith 2016). This myth also offers simple lessons for the scientific community so they can better control their creations: don't be arrogant, don't overreach, don't play with forces beyond your comprehension, don't treat the living as material, and don't go rogue. Therefore, in order to avoid such negative outcomes and safeguard their scientific creations, scientists should gain a better understanding of how their work is taken up by others and integrated into society (Halpern et al. 2016). As Segal (2001) puts it, this myth shows that "scientists must take moral considerations into account before, during and after research and development, and that they must assume responsibility for the outcomes—both intentional and unintentional—of their experiments" (p. 861).

The Frankenstein myth also provides the scientific community with a powerful archetype of the corrupted and monstrous scientist: Victor Frankenstein, who can be seen as a pariah of science, one haunting the field even before it was fully formed. Shelley never uses the word "scientist" in the novel, depicting Victor Frankenstein as an artist and a student, because the word "scientist" did not exist when she finished *Frankenstein*; it was coined nearly 20 years later in 1834 by William Whewell, an influential member of the British Association for the Advancement of Science (Hindle 1990). As the Frankenstein myth evolved through adaptations and retellings,

Victor Frankenstein became closely entwined with the emerging cultural figure of the scientist. By showing how Victor Frankenstein's personal imperfections corrupt his work, Shelley's novel introduced an appealingly understandable image of practitioners of science as flawed individuals walking the razor's edge in terms of sanity and social responsibility. Within this framework, scientists are sometimes considered similar to Victor Frankenstein, living out a dangerous archetype and an unwanted or feared possible self for the scientist. The feared self represents a set of qualities, like being incompetent or feeling like a failure, that people are afraid of becoming in the future (Vignoles et al. 2008). More importantly, as Ogilvie (1987) writes, "the undesired self is an implicit baseline individuals use to subjectively measure their well-being" (p. 384). Occupational choices like becoming a scientist have a significant impact on people's well-being and self-development trajectories, and thus they reflect multiple dimensions of the self (Carlson et al. 2014). Becoming a scientist is often a way of pursuing a certain type of desired self, so scientists might feel that their scientific research, and their conduct as scientists, creators, and communicators about scientific work, are particularly central to their concept of self, and to the types of desired and feared selves they construct (e.g., Martinson et al. 2005; Schofield 2013). As members of Anglophone Western societies where the Frankenstein myth thrives, scientists must contend with the figure of Victor Frankenstein as they construct their own social and professional identities.

Methods for Studying the Influence of the Frankenstein Myth on Scientists

In order to explore how scientists interpret the Frankenstein myth as a cultural reference, this paper presents findings from 12 in-depth interviews with scientists whose work resonates in some way with Victor Frankenstein's scientific enterprise: creating or modifying biological or artificial life. Accordingly, the present study included individuals working on applied scientific projects, with special focus on biotechnology, medical sciences, robotics, and artificial intelligence (AI). This interview data is part of larger research project on how scientists relate to the Frankenstein myth. An earlier study focused on how the Frankenstein myth may help scientists identify popular misconceptions about their work, construct more positive narratives, and ultimately create a more favorable public image (Nagy et al. 2018). In contrast, this paper concerns how scientists incorporate their perceptions of the Frankenstein myth and Victor Frankenstein into their professional identities and ethical codes.

As a first step, the research team identified a large network of scientists across various applied sciences at a public research university in the United States, and invited them via email to take part in this study. All of the scientists have been working as researchers for more than 10 years and have had experience with the forefront of technological advancements. More specifically, they all had extensive research experience in contemporary bioscience and/or computational theories and applications. The researchers from this list were involved in interdisciplinary science projects that heavily relied on modern technologies, such as genetic engineering, synthetic biology, nanotechnology, robotics, and artificial intelligence. Finally, the

scientists had unique educational backgrounds; they were all trained as researchers with special focus on applied science, enabling them to reflect upon various dimensions of technologies and evaluate them not only from a purely scientific perspective but also broader social, business, and ethical perspectives. Of the 81 scientists who were contacted via email, 12 of them were willing to participate (~15%). "Appendix 1" section lists the interviewees' pseudo names, work experience, and educational backgrounds. All pseudo names are randomly assigned to the interviewees; they represent important characters from Mary Shelley's life and *Frankenstein*.

The interview protocol covered three key areas: professional background and public perceptions, the Frankenstein myth and the figure of Victor Frankenstein, and professional and ethical values. The first set of questions incorporated the scientists' professional background and the broader social implications of their research projects. Specifically, these questions targeted scientists' views on the technical and professional aspects of their research (e.g., "Could you tell me a bit about the research you do?", "How then would you define your research topic for someone who is not familiar with your field?"). These questions also explored the interviewees' views of the public understanding of science, with a special focus on the ways scientists think about their professional identity and the work they do (e.g., "What do you imagine ordinary people think about your research?"). The second set of questions covered scientists' views on the popular understanding of the Frankenstein myth and the role this myth plays in shaping people's attitudes towards and expectations for science (e.g., "There are many interpretations of *Frankenstein*. What is your interpretation?", "What does *Frankenstein* tell us about science?"). The present study also focused on how scientists think about Victor Frankenstein as a scientist and on the ethical implications of his scientific enterprise. Finally, the last set of questions targeted scientists' views on the technical and ethical implications of science for humankind (e.g., "Regarding your field, how will the latest scientific discoveries change our life?", "What are the most important ethical dilemmas in your field?"). The interview protocol elicited discussion around values of science, allowing participants to elaborate on their professional experience, responsibilities, and predictions for future scenarios (for the full list of interview questions, see "Appendix 2" section). Each interview lasted for approximately 1 h and was recorded and transcribed.

Interviews were analyzed using interpretative phenomenological research methods (Groenewald 2004). Allowing scholars to generate new ideas and theories, the phenomenological approach focuses on the qualities of human experience, "examining entities from many sides, angles, and perspectives" (Moustakas 1994, p. 58). Phenomenological perspective focuses on the general human capacity to create myths or models as means of describing human experience (Mousley 2016). In the present research, the interpretative phenomenological approach was employed to get a better understanding of how scientists feel about their research and how they think about the Frankenstein myth, by working with the interview data and elaborating on the common themes and frames.

After the interviews were transcribed, they were analyzed by an interdisciplinary research team to identify the general themes and core narratives. Following the interpretative phenomenological research procedure (Creswell 2013), the first author who interviewed the participants tracked the key themes and narratives of the

interviews that may represent what scientists can learn from the Frankenstein myth and how Victor Frankenstein relates to their self-image. After emergent themes were identified, the interviewer looked for possible connections between them, produced a list of the main themes, and eliminated themes that were redundant (Eatough and Smith 2008). The final list contained major themes around the scientist's self-image along with quotes from participants and the interviewer's interpretations. In order to avoid potential misinterpretations, the researcher who analyzed the interviews discussed his interpretations with other team members, who in turn helped him critically evaluate his preliminary findings. By incorporating these comments and observations into the final analysis, the research team was able to better explore how the Frankenstein myth and the figure of Victor Frankenstein may represent a feared self for these scientists. The qualitative analysis produced results feeding into three major themes: the professional and public image of science and the scientist, scientists' interpretation of the Frankenstein myth, and scientists' interpretation of Victor Frankenstein.

It is important to note that we used the same interview data for this study that we analyzed in our previous paper (Nagy et al. 2018). While in the other research we focused on how scientists could create a more favorable public image, some analytical overlaps still occur between the two studies.

Studying What Scientists Say About Frankenstein

Scientists' Perception of the Professional and Public Image of Science and the Scientist

Participants found it easy to talk about their research and define their work for someone who is not familiar with their field. They also pointed out that personal stories and images from popular culture help them talk about their research more effectively. However, when it comes to communicating with people outside their fields, the interviewees argued that they need to be somewhat cautious about which words and concepts they use because laypeople might misunderstand or misinterpret their work (Nagy et al. 2018). Robert, who translates medical knowledge about how the nervous system works into devices to treat neural pathologies, explained that people tend to rely on popular concepts such as "cyborgs" and "human–machine hybrids" to imagine the work he does in his lab. He noted that

> …the cyborg root has a really bad connotation so I try not to use this word. You know, the device that turns against its user is a very strong image for people who read science fiction books and watch these movies. This is like a *Frankenstein* thing, when a scientist creates a monster that turns against him and kills a lot of innocent people.

Here Robert clearly articulates the role of Frankenstein as a negative reference point that continues to shadow the cultural role of the scientist. The researcher Alphonse working in the field of rehabilitative technology mentioned that "people often label technologies as alien things or evil entities," and the computer

scientist Caroline noted that "a lot of people do not know what is possible and what is not possible technologically. They do not know a lot of things about the new technological systems and their capacity." Or as Agatha, a researcher with a synthetic biology background, put it,

> The problem is when we do not have a good, solid logical argument we turn to an emotional one. We hate it because we do not understand it! We hate it because it is the unknown. We live in an era when everything is changing so quickly. Technology is moving so fast, and some people are scared of these changes because they do not want to move.

In these responses, the scientists describe the ways in which cultural narratives like the Frankenstein myth become relevant, as members of the public seek narrative frameworks with which to interpret emerging scientific developments (see also Allen 2009). People respond to powerful cultural narratives, according to the interviewees, when they lack actual technical knowledge.

Although all the researchers from this sample agreed that scientists need to do a better job at educating people about science, they also said that it is very challenging to talk about science because the media tends to portray their fields in a negative light. For example, Elizabeth, who works within the field of nanotechnology, said that

> The way science is portrayed in popular media is often really polarized and sensationalized. It is funny that if the popular media showed what science is really about, people would be bored. Science either saves or destroys the world, there is no middle ground in the media.

Similarly to what this research found in our previous study (Nagy et al. 2018), despite the fact that the scientists argued that people have generally positive attitudes towards their work, the confusion about what science and technology are capable of doing leads to polarized emotional reactions. Nearly all of the participants, 11 of the 12 scientists, agreed that the public tends to rely on popular images from media to understand science because they lack advanced scientific and technological skills and competencies. The interviewees also noted that this fear and confusion about science and technology sometimes affect how the public perceives scientists. In addition, all of the participants argued that people rely on pop culture for science news because they do not know what scientists actually do. Henry, a biochemist who works on a genetic engineering project, noted that

> People don't know what you are doing, and when they don't know what you are doing, they are going to fear it. And if they fear it, they are going to project their ideas from all those science-fiction stories. I don't think that anyone really thinks that I am up here and I want to take over the world. But every cartoon says that's what scientists do. So they are constantly bombarded by this idea that scientists are the bad guys. That's why it is really hard to go out and deal with these people.

Here Henry explicitly describes a feared-self version of the scientist as a figure conjured up by members of the public, and argues that "it is really hard to go out and deal with these people." Past transgressions by scientists (Gunkel 2012), continuing uncertainty about emerging science (Turney 1998), and more abstract and existential fears (Mellor 2001) all fuel the construction of these negative popular conceptions of the scientist. That is, the gaps in information about scientific practices and artifacts are filled by fear, based on the stereotypes of the megalomaniacal "mad scientists" in popular culture (see also Meyer et al. 2013; van den Belt 2009). As such, it can be quite challenging for scientists to distance themselves from the negative fabric of the Frankenstein myth, and create a more positive narrative about their work and identity. These views on the public perception of science and scientists also share many similarities with how participants talked about *Frankenstein*.

Scientists' Interpretation of the Frankenstein Myth

The researchers from this sample all knew the plot of Mary Shelley's *Frankenstein* to some extent and had very similar interpretations of the Frankenstein myth—they saw it as a science fiction story about a scientist who creates something beyond his understanding and control. However, rather than understanding *Frankenstein* as a story merely about the consequences of "playing God," they advanced several additional interpretations (see also Nagy et al. 2018). For Robert who works in the field of neural engineering, *Frankenstein* is "an icon that captures scientific and moral themes so well. It represents the potentially good and bad effects of science. It shows us what happens to society when we expand our knowledge." In addition to the theme "expanding scientific knowledge," *Frankenstein* is also about discoveries. Or as Byron, who focuses on robotics and artificial intelligence, put it,

> Well, when I hear the word "Frankenstein," what immediately pops up in my head is Victor Frankenstein, the creature on the table, Igor, electricity and lighting and you know everything… What also jumps into my head is this passion to ask questions and experiment and discoveries. I think these are the heart of the story.

Although *Frankenstein* is primarily considered a myth of the Anglophone western culture, 7 out of 12 interviewees argued that the Frankenstein myth represents people's general distrust of science, and therefore also functions as a facet of a universal narrative. Mary, who works on a genetic engineering project, said,

> Every country has a variation of the fear about the scientist and what they are capable of. The mad scientist image is so powerful that it becomes the first impression for a lot of people.

From the perspective of scientists, the Frankenstein myth refers to a very specific danger of science: losing something inherently human. People do not only fear science because it may produce dangerous artifacts but also because it may

create alien entities or transform human beings into something unrecognizable. Six participants argued that people's negative feelings about robotics, AI, nanotechnology, or genetic engineering stem from the notion that these artifacts have a strong imagined capacity to undermine individuality. Their perception represents the view that science could be seen as a form of transgression (e.g., Nisbet 2010; Gunkel 2012). According to the mechanical scientist Polidori's interpretation,

> *Frankenstein* is about adding nonhuman or not fully human, or something wrong to scientific research. It is about losing something really important.

In general, the scientists working within the fields of robotics and artificial intelligence agreed that the public would react negatively to science mixing human with nonhuman and organic with artificial. In other words, if someone is working with robots, they do not get the Franken-label, but if they start mixing robotics with human flesh to make cyborgs, they are right in Franken-territory. Scientific applications that are considered "non-human" or "cyber things" tend to evoke more concern and anxiety about the potential negative side effects. These fears are often centered on losing control over one's body (artificial limbs or organs that are "owned" and ultimately controlled by some third party) or cognitive functions (medical devices might hijack or alter the behavior of the human brain).

Contrary to robotics and artificial intelligence, molecular, genetic engineering or nanoscale applications produce different public attitudes, especially when they revolve around GMOs or vaccination (see also Anthes 2013). These bioscientists agreed that, although the public knows about the potential benefits of these artifacts (e.g., being protected from diseases), people are likely to think that scientists modifying biological systems may accidentally poison or contaminate living entities. This is an interesting nuance which complicates the public-blaming narrative that some respondents were articulating before. The interviewees here argued that while the public understands the purpose and benefits of specific classes of scientific artifacts, they are still wary and suspicious. In other words, some scientific fields and research topics are controversial and heavily politicized so they do not necessarily require the Frankenstein myth to be viewed as hubristic and dangerous practices (e.g., climate change). Even in these fields, however, the myth can still be deployed as a metaphor or shorthand for scientific hubris (see also Nagy et al. 2018).

However, in contrast to robotics and genetic engineering, two of the researchers from the sample whose primary research lies in medicine did not think of the Frankenstein myth as a negative image for their work. As Elizabeth put it, "from my perspective, *Frankenstein* is not a common metaphor for what I do. People do not use the Frankenstein metaphor for my work. I do not encounter *Frankenstein* very often." In other words, while some research areas invoke the "Frankenscience" image, others are less susceptible to this negative framing. For instance, William who works as an evolution scientist argued that

> The *Frankenstein* thing depends on the research area you do. Researchers working in areas that are similar to what Victor Frankenstein did in the story must meet the term "Frankenscience" all the time. For them, this story can be a burden. In my area, it is not a thing though.

Still, the majority of the interviewees, eight scientists, agreed that *Frankenstein* touches on several topics that are relevant for the whole scientific community. De Lacey, a researcher focusing on cancer treatment noted that

> The story is a cautionary tale. It is about arrogance. Through this arrogance we can create a lot of suffering. You often think that your work is so great. You start to forget about the suffering your work can cause to other people. You can easily become myopic.

This comment surfaces a surprising result of the interviews: scientists may actively engage with the "stigma" of Frankenstein not just to avoid negative selves but to correct potential errors and actively identify more positive selves. The cautionary tale for De Lacey is not just about public interpretations of scientific work but specifically about how scientific self-esteem might occlude a recognition of possible suffering resulting from scientific work.

For a scientist, unlike a member of the public, that moment of discovery and its excitement outstrips and feels more resonant than the rest of the novel, which is largely about catastrophe. Similarly, Agatha, who works within the field of immunology, argued that the most important elements of the Frankenstein story are "discovery" and "experiments," but she also noted that

> Victor Frankenstein represents interest in discovery and what you can do with science outside of the constraints of the institutions that have made science what it is. And there are obviously risks and dangers to not working within the framework.

This particular scientist puts her finger on the ambivalence surrounding scientific work. Despite that Agatha sees the point of regulations and is herself a responsible researcher, she also appreciates the thrill of imagining herself as a "rogue" or "unfettered" individual. This also echoes a point ecological engineer Kevin Esvelt (2017) made about *Frankenstein*, namely the thrill of achieving remarkable scientific breakthroughs acts like a siren song. The Frankenstein story, however, shows people what problems scientific curiosity and obsession can cause without responsibility and carefulness (Segal 2001).

Scientists' Interpretation of Victor Frankenstein

Echoing what this research found in a previous study (see also Nagy et al. 2018), Victor Frankenstein exemplifies the dark side of science and scientists for the

participants—the dangers that science poses to society. By telling the story of a scientist who goes rogue and engages in dangerous practices, *Frankenstein* dramatizes the unintended or fatal consequences of scientific and technological explorations. The AI researcher Percy noted that "we created some monsters in the past, like toxic organisms, that caused a lot of trouble." According to the majority of the interviewees (eight scientists), *Frankenstein* reflects on what it feels like for a scientist to achieve a remarkable scientific or technological breakthrough that subsequently causes a lot of trouble. Mary, who works on a genetic engineering project, said

> I always think of Doctor Frankenstein as the creator. And the unintended consequences of science and technology. I kind of like the story, although I don't remember too much about it. Lots of people think that Frankenstein tried to play God. For me, it is about unintended consequences.

For eight out of twelve interviewees, Victor Frankenstein encapsulates the image of the irresponsible scientist who loses control over his own experiment and creates a monster (see also Nagy et al. 2018). *Frankenstein* has permeated popular culture in the Anglophone west and created a negative image of the scientist that is prevalent both among members of the public and among professionals in scientific fields. Or as the nanotechnology researcher Henry noted,

> *Frankenstein* exemplifies a whole genre of stories where the bad guy, the nemesis, the problem is generated by the scientist. I think *Frankenstein* is expressing a general or reasonable cultural fear of potential dangers or devastating consequences of science.

Apparently, the "Frankenstein" image has different implications and meanings for scientists, depending on their fields of study and views on the Frankenstein myth, and the figure of Victor Frankenstein in particular. In fact, Victor Frankenstein embodies several important goals of research, notably the goal of achieving breakthroughs. What he lacks, according to the interviewees, is ethics and morality. The scientists' impression about Victor Frankenstein therefore is rather ambiguous: although he represents numerous positive characteristics, such as creativity and determination, he is also a "pariah" or a "feared self" for the scientific community; Victor Frankenstein symbolizes the bad and dangerous alter ego of the scientist (see also Haynes 2003). *Frankenstein* shows what happens to the scientist who is not careful enough. Reflecting on the "dark" side of science, Byron argued that "when people see all these disasters occurred because we did not think through what we wanted to accomplish, then they are right when they think that scientists are dangerous." In fact, scientists caused a wide range of societal and environmental harm alongside their innovations and discoveries throughout history, and Victor Frankenstein represents these dangers or unintended consequences. Or as the medical researcher Henry noted,

> Science is a double-edged sword. It poses dangers but also solves problems. We depend on technology and science. But sure, it creates nuclear bombs and harm to the environment. You know science is human.

Science is human, this interviewees argues, because it represents how people think, solve problems and act. On the negative side, there is Victor Frankenstein, who embodies the scientist who works outside the scientific community and who is blind to the dangers his scientific enterprise poses to the world. On the positive side, there is the scientist who cooperates with others and follows rules and ethical principles. In other words, although science solves problems, it also poses dangers at the same time. The utility and risk of science, according to the respondent, are connected and perhaps inexorably linked. In order to minimize the dangers of scientific exploration, all of the participants agreed that scientists need to follow strict rules and regulations. Percy argued that "you really need to be super rigorously honest. Brutally honest. The best way to minimize risks is to be transparent and self-critical. And… you need to be really cautious." In this sense, being cautious means that scientists should be aware of both the potentially positive and the negative consequences of their research, which can be very challenging in many cases. Formal regulations and ethical guidelines around science may help scientists avoid the potentially negative or dangerous effects of research. Or as Agatha put it,

> We want to do better as humans. It is our natural drive to make everything better, bigger, or more effective. It is a natural tendency to push the boundaries. You need rules and ethics to avoid potential disasters.

This perspective, which embraces ethics and transparency, is a way to fight against the mad scientist stereotype and point toward the scientist's more realistic actual position as a member of a community. In addition to being subject to strict regulations, scientists also work with others and share results and critiques. Thus, the very acknowledgement of these larger regulatory apparatuses works to disarm the mad scientist image by undermining the assumption of solitude and individual action that it is based on.

In contrast to Victor Frankenstein's era, today's scientific world is much more advanced. William stressed that "we have a much better system now that prevents you from doing harm. We have to follow strict regulations now." In fact, the participants argued that research is founded on transparency as a strong ethical principle. Molecular biologist Mary, who works on a genetic engineering project, stated that

> We, as scientists, are trying to do something extraordinary. We would like to open up new fields and have breakthroughs. I get the feeling that Frankenstein was afraid of public scrutiny and he did everything that he could to stay away from people. Certainly, I am not like him, and I feel like that it is my obligation to justify why I am doing what I am doing.

This interviewee is finessing their identity as a scientist to include coping with public scrutiny and managing public perception as core elements of their profession. Recognizing that she will "never get rid of *Frankenstein*" (Turney 1998), she uses the myth as

a negative self to project a more positive self-image and social role. Collectively, these researchers accept the curiosity-driven mission of advancing human knowledge while acknowledging that they need to engage cautiously and strategically with an unknowing public to make sure that their light of truth is not dimmed by irrational fear. They are struggling with shifting boundaries and assumptions regarding the nature of their identity as a scientist and their duty to engage with the public and advocate for the value of their work.

Conclusion

The present study conceptualized Victor Frankenstein as a complicated possible self—encompassing both desired and feared attributes—for the scientist and investigated how scientists whose research may make them susceptible to negative stereotyping talked and felt about the public and the Frankenstein myth, and about Victor Frankenstein in particular. This negative image of science often draws on the specific Frankenstein theme of a mad scientist attempting to transcend human boundaries (see also Huxford 2000). Because the Frankenstein myth presents a handful of metaphors about the dangers of scientific creativity and imagination, scientists may use the Frankenstein myth as an opportunity to reflect upon the various social and ethical dimensions that constantly shape and influence their work (Smith 2016).

The interviews helped the research team gain a better understanding of how Victor Frankenstein, as a figure of the scientist, also fulfills various self-enhancement functions for the participants. Since popular adaptations of *Frankenstein* tend to depict Victor Frankenstein as a reckless man with a God complex, his character has become an ambivalent reference point for the scientist: while he embodies various desirable attributes such as creativity and passion, he also demonstrates what scientists may become if they are not careful enough (Haynes 2003). This ambiguous image serves as an implicit standard that professionals can use to assess their identities and work as scientists. Previous studies have shown that possible selves are important psychological resources for people to motivate and guide their self-development throughout their lives (Cross and Markus 1991). As the source of an iconic possible self for scientists, *Frankenstein* sets various implicit and explicit norms about what is deemed desirable and undesirable in scientific behavior. While several participants noted that Victor Frankenstein was a brilliant scientist who achieved a remarkable breakthrough, similar to how laypeople interpret the story, the interviewees also often considered Victor Frankenstein an overly ambitious and hubristic "rogue" scientist who does not care about the social and ethical consequences of his scientific enterprise.

For most of the scientists who took part in this research, Victor Frankenstein embodies the light as well as the dark traits of the scientist: the passion, the creativity, and the imagination along with the arrogance, the irresponsibility, and the fanaticism (Higgins 2008). This image of Victor Frankenstein gives form, direction,

and self-relevant meaning to members of the scientific community, and helps them articulate the importance of ethical guidelines and values surrounding science. For researchers, transparency, responsibility, and ethical conduct are essential values that allow them to separate and distinguish themselves from their unwanted possible selves, the shades of Victor Frankenstein. The present research suggests that scientists may project their anxieties about ethics, responsibility, and their professional selves onto the Victor Frankenstein character, and onto an imagined public audience to enhance their self-image. In general, projective mechanisms help people attribute their undesirable traits to other people and maintain a positive opinion about themselves (Schimel et al. 2003). The image of Victor helps them both defend their selves ("I am not like him") and enhance themselves ("I am better than him"). By emphasizing the differences between the real scientist and the imaginary figure of Victor Frankenstein, scientists may distance themselves from the negative stereotype of the irresponsible scientist, and ultimately enhance their professional self-image.

Previous research has shown that when perceived as relevant examples, role models—even negative ones—can inspire, guide, and facilitate self-enhancement (Lockwood and Kunda 1997). As such, professional education and training programs could use the Frankenstein myth to help scientists and engineers think more elaborately about the different ways they may navigate social and ethical contradictions and tensions in constructing, experimenting with, and evaluating their professional identities. Seeing Victor Frankenstein as a locus of controversy for science may help scientists and engineers reflect on and cope with their own anxieties about their professional identities and ethical dilemmas. This can be especially helpful for early- or middle-career scientists and engineers, who already tend to pay increased attention to positive as well as negative role models in an effort to create and refine their professional identities (Gibson 2003). By engaging with the Frankenstein myth and the figure of Victor Frankenstein, scientists can add nuance to their perceptions about their profession, their ethical principles, and the work they do in the lab.

Viewing Frankenstein as a lens for understanding how people imagine science and technology invites the scientific community to discover new ways to reflect upon science, ethics, and responsibility. Scientific work does not happen in a vacuum. Science, technology and society (STS) scholars have long emphasized that scientific work is deeply entangled in people's social, political, and cultural lives (Latour and Woolgar 1979; Jasanoff 1995). As a human production, scientific breakthroughs will continually raise new questions around the social and ethical implications of scientific and technological change. Indeed, people continually revisit the Frankenstein myth precisely because it serves as a mechanism for addressing those implications in culturally relevant ways. The myth serves a mediator between the public and the scientist—it provides lenses for the scientists to peek into public anxieties and fears about science, and for the public to peek into the "black-boxed" world of science.[1] Scientists should approach the Frankenstein

[1] The authors would like to thank one of the anonymous reviewers for bringing this important argument to their attention.

myth as an opportunity to revisit their own as well as the public's views on social, political, and ethical implications of their work, as well as the cultural vocabulary, analogies, and shorthand we use to think about and talk about science. This is especially important considering the fast and unprecedented pace of scientific progress that has the potential to give birth to new machinelike (e.g., robots, AI) or organic (e.g., chimeras, clones) "Frankenstenian monsters" with seismic and unpredictable consequences for society.

Scientists may find it difficult to accept that science sometimes produces unintended consequences. In this sense, the story of Victor Frankenstein has a practical message for scientists: because science is inherently messy and disruptive, they must do their best to conceptualize the limits of their work and understand their own motivations for pursuing it as well as its potential for misuse and abuse (Davis 2004). Esvelt (2017) has argued that the Frankenstein story has a clear message for scientists: "wisdom is knowing whether, when, and how to develop new technologies—and when to lock them away for as long as we can." Or as the neuroscientist Bird (2014) noted, "researchers have a responsibility not only to oppose the misuse of their work, but further, to attend to its foreseeable societal impacts" (p. 170). Understanding the effects of the Frankenstein myth on their own self-image and on public perception of themselves and their work may allow scientists to engage in a more constructive public discussion about the roles, conflicts, and responsibilities of scientists in society. By embracing rather than denying the Frankenstein image, scientists could make real progress in gaining a more nuanced understanding of the potential social and ethical consequences of their work.

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Appendix 1

See Table 1.

Table 1 Interviewees' pseudonyms, general research interest and scientific focus

Interviewees	Research interest	Scientific focus
"Robert", neural researcher	Using medical knowledge about how the nervous system works and translating it into devices to treat neural pathologies	Biology and biomedical engineering
"Elizabeth", organic chemist	Developing artificial molecules to treat infectious diseases and neurological disorders	Organic chemistry, nanotechnology, and biomedical engineering
"Caroline", computer scientist	Understanding the different ways human users interact with computers and robots	Human–computer interaction, artificial intelligence, and robotics
"Alphonse", health systems researcher	Developing rehabilitative technologies for patients with disabilities	Computer science and biomedical engineering
"Henry", biochemist	Creating nanoscale devices to monitor and profile people's health more effectively	Biochemistry and nanotechnology
"De Lacey", cancer biologist	Developing new methods to prevent cancer and improve cancer management	Computational cancer biology and ecological theory
"Agatha", genetic researcher	Gaining a better understanding on how to develop better vaccinations	Immunology and genetic engineering
"William", evolution scientist	Understanding how cancer cells interact with normal cells	Cancer biology and evolution theory
"Mary", microbiologist	Improving crop production by genetically modifying plant cells	Plant biology and genetic engineering
"Byron", robotics scientist	Developing new brain-machine interfaces	Computer science, artificial intelligence, and robotics
"Polidori", mechanical scientist	Investigating how to control robots using the human brain	Robotics, artificial intelligence, and human–computer interaction
"Percy" artificial intelligence researcher	Creating new cyber-socio intelligent systems	Artificial intelligence, robotics, and computer science

Appendix 2

See Table 2.

Table 2 Main interview questions

Theme: *Professional background and public perceptions*
Could you tell me a bit about the research you do at [*workplace*]?
What do you imagine ordinary people think about your research?
What do you think most people don't understand about your research?
How then would you define your research for someone who is not familiar with your field?
Theme: *The Frankenstein myth and the figure of Victor Frankenstein*
What comes into your mind when you hear the word 'Frankenstein'?
There are many interpretations of Frankenstein. What is your interpretation?
What does Frankenstein tell us about science?
How would you describe Victor Frankenstein?
Do you see any similarities between Victor Frankenstein's work and your research? [Why?]
Imagine for a moment that Victor Frankenstein worked as a scientist in your field. What steps can you take to avoid the mistakes he made?
So, what does Frankenstein tell us about ethics?
Theme: *Professional and ethical values*
What are the most important ethical dilemmas in your field? [Why?]
Could you mention some of the potential risks or dangers your research can pose to society? [What can you do to minimize these risks or dangers?]
Regarding your field, how will the latest scientific discoveries change our life?
What does it mean to be a responsible researcher in your field?

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