

# Introduction

## The communicative functions of silence in science

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Discussions about the communication of science often rest on an unquestioned assumption that open and efficient channels of communication are always of greatest benefit to both science and society. Increasingly, scientists are urged to maximise their communications by joining large collaborations, increasing their publication rates, sharing their data online, taking part in public outreach events, advising policymakers and talking to the media. Journalists and other media producers, for their part, are often told that they should cover more science, more often and at greater length. Yet too much communication can sometimes become a barrier to effective communication. For instance, a recent overview of efforts to engage the public with science suggests that unreflexive public engagement can close down debate rather than open it up. Despite some successful and productive engagement initiatives, the authors reflect that they now find themselves advising scientists and policymakers ‘how and when *not* to engage’ (Stilgoe et al., 2014: p. 11). Sometimes it might be best – for the scientific community and for wider society – if scientists stay silent.

This book emerges out of a series of AHRC-funded workshops which aimed to draw attention to the role that silence can play in the communication of science. Contrary to the ideal of science as an open enterprise, scientific innovation relies as much on discontinuities – on barriers and lacunae – as it does on the free flow of information. For instance, the fear of competing research groups stealing ideas can restrict scientists’ willingness to discuss their work openly. Journalists, too, may hold back on a story if publishing could provoke litigation suits or compromise future access to sources.

Such closing down of communication can be understood as the production of silence. Crucially, these silences can communicate in their own right. The silence of a scientist who shuts herself away in her laboratory, for example, could be variously interpreted as signifying hard work, an imminent breakthrough, an uncollegiate attitude or disengagement from society; whatever the interpretation, her silence has carried meaning for those who attend to it. Not all silences have communicative value, but those silences that do communicate have the potential to complement and enhance, rather than just limit, communication through verbal language.

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Silence, then, is more than simply the absence of noise; silence signifies. This is the fundamental message of scholars who have studied the nature of silence. Scholars working in a range of disciplines – including linguistics, rhetoric, literary studies, feminist studies, political theory, organisation studies, theology and philosophy – have examined the nature and meanings of silence in different contexts. Even as early as 1973, Thomas Bruneau was able to draw up a bibliography of some 250 academic studies of silence (1973: p. 42). One aim of this book is to show that science is another context where silence is worthy of academic attention.

As well as adding to the silence studies literature, the contributions in this book also complement and extend recent work in the emerging field of ignorance studies. There, scholars have drawn together interests in uncertainty, risk and absent knowledge to examine the social construction of non-knowledge. One branch of work in this field, known as ‘agnotology’ (Proctor and Schiebinger, 2008), takes nonknowledge to be either the outcome of cultural biases that suppress knowledge production or the product of a deliberate strategy to obstruct the dissemination of knowledge. Focusing on issues where nonknowledge claims have been deployed to prevent or delay policies that would be in the public interest – such as tobacco legislation or climate action – agnotology draws attention to the construction of ignorance as the outcome of political struggles.

This approach has been criticised by some for its normative tendency to identify the strategic use of ignorance claims with anti-scientific interest groups and ‘bad’ science (Gross and McGoey, 2015; Pinto, 2015). By contrast, other work in ignorance studies takes nonknowledge to be an inherent feature of the knowledge society: knowledge and nonknowledge of scientific issues are, by this account, co-produced (e.g. Gross, 2010). Areas of interest highlighted by such work include the varying degrees of intentionality regarding nonknowledge on the part of social actors, the existence of differing epistemic cultures of nonknowing within science, and the strategic uses to which non-knowledge claims are put in public debates (Böschen et al., 2010). For silence studies, too, individuals’ intentions regarding their silences, the cultures that produce silence, and the circulation and distribution of silences in public fora, are all of interest. This book is therefore divided into three parts – ‘Choosing silence’, ‘Cultures of silence’, and ‘Silences in the public sphere’ – which consider each of these aspects in turn.

Like ignorance studies, the study of silence draws attention to the ways in which absences are constructed and the ends to which such absences can be put. But where ignorance studies highlights epistemological issues arising from nonknowledge claims, the study of silence emphasises the communicative value of absent speech – something that, crucially, is both relative and context-dependent. Since, as I discuss below, silence carries positive as well as negative connotations, a focus on silence also reminds us that leaving some things unsaid may aid knowledge production rather than being necessarily obstructive.

The case studies presented in this book examine the varied meanings that silence takes in the production and communication of scientific knowledge. This Introduction develops a theoretical framework in which these case studies can be placed. In what follows, I first present an overview of some of the key insights of the silence studies literature and then propose a typology of silence which I use to explore some of the contours of silence in modern science.

### **Signifying silence**

Whilst the aim here is to move beyond a view of silence as absence, it is worth first considering how even absence implies that silence is more than nothing. What is it that is absent and to what degree? Absence is relative, implying a potential presence through the very act of negating it. In his composition 4'33" – in which a musician sits at an instrument for 4 minutes and 33 seconds without playing anything – John Cage famously drew attention to the environmental noises that constitute a situation that would otherwise be perceived as silent. Cage's piece, highlighting the impossibility of absolute silence, was inspired by his experiences in an anechoic chamber. Even in this specially engineered sound-insulated chamber, he had found that he could still hear noises, which the engineers later explained were the pumping of his heart and the hum of his nervous system (Cage, 1957). Cage concluded that an objective demarcation between sound and silence was untenable; whether or not a specific situation is silent is a subjective judgement and the qualities of that silence are dependent on context and expectations (Cage, 1955).

At the first of the series of workshops that led to the current volume, pianist Rolf Hind performed Cage's piece. As the workshop participants listened to the silent performance, we heard many things, including the creaks and groans of the building as preparations were made for some renovation works. Those who worked in the building could locate and identify these noises, conjuring a familiar architectural and social space. For the rest of us, the noises signified the unknown and anonymous space that surrounded us that day. Not only did the performance resignify silence, but the meanings the silence carried depended on the listener.

Since absolute silence is never possible, the absences that characterise silence will vary, depending on the situation. Linguist Michal Ephratt (2008) distinguishes stillness, the antonym of noise, from silence, the antonym of speech (or, we might add, of verbalisation more generally). Stillness describes a state that is external to the act of communication. By contrast, silence that is defined as the absence of speech is located within the communicative act. It is these silences that have been of most interest to silence studies scholars.

Silence is both a necessary accompaniment to speech, as with the gaps that separate words and sentences, and can also be identified with that which is excluded from speech. As the rhetorician Robert L. Scott put it:

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Every decision to say something is a decision not to say something else, that is, if the utterance is a choice. In speaking we remain silent.

And in remaining silent, we speak.

(Scott, 1972: p. 146)

Silence is thus a constant presence in speech, as much as it is an absence of speech. The conception of silence as absence fails to attend to the complexities implied by this co-existence of speech and silence. For instance, although silence can be thought of as corresponding to a gap in communication, speech too can generate a communication deficit, as the writer W. R. Espy highlighted when he joked: 'I have nothing whatever to communicate, and words are the best means of non-communication I know' (cited in Sobkowiak, 1997: p. 55).

Conversely, silence can lead to a proliferation of speech. Maggie MacLure and co-authors (2010) give the example of a five-year-old child called Hannah. At the start of each school day, a register is taken and each child responds by saying 'good morning' to the teacher – each child, that is, except Hannah, who remains silent when her name is called. Paradoxically, Hannah's silence calls forth an excess of speech in response – of meetings and charts and analyses – as teachers, parents, researchers and even the other children all try to work out what Hannah's silence means and how they can make it stop. Hannah's silence is a presence which others try, unsuccessfully, to undo through an onslaught of language.

As this example illustrates, speech and silence are closely entwined, each capable of generating the other. Adam Jaworski thus recommends that they should be treated 'as fuzzy, complementary categories, and not as discrete and opposite ones' (1993: p. 48). Similarly, Kris Acheson argues that: 'silence and speech, paradoxically, are parallel communicative events in addition to opposite poles of a binary' (2008: p. 543). For Acheson, not only can silence function as a zero sign – an empty signifier that replaces missing words – but it can also function as a sign in its own right:

silence and speech (like stillness and action) gain the capacity to live in a paradox of simultaneous opposition and correspondence because they both constitute signs in a semiotic system. Because, together, they comprise language, they are oppositional in their relationship with each other and corresponding in the relationship they share with language.

(Acheson, 2008: p. 543)

Central to this conception of silence as a sign is a distinction between communicative and non-communicative silences. Not all silences signify; for instance, Jaworski identifies muteness as a non-communicative silence (1993: p. 4). Communicative silences, by contrast, enfold some measure of intent – they have meaning because they are meant. This implies that such silences are an active construction in contrast to the typical assumption that silence is a passive state. As Scott argues, the production of silence requires great effort:

‘Silence is the withholding of speech, it is desire conquering desire, it is not simply not saying. Not saying is failure. Silence is to be achieved’ (1993: p. 6).

As well as a degree of intention on the part of the producer of the silence, communicative silences also rely on the expectations of the receivers of the silence. If no communication is expected, a silence will not be interpreted as communicative. Thus communicative silence is co-created by speaker and listener (Scott, 1993). It was Hannah’s teachers, confronted with the child’s silence at a moment when they expected speech, who construed the silence as meaningful, even though what precisely it meant – fear? anxiety? excitement? – remained unclear to them (MacLure et al., 2010).

The role of the listener also implies that silences can be directed at specific addressees. Giving someone ‘the silent treatment’, for instance, sends a message to that particular person. In an analysis of silence as political strategy, Barry Brummett notes that a silence can also be ‘overheard’ and that this may be intentional on the part of the producer of the silence (1980: p. 295). He gives the example of China being expected to take note if the United States stops speaking to Taiwan. A critical analysis of silence therefore needs to take account of both the targeted audience and the indirect audience of the silence.

One prominent feature of silence is its potential for ambiguity. This again relates to expectation. The meanings of conventional silences – such as a minute’s silence to mourn a death or the silence of a quiet space like a library – are highly constrained, denoting, in these particular examples, respect and concentration respectively. By contrast, freely chosen silences, such as Hannah’s silent response to the calling of the register, can be highly ambiguous. For instance, a silence during a conversation could convey any of the following contradictory meanings among many others (adapted from Johannesen, 1974):

The silence expresses agreement.  
The silence expresses disagreement.

The silent person is bored.  
The silent person is attentive.

The silence marks anger.  
The silence marks empathy.

The silence signals disrespect for the other.  
The silence signals respect for the other.

The silent person feels ill at ease.  
The silent person feels entirely at ease.

The degree of ambiguity in the meaning of a specific instance of silence depends on the culture in which the silence occurs. In his landmark study of the extensive use of silence in Western Apache society, anthropologist Keith Basso (1970) found that his subjects understood acts of silence to have tightly constrained functions as appropriate responses to socially ambiguous and

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unpredictable situations. To Basso's subjects, these silences had well-defined meanings. Onlookers from outside the culture, however, may misread such silences, as happened with the stereotyping of Native Americans as sullen and uncooperative or as dignified stoics. Since communicative silences are part of the language system, it follows that their meanings must be learnt; to learn a language thoroughly entails learning how it uses silence.

Whilst the meanings of culturally learnt silences are circumscribed by their conventional uses in specific contexts, other silences escape this semiotic delimitation. Indeed, the inherent ambiguity of silence in contexts where speech would fix meaning is one of its most powerful communicative functions. Jaworski argues that one aspect of the semiotic openness of silence is that it can serve to keep communication channels open in situations where speech would close them down. Giving the example of an angry exchange in which a silent response can avoid the long-term damage inflicted by words said in anger, Jaworski suggests that: 'It is easier to undo silence than to undo words' (1993: p. 25).

As this implies, like speech, silence can be used to positive ends as well as negative. In addition to the negative silences of, say, a sulk or anxiety, there are the positive silences of intimacy or respect. This again moves beyond the assumptions embedded in the view of silence as absence, where silence is most readily construed as negative, as a failure to speak. Rather, whilst communicative silence can be suppressive, refusing to acknowledge that which is unsaid, it can also be generative, opening up multiple interpretations and allowing for new understanding.

So far, this overview has focussed on silence as a feature of the communicative system that is freely deployed by the person who produces it. However, silence is not always chosen, as the verb form of the word reminds us: to be *silenced* is to have silence imposed. Silencing enacts power relations, entailing submission to whatever authority enforces the silence. Indeed, Scott (1993) argues that silence can mark out hierarchies of authority even more effectively than speech can, since assent verbalised at least makes possible the idea of non-assent in a way that the tacit agreement of silence does not.

Silence studies scholars have paid particular attention to the historically gendered significance of silencing; in Western societies, male speech and female silence has dominated the public sphere, whilst female speech and male silence has characterised the domestic sphere. Silence in the public sphere – for instance, from a political leader at a time of crisis – is typically interpreted as a sign of weakness, whilst the interpretation of silence in the domestic sphere is more varied (Brummett, 1980). The values attached to silence thus both mirror and sustain power relations. Those in positions of power can choose to use silence strategically; for instance, managers can use silence as a form of punishment or as a way of distancing themselves from others, whilst the silences of those in subordinate positions are more likely to indicate that they are prevented from speaking out or feel unable to do so (Glenn, 2004).

However, as Thiesmeyer (2003) notes, silencing is not necessarily coercive. Furthermore, it can be most effective when concealed, the silences masked by other discourse. For instance, John Keane (2012) gives the example of complex large-scale engineering projects that sidestep democratic accountability by masking corporate silences regarding safety and governance with extensive media relations and fabricated positive stories.

Although silencing enacts power relations, silence can also be used as a form of resistance to power. The sulking teenager, the accused who exercises the right to silence, the victim of torture who refuses to yield, and the activists who protest in silence as a response to an oppressive regime – all use silence in their confrontation with the agents of power. Silence, then, should not automatically be read as submission.

Similarly, silence does not necessarily indicate political passivity. Sean Gray argues that the equation of silence with disempowerment betrays the speech-centric foundation of democratic theory, which he characterises as the ‘speech clause’:

The speech clause is premised on the idea that citizens rule when democracies empower public forms of self-expression – enabling citizens to voice opinions, interests, beliefs, arguments, reasons, and, above all, judgements over what to support and whom to hold to account. The speech clause carries the underlying logic of this idea to its ultimate conclusion: if practices of democratic citizenship are artefacts of language, then citizens’ capacity for self-rule is contingent upon their ability to speak.

(Gray, 2012: p. 3)

Attempts to enhance democracy, such as exercises in deliberative democracy regarding new technologies, thus strive to facilitate civilian speech as a counter-balance to expert speech. The speaking citizen is valorised as the ideal type whilst the silent citizen is interpreted as a ‘deficit in democracy’ (ibid.: p. 7). Such a view, Gray argues, fails to acknowledge forms of silence that are deeply embedded within the functioning of democracy. Although silence can be used to suppress dissent – as when certain subjects are circumscribed as out of bounds for citizen input in favour of, say, expert-led decision making – it can also mark tacit approval, enable consensus building or signal dissatisfaction with the choices available. In democratic processes, as in other forms of communication, silence should not be reduced to a deficit.

### **A typology of silence**

In summary, then, silence is an element of discourse that can both suppress and enhance communication and that can be both actively chosen from within the discourse community or imposed from without. This suggests a typology that can help highlight the agency of communicative silences by characterising silence along a producer-oriented dimension of choice (is the

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silence internal, chosen by the party that is silent, or is it external, imposed by another party?) and an audience-oriented dimension of the actual or intended communicative effect (is the silence suppressive or generative?). This allows us to distinguish between four types of silence that help draw attention to both the similarities and differences between different manifestations of silence (see Table 0.1). For instance, both censorship imposed by the state (an externally imposed silence) and an individual's choice to withhold information in order to protect their privacy (an internally produced silence) have in common that the use of silence suppresses communication. By contrast, the chosen silence of an intimate relationship and the imposed silence of a remembrance service both serve to enhance the meaning of the communication.

It is worth emphasising that neither the dimension of choice nor that of communicative effect correspond with positive or negative attributes. An externally imposed, suppressive silence can have positive effects – as in legislation that prevents racial abuse. Equally, a chosen, generative silence can have negative effects – if, for instance, it results in a failure to share information that others may need.

The distinction between silences that are chosen by those who are silent and those that are imposed externally is not clear cut, since individuals can sometimes choose whether or not to comply with that which is imposed on them. However, foregrounding the dimension of choice helps remind us of the difference between being *silent* and being *silenced*, and thus draws attention to the power hierarchies that silence can reproduce. Distinguishing between suppressive and generative forms of silence also has its limitations, ignoring as it does the fact that enhancing communication in one respect frequently entails degrading it in other respects. Nonetheless, the focus on the communicative effect of silence helps draw attention to the ends to which silence works within the wider communication context. Focussing on the dimensions of choice and effect thus ensures that we consider both the production context and the reception context for specific instances of silence. My aim in

Table 0.1 A typology of silence

	<i>Suppressive (minimising communicative efficacy)</i>	<i>Generative (maximising communicative efficacy)</i>
<i>External (being silenced)</i>	Censorship Defamation and anti-hate laws Official secrets legislation	Libraries Memorial silences Media embargoes
<i>Internal (being silent)</i>	Conflict avoidance Protecting privacy Self-censorship	Retreats Intimacy



proposing this typology is therefore not to reify these four different types of silence, but rather the opposite: to better understand the struggles that are entailed in both the production and interpretation of silence by highlighting how silences migrate across these blurred boundaries.

In what follows, I use the above typology as an organising device to draw out some of the ways in which silence is enacted in scientific contexts. I discuss exemplars of each type of silence, paying particular attention to the dynamics of the production of silence as different parties struggle to control communication. These examples all focus on silence as enacted. However, silence also exists in the analytical plane when researchers encounter gaps in the historical record, areas of missing knowledge or the ineffability of aspects of human experience – silences that may have had no communicative value for the actors involved, or may not even have been present at the time, but that must nevertheless be interpreted by the scholar. I finish with a discussion of these epistemological silences.

### **External, suppressive silences**

The secrecy of state-sponsored security regimes is perhaps the most notable mechanism through which imposed, suppressive silences are produced within science. A secret consists of a silence produced with the deliberate intent to conceal information from those who might wish to be informed. Secrecy can be freely chosen by individuals, but regimes of secrecy – which by their nature entail an institutionalised, collective system – typically involve an element of imposition and coercion.

In his famous 1942 essay outlining the institutional imperatives comprising the ethos of science, Robert K. Merton characterised science as opposed to secrecy. For Merton, science was an open enterprise entailing full disclosure. His norm of communalism required that all scientific knowledge be shared collectively: ‘Secrecy is the antithesis of this norm; full and open communication its enactment’ (Merton, 1973: p. 274). Open science remains a widely accepted ideal in science (see Grand, Chapter 11), yet, in practice, scientific research has also frequently depended on secrecy.

Merton’s idealisation of science was born out of the wartime context in which he was writing, a riposte to the conditions for science in Nazi Germany (Kellogg, 2006). It is ironic, but not a coincidence, that just as Merton was praising the openness of democratic science, many US scientists were being recruited into a regime of institutionalised secrecy that would continue long after the end of the war. The Manhattan Project serves to illustrate how suppressive silences can be imposed through a tightly controlled security regime. It also shows how this imposition can involve an element of choice and reveals the partial nature of the silences that constitute a state of secrecy.

When General Leslie Groves took control of the Manhattan Project in 1942, he instituted a strict policy of ‘compartmentalization’ across the research laboratories and production facilities that were to build the first atom

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bombs. Information about the project was circulated on a strict need-to-know basis managed through a system of classification. In addition, letters were censored, access to the five sites was controlled by the military, media outlets were asked to refrain from reporting stories containing certain key words, and scientists were forbidden from talking to scientists at other sites without the permission of their manager.

Through such means, silences were imposed on all aspects of the Manhattan Project with the aim of suppressing its communication. Compartmentalisation not only prevented information about nuclear research reaching the Germans, but also suppressed communication between those working on the project. However, to the knowledgeable listener, an unmasked silence could itself communicate that which it was intended to suppress. As early as 1941, the Russian physicist Georgii Flerov had interpreted the absence of publications by US nuclear scientists as evidence that they were working on an atom bomb: ‘a stamp of silence has been laid on this question, and this is the best sign of what kind of burning work is going on right now’ (Vermeir and Margócsy, 2012: p. 10). Robert Oppenheimer, director of the Los Alamos Laboratory, would later claim that US physicists not involved in the project had also known about its work but had kept silent for the sake of national security (Quist, 2002: p. 85).

The strict secrecy regime was resisted by some, both through individual actions and through more organised means. For instance, one formal initiative often interpreted as a challenge to compartmentalisation came when Oppenheimer instituted a weekly seminar open to all the Manhattan scientists (Dennis, 1999). The scientists thus continued to appeal to the ideal of the free exchange of ideas within the scientific community; this was despite a version of compartmentalisation having been first introduced by physicist Gregory Briet, before Groves took control of the project, in an attempt to persuade the military authorities that they could work with the scientific community (Goldberg, 1995; Quist, 2002).

Groves himself also ignored compartmentalisation when he thought it would impede progress, and on occasion he would allow a scientist to communicate with another site (Goldberg, 1995). Indeed, the creation of the centralised Los Alamos site was itself a result of the difficulties scientists experienced working within a compartmentalised system when they were scattered across the country (Hales, 1997). By gathering many of the scientists in one place, and thus containing their talk geographically, an external silence could more easily be maintained whilst still enabling some level of communication between scientists.

The scientists perceived the silences imposed by compartmentalisation as restrictive, even if to some degree necessary. By contrast, General Groves argued that it aided the production of knowledge by preventing the scientists from being distracted by the many interesting, but not relevant, problems that came up in the course of the research (Quist, 2002: p. 85). As this suggests, whether the communicative effect of a silence is seen as suppressive or

generative depends on the point of view. Those who silence others will see benefits where those who are silenced do not.

The secrecy of the Manhattan Project was achieved not only by prohibiting communication but also by generating alternative communication. Code words replaced sensitive terms such as ‘uranium’ or ‘bomb’ and, in the later years of the war, the media were fed a steady stream of misleading information to cover up the true purpose of the production sites. Despite these measures, information did leak out. By 1944, Groves had noted 104 published references to the project over the previous five years (Washburn, 1990). By then, the existence of military establishments at the large production sites was common knowledge, newspapers had made passing reference to the production of a weapon that could end the war, and Cleveland Press reporter Jack Raper had identified the Los Alamos site and had even commented on its policy of compartmentalisation (Jones, 1985; Wellerstein, 2013). Yet, despite the partial nature of the silences surrounding it, the project failed to impinge on public consciousness until the Little Boy bomb was dropped on Hiroshima.

In Chapter 5 of this volume, Daniele Macuglia examines how, as the nuclear sites began to come under scrutiny from concerned citizens in the decades after the war, silences about serious problems were maintained through the selective release of information about lesser incidents. Macuglia argues that local residents near the Hanford nuclear site existed in a midway state between knowing and not-knowing. Decoy stories successfully masked Hanford’s silences for some years, but eventually – as those living downwind of the site started to record instances of animal deformities, human miscarriages and high rates of cancer – the bodily manifestations of the site’s history drew attention to the silences. At this point, local journalists, who initially had helped circulate the partial silences emanating from Hanford, transformed their role and joined with activists in attempting to break the silences.

The history of nuclear silences shows that even those silences that are imposed through an elaborate culture of secrecy are dynamic and partial in nature. That the silences of the Manhattan Project and later nuclear weapons development co-existed with, and were in part produced by, carefully chosen language and that they could dominate even as information leaked out, reveals both the relativity of silence and the effort that has to be invested in its maintenance. Security regimes have constructed silences around biological and chemical weapons research through similar means. Suppressive silences can also be found in technoscientific contexts other than weapons development. In current-day Russia, all scientific research that could be used to develop ‘new products’ is treated as potentially classifiable and researchers must apply for security clearances before publication of their work in journals or as conference talks (Schiermeier, 2015).

Science and Technology Studies scholars who have examined the dynamics of secrecy in contexts such as these argue against an opposition between, on the one hand, open communication associated with the production of knowledge and, on the other hand, suppressive regulation associated with the

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construction of ignorance. Vermeir and Margócsy (2012), for instance, argue that secrecy entails a dynamic process of veiling and revealing in which different actors are privy to varying degrees of knowing, as seen in the above example of nuclear silences. Similarly, Balmer (2012) challenges the assumption that the object of secrecy is unperturbed by the silences that surround it. Secret science, he suggests, is not just open science done behind closed doors. Rather, secrecy dictates specific geography, cultural practices and social structures; by so doing, it actively constructs new forms of knowledge as well as generating ignorance.

Not all suppressive silences are created through the deliberate implementation of a secrecy regime. They can also arise through less direct means, as the result of a complex interplay of multiple social and cultural factors. Carolyn Cobbold (Chapter 10) examines the case of the introduction of synthetic dyes into food in the second half of the nineteenth century. The use of these new additives, which in some cases were later found to be highly toxic, went largely unremarked in the media, despite widespread concerns about other aspects of food adulteration. Cobbold finds that a combination of factors – including a dominant media discourse celebrating the new chemistry, the vulnerabilities of the newly emerging profession of public analysis and consumer expectations about what certain foodstuffs should look like – all contributed to the imposition of a public silence around the use of the new dyes in food.

The opposition between silence and transparent open communication is further challenged if we consider the ways in which openness itself can engender silences. Catriona Gilmour Hamilton (Chapter 7) shows how a culture of openness can serve to generate new forms of silence. She traces the evolution of informed consent in cancer research in the UK over the past four decades. The substitution of the imposed silences of the paternalistic health care system of the 1970s (which assumed that patients should not be troubled with the details of their diagnosis and treatment options) with today's culture of openness (which envisages patients as research partners capable of giving their informed consent) has not eliminated silences from the consent process. Rather, Gilmour Hamilton finds, preoccupations with the evidence hierarchy have resulted in the silencing of individual, subjective experience.

Imposed, suppressive silences take their most elaborate and wide-reaching form in cultures of secrecy, but they cannot be reduced to these deliberate acts of concealment. As Gilmour Hamilton's work suggests, they can also be uncovered in cultures that strive to eliminate secrets. Being silenced can be an unintended, and often unacknowledged, consequence of protocols for openness as well as the intentional, but often contested, product of mechanisms of secrecy.

### **Internal, suppressive silences**

Security regimes impose silences on researchers. However, in other situations researchers themselves – either individually or collectively – may choose to stay silent in order to suppress communication about their work. As noted above, even before the Manhattan Project took shape, many US physicists

had already chosen a policy of silence, withholding research on nuclear fission from publication in order to prevent the Germans gaining access to the new results. The physicists continued to submit papers to journals in order to evidence their priority claims, but they would request that publication be deferred until after the war. Self-censorship had its difficulties, but from the start of 1940 some significant results were withheld from publication and the system was formalised by the National Research Council later that year (Weart, 1976).

However, a collective voluntary silence is difficult to maintain and, when proposed for reasons of national security or public safety, is unlikely to be a choice that can remain with the research community (Kaiser and Moreno, 2012). In recent years, self-censorship of unclassified research has been considered by microbiologists whose findings could be used in biowarfare, with some researchers wanting to publish papers with key information redacted (Couzin, 2002). One high-profile example, which highlights the ways in which the choice of self-censorship can segue into an imposed system, is the case of research on avian flu. As this case shows, the tensions over the suppression of communication result in a multiplicity of additional communications; a temporary silence may be generated only in the midst of much speech.

In November 2011, the US government's National Science Advisory Board for Biosecurity (NSABB) requested that the journals *Science* and *Nature* refrain from publishing in full two papers on the transmission of the H5N1 influenza virus. The work had shown that a modified variant of the virus could spread between ferrets, which provide a model for human-to-human transmission. The NSABB feared that, if published in full, the studies could enable bioterrorists to create a flu strain that would be deadly to human populations. The Board therefore asked that no details of the methodology or data be released. The authors and journal editors agreed, provided that some other mechanism could be found for communicating this information to legitimate researchers (Butler, 2012). A silence targeted at a general audience was acceptable, this agreement implied; a silence that also encompassed the community of researchers was not.

As a press release explained (NIH, 2011), the NSABB recommended not only deleting information from the papers but also *adding* information to explain the potential benefits and safety measures of the research. Shortly afterwards, leading flu researchers proposed a 60-day moratorium on such research in order to discuss its benefits in a public forum (Fouchier et al., 2012). As one of the authors of the *Nature* paper put it: 'Scientists need to have their voices heard in this debate' (Butler, 2012). The effect of the silence was thus to call forth a great deal of talk; for the scientists, agreeing to stay silent became a means of having their voices heard.

Many scientists disagreed with the decision not to publish. Some argued that the publication restrictions were pointless since the research had already been shared with other researchers and talked about at conferences. They suggested that enough information was already in the public domain to pose a risk (Butler, 2011; Kawaoka, 2012). However, the non-publication did limit

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the information about the research available to the many journalists who were busy reporting the story. *Washington Post* reporter David Brown, for instance, complained that journalists were having to write reports on the basis of ‘woefully inadequate’ information. He argued that if the decision not to publish were to become a habit, such silences would breed conspiracy theories and a distrust of scientists’ motives. Yet Brown and his editors also silenced themselves, backing off from searching out copies of the censored papers on the internet so that they would not have to face the decision of what to do with the information if they found it (Brown, 2012).

In March 2012, following the release of new US guidelines on the management of dual use research, the NSABB reversed its decision and recommended full publication of the two papers. The *Science* paper was further delayed when the Dutch government requested that the authors, who were based in the Netherlands, apply for an export licence on the grounds that the research fell under the regulations controlling the export of weapons technology. The head of the research team, Ron Fouchier, objected and threatened to publish anyway, but in the end complied and was granted a licence (Frankel, 2012). Research on the H5N1 virus resumed in 2013. The new US guidelines included measures to determine how, and to whom, research judged to be risky should be communicated. Voluntary redactions could now be replaced with silences enforced by the federal government through use of the classification system (Butler and Ledford, 2013).

Similar considerations are also beginning to arise in relation to ethical concerns about research with no immediate dual use implications. In April 2015, the Chinese journal *Protein and Cell* published a paper reporting the use of the CRISPR gene editing technique to modify the genomes of human embryos. The author claimed his paper had been rejected by both *Nature* and *Science* in part on ethical grounds. The journals’ choice not to publish was interpreted by some as censorship on extra-scientific grounds (e.g. Gyngell and Savulescu, 2015). As in the avian flu case, rumours about the work prior to publication prompted debate about the need for a moratorium on research of this type (Kaiser and Normile, 2015). The alleged act of silencing was again constructed through heightened levels of discussion.

In cases such as the H5N1 moratorium, collective choice – a voluntary agreement not to publish or to halt further research – can generate a temporary silence, but only by drawing attention both to the silence itself and to its legitimacy. Joanna Kempner and her colleagues argue that these publicly announced silences are aimed at public reassurance (Kempner et al., 2011). They note that in addition to these acknowledged silences, research into socially and culturally sensitive topics is also imbued with unacknowledged silences arising from an internalised set of values that are embedded in the very practice of science. These norms are fashioned from cautionary tales about what happened to scientists who breached them in the past. The mere anticipation of public reprobation, regulatory sanction, time-sapping controversy or loss of funding can be sufficient to silence some lines of inquiry.

Over a third of the scientists interviewed by Kempner said they would not pursue or publish research results that deviated from the accepted dogmas of their discipline (*ibid.*). Unlike the publicly announced silences, these silences are enacted silently as private decisions reached through reference to unspoken rules.

The internalised silences of modern scientific practice serve to save scientists from potentially career-blocking confrontations. Similarly, discursive omissions that arise in potentially controversial situations can function as a way of bracketing uncertainty without denying it. Choosing silence in such situations can enable action to be taken even in the absence of evidence-based consensus. In Chapter 12 of this volume, Abi Dymond examines how staying silent enables policy to proceed in the face of uncertain knowledge. By choosing silence, those charged with drawing up policy are able to defer decision making. Dymond considers the case of the ‘less-lethal’ policing weapon TASER, where silences in the policy discourse surrounding the relative safety of the weapon have the effect of devolving responsibility over its use onto police officers on the ground. Officers must temporarily fill these silences through their own actions, weighing up on the spot whether or not to use the weapons, at what strength and for how long. However, silence is reinstated when, after the event, justification of TASER use is diffused once more thanks to the singular circumstances of each decision.

The above examples deal with internally produced silences that are chosen at the level of the discourse community or that have come to be accepted cultural norms within that community. However, individuals may choose to violate the community norms for sharing information, remaining silent when the expectation would be to publish. Kees-Jan Schilt (Chapter 3) considers the case of Isaac Newton’s year-long withdrawal from correspondence about natural philosophy. Despite his lasting fame, Newton’s publication record is slim in comparison to his contemporaries and he made repeated attempts to leave off correspondence with other philosophers. Rather than attribute such behaviour entirely to Newton’s personality, Schilt argues that it was in part the outcome of a specific communication strategy influenced by Newton’s other focus of interest, alchemy. Newton, Schilt suggests, approached the dissemination of natural philosophy according to the obscurantist norms of alchemical discourse. In contrast to the rhetoric of openness and disclosure that shaped natural philosophic discourse, the alchemical reader was expected to work hard to extract meanings hidden in the text. The differing expectations of Newton and his readers inevitably led to conflicts, which Newton resolved with silence.

Today, scientists are unlikely to base their publishing strategy on a communicative ideal that privileges private knowledge. However, other pressures can lead modern-day scientists to delay publishing. Today’s scientists operate in a competitive environment, competing for recognition and the grants, jobs and students that go with it. In a study drawing on focus groups with fifty-one early- and mid-career scientists in the USA, Melissa Anderson and her

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colleagues found that increased secrecy was among the detrimental effects of competition, with scientists hesitating over sharing ideas with others and deliberately withholding details from papers to prevent replication (Anderson et al., 2007). Ironically, the pressure to publish brings with it a concomitant incentive to limit communication.

Publication itself may also be delayed. Mario Biagioli (2012) interprets this as a protective response to the risks of publication that arise out of an inevitable moment of instability in establishing priority. Publication is necessary to secure priority, yet it also risks losing priority through leaks by those privy to the process. Researchers and inventors may therefore temporarily guard their ideas with silence even though that silence is ultimately aimed at making the ideas public. In a reward system that prioritises priority, successfully staking a claim becomes more important than gaining immediate publicity; a temporary silence is one mechanism through which to achieve that end.

### **Internal, generative silences**

Whilst some silences are forged with the intention of suppressing communication in order to achieve other ends – such as securing priority claims or protecting national security – other silences are intended to enhance the communicative act. The textual silences of scientific papers afford one such example. As Dacia Dressen (2002) has discussed in her study of geological discourse, genre conventions dictate that much is left out of a technical report. The research narrative, established or tacit knowledge that is assumed to be shared by readers, and the researchers' agency and emotional reactions are all routinely omitted from the scientific paper in its modern form. Such omissions enable scientists to communicate efficiently with each other those aspects of their research that are deemed most salient to building a body of objective knowledge. Whilst also having the effect of excluding readers from outside the discourse community, these 'silential conventions', as Dressen calls them, increase the communicative efficiency of the genre for those within the community.

As Dressen notes, these 'laws of silencing' do not necessarily erase content; rather, authors can use conventional rhetorical devices, such as understatement, to draw the attention of knowing readers to the missing content. Furthermore, the boundaries of such textual silences are dynamic, developing over time; and they can be purposefully transgressed or manipulated by individual authors in response to specific situations.

Textual silences are enacted as collectively agreed conventions. Other generative silences are chosen by individuals who, temporarily or partially, withdraw from interactions in order to develop their ideas. Such withdrawals provide a generative phase in preparation for full and open communication. Communication is delayed, not out of a secretive, competitive urge as is the case for suppressive silences, but in order for the scientist to achieve some clarity of thought so that the communication, when it comes, is clear and compelling. In the generative silence of withdrawal, then, the two meanings of silence



come together – the silence of stillness (often accomplished through solitude and isolation) and the silence that is the necessary complement to speech. Where the former has the potential to minimise distractions and increase concentration, the latter marks the beginning of the communicative acts that are to come.

The appeal to withdrawal as a requisite for intellectual labour has a long history. Steven Shapin (1991) has argued that a distinctive feature of early modern science was its fusing of two contrasting ideals – that of the gentleman citizen engaged in public activities and that of the reclusive scholar engaged in private study. The early Royal Society forged a novel combination of these two ideals, continuing to appeal to the rhetoric of solitude ('the hermit's voice', as Shapin puts it) regarding the context of discovery, even as the rhetoric of public display dominated the context of justification.

Whilst rarely acknowledged in modern research settings, the importance of withdrawal to scientific creativity has, at times, been recognised institutionally. For instance, when Robert Oppenheimer went scouting for a site to house the Manhattan Project scientists, he had in mind a place that could function as a 'monk's colony', its isolation not only affording security but also protecting its scientists from distractions in what he envisioned would become a scientific 'Shangri-la' (Hales, 1997: p. 42).

Writing in 1931, Abraham Flexner, the first director of the Institute for Advanced Study in Princeton, had articulated a similar vision: his institute was to be 'simple, comfortable, quiet without being monastic or remote; ... and it should provide the facilities, the tranquillity, and the time requisite to fundamental inquiry into the unknown' (Institute for Advanced Study, n.d.).

Three decades later, the idea that scientific creativity benefited from periods of retreat and tranquillity was still influential in the founding of the Aspen Center for Physics. The Center was planned in 1961 as a summer retreat where physicists could be free of distractions. Although promoted as a place for talking, collaboration and the exchange of ideas, these appeals are bookended with references to solitude, isolation, and peace and quiet. Thus the Center's website explains that the Center 'is conducive to deep thinking with few distractions, rules or demands. In our "circle of serenity," physicists work at their own speeds and in their own ways.' Quotes from scientists who have visited the Center attest to the benefits of this 'circle of serenity': 'I desperately needed the peace and quiet provided by the Aspen Center for Physics to just think and reflect'; 'Aspen remains the best place on earth to have a chance to actually think deeply and without interruption'; 'an idyllic sanctuary where scholars abandon their cares, explore in solitude, or more often, in one another's company, where new ideas brew and old ones take flight' (Aspen Center for Physics, n.d.).

It is worth emphasising that to acknowledge the importance of withdrawals and retreats to scientific creativity is not to reinstate the mythology of the lone genius. Both the Institute for Advanced Study and the Aspen Center for Physics aim to facilitate collaboration and discussion between scientists, as the last quote above makes explicit. However, they do this by silencing communication

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of other sorts. Rather, to attend to the creative role of withdrawal is to restate the balance between speech and silence that is required for effective communication. Mara Beller's examination of the history of quantum theory makes this point well (Beller, 1999). Beller is concerned with the way in which new scientific knowledge emerges out of conversations between scientists, conversations that are filled with doubt and uncertainty. She argues that the radically new ideas of quantum theory formed dialogically, as physicists constantly addressed and responded to each others' ideas. Yet these conversations were necessarily punctuated and interrupted with periods of relative silence. Thus Niels Bohr and Werner Heisenberg engaged in intense discussions with each other, but it was only once they were apart that Heisenberg laid the basis for his approach to quantum theory. As Beller puts it, Heisenberg needed time away from Bohr 'in order to strike a proper, uncoerced balance in his own communicative network of cognitive responses' (p. 7). Gaining the communicative control necessary for articulating new ideas requires balancing periods of speaking out with periods of staying quiet.

Perhaps the most famous silence in the history of science is Darwin's long delay before publishing *The Origin of Species*. As Stephen Webster discusses in Chapter 2, Darwin sought a balance between isolation and collegiality, which enabled him to forge trusting friendships that served him well when he found himself under pressure to publish. Webster argues that Darwin can be used as a guide for navigating the pressures of the modern research life, reminding us of the need for retreat and delay punctuated by 'accelerative moments'. Darwin's case is especially instructive because his silence was not easily won, being frequently disrupted and intruded upon, not least by his recalcitrant, complaining body. Yet this bodily uproar also helped him justify his retreat into quietude. With Darwin, then, we see silence as a state that is performed, a physical struggle located in both body and place.

In Chapter 1, Paul Merchant considers the case of another scientist who chose long periods of silence: Joseph Farman, the atmospheric scientist who discovered the hole in the ozone layer over Antarctica in the mid-1980s. Drawing on oral history interviews, Merchant reconstructs the ways in which Farman constituted a silent presence at the British Antarctic Survey where he worked. Farman expected his data to speak for itself; his own silences gave it the opportunity to do so, both by facilitating the actual process of data collection and by allowing the data to gradually accumulate over many years until the measurements could be heard without doubt. Merchant paints a picture of a scientist whose own silence mirrored that of the ozone layer he studied – the taciturn researcher corresponding with reticent nature until, finally, both spoke out, the unambiguity and seriousness of the message emphasised by the silences that had framed it.

Merchant argues that some of Farman's silences were strategic. Nick Verouden, Maarten van der Sanden and Noelle Aarts (Chapter 4) draw attention to another form of strategic silence, where silence is deployed as a way of managing complex collaborations. Scholars of organisation studies have

examined the ways in which silence permeates hierarchical workplaces. Verouden and his co-authors look at the case of silences in the less hierarchical context of cross-disciplinary university collaborations. Collaboration is seemingly premised on the drawing out of verbal interactions, but as this chapter shows through an ethnographic analysis of a teaching collaboration at the Delft University of Technology, silence also plays an important role in enabling collaboration to proceed by facilitating compromise and consensus.

In Chapter 6, Alice White presents a further example of chosen silences that were claimed to have generative effects. White examines the layers of silence that coalesced around the role of psychiatrists in British Army selection boards during the Second World War. The introduction of the psychiatric interview in 1942 gave psychiatrists a formal role in the assessment of soldiers put forward for a commission. At one level, the psychiatrists' approach to selection board interviews encouraged talk, drawing the candidate officer into a conversation with the selection panel. Yet they did so by strategically deploying silences aimed at prompting the candidate to reveal aspects of his personality. By remaining silent on certain topics or at certain points during the interview exchange, the psychiatrists believed the interview would furnish greater insights. The psychiatrists' silences were aimed at drawing out revealing talk; however, they saw silence on the part of the candidate as a problem. The psychiatrists', sometimes silent, probing of intimate matters provoked fears that such encounters would be disturbing to the soldiers. White explores how the Army authorities responded to such fears, eventually withdrawing psychiatrists from the interview process. The psychiatrists' chosen, generative silences were now replaced with an imposed, suppressive silence.

### **External, generative silences**

It is telling, perhaps, that it is harder to identify externally imposed generative silences than it is generative silences that are chosen by the silent party or are communally agreed by the discourse community. Nevertheless, two examples – media embargoes and trade secrets – illustrate imposed silences that are often justified on the grounds of their ability to enhance the communication of science, in the first case by improving the communication itself and in the second case by providing the preconditions for the production of the knowledge to be communicated. In both these cases, however, the claims for enhanced communicative efficacy are regularly disputed either by those on whom the silences are imposed or by those who encounter the silences.

The first example concerns the widespread use of media embargoes in the reporting of research news. In the embargo system, scientific journals pre-release information about forthcoming papers to journalists, usually in the form of press releases accompanied by quotes from the researchers and their contact details. In return, the journalists withhold from publishing the news until the embargo date has passed; this usually coincides with the date of publication of the journal. In this way, the scientific journals and their press offices

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control the dissemination of science news by imposing temporary silences on journalists.

Unlike regimes of secrecy, media embargoes entail a withholding rather than a concealment. Nevertheless, the system is punitive. Journalists who break the embargo are usually punished by being blacklisted from future press announcements. In some cases, even journalists who have sourced a story independently have been removed from a journal's mailing list for covering the story prior to the embargo date (Kiernan, 2006: pp. 30–33). Since losing access to a major source of science news is a significant handicap for a science journalist, violations are relatively rare.

In any case, journalists also benefit from embargoes since the receipt of media-ready press releases minimises the amount of time the journalist needs to invest in a story. Indeed, when the system developed in the mid-twentieth century, the initial impetus came from science and medical journalists, who argued that having a preview of newsworthy papers would help improve the accuracy of their reporting of complex topics (Kiernan, 2006). By improving accuracy, journalists hoped also to improve relations with their sources. Today, the embargo system is still justified on the grounds that it helps ensure the accuracy of science journalism. Some also claim that it promotes more extensive coverage of science in the news media than would otherwise be the case (*ibid.*). Thus, to the proponents of the system, the pre-embargo silences imposed on journalists serve to enhance the communicative value of the journalists' reporting.

Many scientific journals also impose a similar system of temporary silences on scientists. Under what is known as the Ingelfinger rule – named after Franz Ingelfinger, the editor of the *New England Journal of Medicine* who first articulated the policy in 1969 – journals refuse to publish research findings that have already been reported in the media. Researchers must therefore avoid contact with journalists until after they have published their findings in a journal. Ingelfinger's original motivation was to ensure that his journal maintained competitiveness by only publishing new results, but his rule came to be seen as a way of ensuring that the media did not report research that had not yet been validated by the peer-review process (Toy, 2002).

As with the embargo system, the Ingelfinger rule was justified on the grounds that it would improve the quality of the public communication of science, in this case by ensuring that premature results or poor research would not be reported in the media. Writing in 1977, Ingelfinger observed that 'although [journalists] pride themselves on reporting accurately, there is no assurance that what they report is accurate in the first place' (Toy, 2002: p. 197). The system still holds today, with many journals warning researchers to be cautious about talking to journalists when presenting their work at conferences. If scientists do court media coverage before their findings are published in a journal, they risk having their paper rejected even if it has already been accepted for publication (Kiernan, 2006).

Despite the threat of punitive sanctions, proponents of both the Ingelfinger rule and the embargo system defend the imposition of these silencing

protocols as a means of improving communication with public audiences; that is, they are seen as having a generative, rather than a suppressive, function. However, they have also been charged with the opposite. Vincent Kiernan (2006), for instance, argues that not only is there no evidence that embargoes improve the accuracy of science journalism, but they encourage a pack mentality among journalists and distort the media coverage of science by encouraging a focus on research findings rather than the research process, and on a small number of elite journals rather than the full range of scientific research.

Both the Ingelfinger rule and the embargo system could also be seen as counter to current calls for open science. Indeed, the open data movement could be understood as the mirror image of external, generative silence in that, in the hope of improving communication, it imposes a requirement for non-silence regarding those parts of the scientific process that have formerly been kept private. Where the Ingelfinger rule configures publication as the end-point of a closed system, open science breaks all the boundaries of that system, allowing multiple voices to enter at any stage of the research process. In Chapter 11 of this volume, Ann Grand considers the challenges that this imposed un-silencing might entail. Grand argues that simply breaking a silence is not sufficient to ensure communicative efficacy. For data to be meaningful to public audiences, it needs to be addressed to those audiences – a process that requires time, effort and skill. At the same time, researchers have to find ways to compensate for the loss of the benefits of silence that have been discussed above.

My second example of external, generative silences is trade secrets. One of the concerns that Grand highlights in the transition to open science is the ambiguity it creates over the ownership of intellectual property. Such concerns are deeply embedded in modern scientific practice, both through cultural norms pertaining to priority claims and through legal instruments safeguarding the commercial value of research. As noted above, priority claims must navigate a moment of instability in which the risks of publication may outweigh the benefits. Similarly, the legal processes for establishing intellectual property rights (IPRs) frequently entail a movement from the non-disclosure of trade secrets to the disclosure of a patent application. As a draft proposal for a European Commission directive to harmonise trade secrets law across the EU puts it: ‘Every IPR starts with a secret’ (European Commission, 2013).

The knowledge that might later build into a patentable idea or product may in earlier stages of research and development not qualify for patent protection yet still be of commercial value. In such cases, companies typically use non-disclosure agreements to prevent the circulation of the knowledge to competitors. Such contracts impose silences on employees which are defended on the grounds that investment in the research will only be forthcoming if the commercial value of the research is protected. In other words, it is claimed that the conditions for the knowledge to be created are dependent on silencing mechanisms. For instance, the European Commission directive sees trade secrets as ‘a key complementary instrument for the required appropriation of intellectual assets that are the drivers of the knowledge economy of the

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21st century’ (European Commission, 2013). Whilst trade secrets are primarily invoked for their ability to enhance economic value, they can also be seen as having a communicative effect by creating the conditions that make possible the later communication of a patent.

In an ethnographic study of the control of information flow in scientific settings, Stephen Hilgartner (2012) suggests that trade secrecy is an example of an institutionalised practice through which a ‘regime of closure’ is enacted. Hilgartner gives the example of a company’s secrecy about a new development being accepted as normal, even though both the act and object of concealment are partially revealed through a scientist’s comportment and tone. Hilgartner argues that in such situations those involved ‘manage a dialectic of revelation and concealment through which knowledge is selectively made available and unavailable to others, often in the same act’ (Hilgartner, 2012: p. 268). In such ways, the imposed silences of industry-sponsored research are selectively navigated by those who are expected to reproduce them.

As Hilgartner’s example suggests, the silence of a trade secret can itself convey meaning. For instance, Coca-Cola’s brand identity is supported in part by the mystery surrounding its secret recipe and Apple selectively releases parts of its secrets to foster an image of innovative creativity (Bos et al., 2015). The value of secrets can therefore derive as much from their status as secrets as from their actual content; a silence can generate a meaning that would be punctured if expressed through language. Vermeir and Margócsy (2012) give the example of alchemists, who guarded their knowledge closely but were often disappointed when they did hear the details of others’ work. Often, then, it is the status of secret as secret that has most value and invites desire in others for as long as they don’t know what the secret is. Yet this value also requires that these others know that the secret exists. In such instances, the value of a secret requires that the secret be announced even as its content is kept hidden.

The example of trade secrets also illustrates the ways in which the suppressive effects of externally imposed silences can be hard to eliminate. Restricting the flow of information within an organisation can limit, rather than enhance, innovation; and restricting the flow of information externally can curtail collaborations (Bos et al., 2015). Concerns also arise where non-disclosure agreements are used to prevent employees from speaking out on matters of the public interest, or, especially given widespread industry sponsorship of university research, where similar contracts are used to prevent publication of research findings (Gøtzsche et al., 2006).

### **Epistemological silences**

The four-fold typology presented above locates silence at the level of the actors generating or receiving the silence. However, silence can also be encountered at one remove – for instance, as a gap or omission in the historical record that may not have existed in the contemporary discourse, as a

consequence of analysts desiring to articulate experiential or tacit knowledge, or as a non-communicative silence rendered meaningful as a result of recontextualisation. Here, rather than examining how silences are maintained and experienced as in the previous examples, the question is how such encountered silences are to be understood and interpreted. In confronting the epistemology of absence, analyses of this category of silence resonate with work in the field of ignorance studies.

In Chapter 9, Brian Rappert, Catelijne Coopmans and Giovanna Colombetti consider the intersection of experienced silence and epistemological silence by examining the ways in which scientists have attempted to fashion accounts of Buddhist meditation practice. In contemplative practices such as meditation, the impossibility of verbalising the lived experience is at its most acute. Yet repeated attempts have been made to do just that, most recently in the guise of neuroimaging experiments on the effects of meditation on the brains of its practitioners. Rappert et al. argue that such accounts are characterised by various forms of indirection, which enable researchers to speak of the meditative *state* whilst remaining silent about the meditative *experience*. In such accounts, scientists negotiate the silences they encounter by generating silences of their own, including silence about which aspects of meditation should remain silent.

The inevitable incompleteness of the historical record offers another form of epistemological silence that researchers must grapple with. Do the silences of the historical record represent the boundaries of what was then known or do they signify nothing more than the limited survival of documents? In Chapter 8, Elizabeth Hind considers the difficulties modern scholars face in interpreting the silences they encounter in Ancient Egyptian mathematical texts. Only a few mathematical papyri survive, and with those that do, holes in the document may compound the already considerable challenges of translating terms that occur in few other documents. The scholar must weigh up whether the silence derives from this modern absence of evidence or from a contemporary absence; and if the latter, whether this signifies an absence of knowledge on the part of Egyptian mathematicians or the opposite, the presence of tacit knowledge. Hind argues that, by severing mathematical texts from their cultural contexts, interpretations of Egyptian mathematics have often assumed that encountered silences should be interpreted as absent knowledge and that this risks incorporating a cultural bias into our historiography.

The epistemological silences that Hind studies derive from the inherent incompleteness of the historical record. Epistemological silences can also derive from historians themselves, as a result of their patterns of inattention. In Chapter 13, Charlotte Sleight explores the case of Charles Hoy Fort, the writer whose name was appropriated by the International Fortean Society long after his death but who has been largely ignored by historians and literary scholars despite his sustained critique of modern science. Sleight examines the reasons behind this scholarly inattention to Fort, tracing the confluence of his humorous and provisional writing style with his insistence on the significance of anomalous data and amateur collecting. In his writings, Fort attempted to

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combat the silencing tendencies of contemporary science with a barrage of words and data, giving voice en masse to data that, if presented individually, would have been silenced. Yet, Sleigh suggests, this voicing was of such excess that, ultimately, it constituted a silence of its own.

### Tuning in to silence

We hope that the case studies presented in this volume make the case for the role of silence in the practice and communication of science. As silence studies scholars have argued, silence can have a communicative value, functioning as a dynamic context-dependent sign that is actively produced to convey specific meanings. Scientists, like others, choose silence, experience silence and are silenced, for a variety of reasons with a variety of effects. If we are to understand the ways in which scientists generate knowledge and how this knowledge is brought to bear on social concerns, then we must attend to what scientists don't say, and why they don't say it, as well as to what they do say.

We hope also that attending to silence will encourage some reflection on the communication policies that currently dominate within the scientific community. Without verbal communication, there would, of course, be no science. Policies that encourage collaboration, publication and public engagement therefore play a vital role in furthering scientific research and embedding science within society. Indeed, staying silent can carry risks. The University of East Anglia climate scientists who attempted to stay silent when barraged with Freedom of Information requests from climate sceptics were ultimately unsilenced in a more damaging way when their private emails were leaked. Yet not staying silent can also incur costs. When, in 2011, a team of scientists announced to the media that they had observed neutrinos travelling faster than the speed of light – a finding that would have been difficult to accommodate within special relativity – it cost two of the team leaders their positions after mistakes in the initial measurements came to light. In this instance, a degree of silence would have served the researchers better.

As many of the case studies in this volume show, silences can bring strategic benefits to those who produce them. Directed silences can smooth the progress of research, fostering collaboration and deferring hard-to-resolve questions; temporary silences, such as those brought about by retreats and withdrawals, can provide the conditions for research to take place. Paying attention to silence highlights the ambiguities inherent in all communicative acts and reminds us of the dialectical relationship between speech and silence. Successful communication requires a balance between the two. The logorrhoea of the modern research environment risks upsetting that balance.

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