# AFTER THE FACT(S)

# COMMUNICATING ABOUT SCIENTIFIC COMPLEXITY, RISK, AND UNCERTAINTY IN AOTEAROA

BY

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Abstract

This thesis draws on social constructivist theories of scientific knowledge to analyse the public engagement practices of a cohort of scientist-communicators in Aotearoa as they represent scientific complexity, risk, and uncertainty in public. Through semi-structured interviews and thematic analysis, this thesis demonstrates that participants think defensively about the publics they communicate to, drawing boundaries between science and publics that minimise exposure of the elements of scientific knowledge they perceive might undermine scientific authority. Such boundary-work often demarcates public engagement from scientific knowledge production, constructing public engagement as a subjective process applied to scientific knowledge after the fact. These science-communicators also work to overcome these very same boundaries by making science more accessible and democratic. Such tensions suggest that participants not only socially construct science, but also contribute to the social construction of public engagement with science as they work to transform systemic and cultural barriers acting to entrench science as an inaccessible, exclusive, and unilateral arbiter of knowledge. In doing so, participants found that presenting a more accurate, complex picture of science—with all its uncertainties and failures—had not undermined public confidence in science. Instead, complexity, risk and uncertainty could become transparent elements of scientific knowledge production, thereby open to public scrutiny and definition. Participants' representations of complexity, risk, and uncertainty were influenced by accessible, local publications, and economic and institutional conditions, but rarely by established public engagement scholarship.

I would like to express my gratitude to Te Pūnaha Matatini for funding this work and providing a welcoming space for a new researcher; to my participants for generously sharing their time and knowledge; to my parents for their constant support; to my academic parents, Rebecca and Nayantara, for their advice and mentoring; to Navana and Zoe for lifting my spirits; to my cat, Goose, for keeping me humble; and finally, to my partner of eight years, Ash, for ensuring all punctuation was appropriately curly.

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Notes:

1. I have endeavoured to exclusively use gender neutral language throughout this thesis. It would be impractical to obtain the preferred pronouns of everyone mentioned or cited so, in order to avoid making assumptions and to maintain consistency, I opted to use the singular 'they' throughout.
2. I use the terms 'Aotearoa' and 'New Zealand' interchangeably throughout this thesis. I prefer to use the te reo Māori name Aotearoa, though in some circumstances—for example, discussing the policies of New Zealand's colonial government—it felt misplaced. In addition, the concatenation 'Aotearoa New Zealand' is a compromise I choose to avoid. It preserves the colonial name appending 'Aotearoa' in a tokenistic manner.

# Section I: Introduction

Public truths cannot be dictated…neither by a pure, all-knowing science nor unilaterally from the throne of power. Science and democracy, at their best, are modest enterprises because both are mistrustful of their own authority. Each gain by making their doubts explicit.

(Jasanoff, 2017)

# Chapter #1 Understanding scientific knowledge: social construction and public engagement

In 2014, the journal *Public Understanding of Science* released a retrospective special edition reflecting on 20 years of research in the field. This issue focused on the discipline's development from researching 'public understanding' of science to a reconceptualised 'public engagement' with science (Bauer, 2014). This shift reflects the discipline's critique of scientific communities as relying on a 'deficit model' of communication, in which the public is characterised as homogenous and ignorant, but responsive to the injection of expert scientific knowledge that fills a gap in their understanding. This mode of communication assumes that people who know more about science, its processes and methodologies, will be more accepting of it—or will make decisions that are consistent with the scientific evidence. This assumption has been widely debunked (see Irwin & Wynne, 1996; National Academies of Sciences, Engineering, and Medicine, 2017; Nowotny et al., 2001). In contrast, the study of public engagement with science (PES) is rooted in an expanded and more nuanced articulation of the relationship between science and public that highlights the constructed, contested and contingent nature of scientific knowledge (Stilgoe, 2007). 'Public engagement' suggests dialogic and participatory methods of science communication that attempt to enable greater democratic participation in science (for example Lach & Sanford, 2010).

While more participatory scientific practices have proliferated since the establishment of *Public Understanding of Science* in 1992, the contributions in the 2014 special issue describe only partial progress towards a greater democratic participation in science (Irwin, 2014b). One author characterised the ongoing scientific contribution to the relationship as the ongoing 'public disorientation by science' (Wynne, 2014). Another speculated as to whether scientific practice was so far behind the development of theory that their talk from the 1990s, 'from

deficit to democracy', would be just as relevant today (Irwin, 2014b). These scholars of public engagement did not feel their efforts had produced a significant behavioural shift in the practice of science communication. Some of this frustration, however, may be a specific response to political circumstances in the United Kingdom (see Irwin, 2014a; Rayner, 2012).

In response to the special issue a group of interdisciplinary researchers, each variously involved in public engagement with science in Aotearoa, published a paper entitled "The Reflexive Scientist" (Salmon et al., 2017). The authors identified possible reasons why a gap exists between PES theory and the actions of science communication practitioners; noting that the literature does not "speak for itself" (p. 53) and has developed somewhat independently of any meaningful engagement with those who might utilise it. This critique suggests not only a disconnect between those studying public engagement and those practicing it, but that PES scholars have been guilty of enacting their own deficit model as little analytical literature seeks to engage scientists in a way that allows them to learn from or contribute to it. A potential solution, the authors suggest, is exploring a practice of reflexivity for those involved in scientific outreach[1]. They describe reflexivity as:

> … a willingness and ability to question one's own assumptions, how they relate to societal power structures, and how they shape one's actions. More specifically, [reflexivity is] a theoretically informed capacity to critically analyse one's underlying assumptions, expectations, and positioning in relation to one's involvement in outreach. It is not simply an internal thought

[1] The authors use 'outreach' to describe the public engagement activities of scientist and science-trained communicators, distinguishing them from those trained in PES, institutional public relations professionals, or professional communications consultants.

> process, but rather a type of thinking tied to action. Reflexive thinking makes possible ways of acting that would not otherwise be possible (p. 68).

The authors imagined a reflexive scientist-communicator who reflected on their political and institutional context, and their own personal assumptions about publics. This hypothetical scientist, they argued, could become more socially responsive through participation in interdisciplinary research, and regular collaboration with PES scholars. They also suggested that PES scholarship could help foster reflexivity by "disaggregate[ing] the monolith of science" (p. 65): avoiding representing science as singular, instead becoming more attentive to the particular politics of research fields and the institutional contexts of scientists who are interacting with the public.

When "The Reflexive Scientist" was published, The National Academy of Sciences in the US also released a research agenda that detailed the major challenges for research and practice in science communication. It specifies practical challenges of communicating science: the complexity of scientific information, the complications of communicating uncertainty and concerns about risk (particularly in controversial situations), and the multiplicity of responses to communication activities from different audiences and in different contexts (National Academies of Sciences, Engineering, and Medicine, 2017). Broadly, the agenda highlights the need for a coherent 'science communication research enterprise' where partnerships are formed between researchers and practitioners of science communication so that research can be translated into practice, and practitioners can ensure research is realistic and pragmatic (National Academies of Sciences, Engineering, and Medicine, 2017, p. 9). Specifically, it recommends "[r]esearchers and diverse science communicators … have opportunities and mechanisms for the regular exchange and synthesis of information and ideas, and … work together to study science communication in real-life contexts, where it occurs" (National Academies of Sciences, Engineering, and Medicine, 2017, p. 9).

The lack of a coherent research enterprise, as outlined by The National Academy of Sciences, maintains the disconnection between those who study PES and those who practice it. As Salmon et al. (2017) point out, this lack of coherence results in communication activities that 'tend to occur in a knowledge vacuum, are generally developed based on "what feels right" and personal or institutional motivations, and are neither informed by theory nor informing research in this field' (p. 62). Bridging the gap between the learned expertise of scientist-communicators and the various bodies of scholarship relevant to PES presents an opportunity to critically examine the challenges of communicating scientific complexity, risk and uncertainty; and of communicating effectively with a plurality of audiences.

This project's focus on complexity, risk, and uncertainty originates from Te Pūnaha Matatini, a government funded Centre of Research Excellence (CoRE) in Aotearoa. Te Pūnaha Matatini is a scientific research organisation with a focus on complex systems and data, and the potential societal applications thereof. They note that "[e]ffective communication of complexity, risk and uncertainty is one of the biggest challenges of science communication" (*Complexity, Risk, and Uncertainty*, n.d.) and communicating these features of scientific knowledge to non-experts "often results in the loss of nuances and changed meanings and messages" (*Complexity, Risk, and Uncertainty*, n.d.). As a post-graduate student within the Centre for Science in Society, and with a background in Law and Computer Science, I have my own interest in the ways complex, technical, and expert knowledges interact with social systems and systems of power—particularly, in relation to contemporary issues requiring political action, such as climate change. Te Pūnaha Matatini provided funding for this thesis as part of a broader response to "The Reflexive Scientist", of which two authors are Te Pūnaha Matatini investigators. Such funding reflects a desire within the wider science communication community to be more research informed, and a drive within Te Pūnaha Matatini to increase the organisation's capacity for reflexivity. For Te Pūnaha Matatini researchers, it is important

to understand the interaction between public engagement with science and the complex, uncertain, and risk-related elements of scientific research to ensure their research has societal impact.

To that end, this research project asks: to what extent do the experiences of scientist-communicators engaged in communicating about complexity, risk, and uncertainty reflect the literature on public engagement with science? It represents an exploration of the gap between PES theory and practice identified, in their own ways, by The National Academy of Sciences, the authors of "The Reflexive Scientist", and the contributors to the 2014 special issue of *Public Understanding of Science.* It is an attempt to contribute to a coherent science communication research enterprise by inviting practitioners into conversation with PES literature on communicating complexity, risk, and uncertainty, and provides an opportunity to study the learned experience of scientist-communicators in real-life contexts. This research documents the experiences of several scientists who are involved with public engagement activities, with a specific focus on the dimensions of scientific complexity, risk, and uncertainty in their work.

This research takes disaggregating the monolith of science (per Salmon et al., 2017) as a primary aim by bringing big-picture PES literature on communicating complexity, risk and uncertainty into conversation with the experiences of individual practitioners. The aim is to complicate both the theoretical narratives of PES and those told by scientist-communicators themselves: to understand the extent to which science communication practice already reflects or is influenced by PES scholarship, to discover what the established scholarship stands to learn from the unique experiences of practitioners, and to examine experiences across a diverse range of scientific disciplines, engagement methods, and potential audiences. This project aims to inform an understanding of the ways scientists communicate about complexity, risk, and

uncertainty; to explore the ways in which they strive to transcend the deficit model; and to situate them as individuals in a broader, intersectional, social and political context.

### *1.1 The constructivist approach to science and society*

The 'deficit model' of public understanding of science defines a linear relationship between science and its publics—i.e. science provides knowledge publics lack (see Irwin, 1995; Irwin & Wynne, 1996; Nowotny et al., 2001). This model assumes a positivist perception of scientific knowledge: that science is certain because it is based on the strict observation of natural phenomena; scientific advancement produces societal development and enlightenment; advancing scientific understanding inevitably reduces uncertainty; and scientific knowledge, properly consumed by the public, will produce rational decisions in concordance with scientific evidence (Jasanoff & Wynne, 1998). Critiques of both the deficit model and these positivist assumptions highlight the "constructed, contested and contingent nature of scientific knowledge" (Stilgoe, 2007, p. 47; or see Irwin & Wynne, 1996). Scientific knowledge is 'socially constructed' in that it cannot be produced without social interaction: consensus about what is true and what is not must be agreed socially (see Smithson, 1993, p. 137). Scientists observe the physical world but then *represent* it, however imperfectly. The character and validity of these representations are then negotiated as scientists make competing claims about both what is known, and, importantly, what is not known (Smithson, 1993; Stocking & Holstein, 1993). Constructivist analyses of the relationship between science and society reject the positivist formulation as reductive, instead focusing on the "… diversity of investigative, argumentative, institutional and material resources that human beings bring to bear in creating the universal truths of science and applying them to technical problem solving" (Jasanoff & Wynne, 1998, p. 4). These analyses interpret how scientific knowledge is produced through human agency, social norms, cultural practices, and discourses.

This project, inspired by these interpretive methods, investigates the ways scientist-communicators construct complexity, uncertainty, and risk in public. Reviewing this literature, it became clear there was a divergence in the theoretical approaches and methodologies used to investigate scientific representations of complexity, uncertainty, and risk to publics. Studies tended to (loosely) correlate with either quantitative or constructivist methods of interpretive inquiry. A significant critique levelled by the latter at the former is that the quantitative approach often uncritically embeds core assumptions about the privileged character of scientific knowledge in the relationship between science and society (Jasanoff & Wynne, 1998; Wynne, 1995). Specifically, the measurement of public understanding of scientific knowledge—for example through mass surveys or one-off structured interviews—does not differentiate between *understanding* and *assimilation* of scientific information (Wynne, 1995). The 'correctness' of public knowledge can only be measured against scientific knowledge itself, and 'understanding' is thereby synonymous with reproducing a dominant scientific narrative.

The implied outcome of this line of research is often to determine how to *more effectively* communicate science to the public. This problematises publics and their understanding of science; inadvertently precluding a critical analysis of science and its culture as a potential barrier to understanding. This approach ignores the possibility people may present alternative understandings of the way the world works for reasons other than a lack of technical expertise or understanding. People experience science socially and therefore their understanding of the contents of scientific knowledge cannot be divorced from their understanding of its methods and processes, or their relationship to its institutions, organisation and control (Wynne, 1992). In this way quantitative analyses of science communication tend to embed assumptions about the privileged character of scientific knowledge, and often fail to problematise the role of science itself in the science/society relationship. To avoid these assumptions, and in order to effectively interrogate the political, institutional, and social context that surrounds public

engagement activities in Aotearoa, this thesis is largely based on constructivist literature. That is not to say that knowledge produced through the quantitative approach is inaccurate or unhelpful. It simply provides a partial perspective that must be contextualised through other means.

In this thesis I draw on constructivist analyses of scientific knowledge to analyse the work of scientist-communicators as an example of ‘public science’: scientific knowledge is generated, repackaged and represented for public consumption with a particular model of 'the public' in mind. As such, public engagement is not a distinct process that occurs after the scientific facts have been generated, but is itself a part of scientific knowledge production and representation. This perspective finds commonality between complexity, risk and uncertainty as rhetorical tools within which scientific knowledge can obscure (often unexamined) assumptions about society, social relations, and dynamics of power. These assumptions often serve to protect the epistemic authority of science, or to limit publicly available scientific information to that which can be domesticated within scientific norms of control.

Viewing science communication through this lens may be useful to scientist-communicators because public resistance to assimilating dominant scientific narratives may be less a reaction to evidence, or a result of public misunderstanding, but a reaction to unexamined assumptions about the public and their relationship to science, packaged into representations of scientific knowledge (Wynne, 2001). In this way scientist-communicators may potentially reinvent the (much maligned) deficit model—substituting a deficit of knowledge for a lack of capacity to understand complexity, risk and uncertainty—in ways that reinforce public mistrust of scientists and scientific institutions. I look to literature which examines both public engagement with science and social construction of scientific knowledge, specifically that which addresses scientific complexity, risk, and uncertainty. I use this literature to establish an understanding

of how these features of scientific knowledge might affect public engagement, and with which to compare the practices and perspectives of scientist-communicators in Aotearoa.

## *1.2 A constructivist approach to complexity, risk, and uncertainty*

> How far, in this sense, is scientific knowledge public knowledge from the start, and not purely laboratory knowledge later applied to new situations?
>
> (Wynne, 2005, p. 68)

Science is not simply objective knowledge, generated in a laboratory and diffused through society. Science is made with particular social worlds in mind (Wynne, 2005). These imagined worlds—hypothetical end-users of technology, interested audiences, relevant decision-makers, potential societal benefits—inform the production of scientific knowledge and are thereby packaged into that knowledge and diffused along with it. This implicit social dimension of science suggests that science is not 'pure' knowledge only later 'applied' by decision-makers, users, or public audiences. For scientist-communicators involved in both the creation and diffusion of scientific knowledge, this conceptualisation of science as 'public science' (Wynne, 2005) highlights that their public-engagement work communicates more than simple scientific 'fact'. It also reveals to the public, among other things, the ways in which they are imagined by scientists and science communicators. As Stilgoe puts it:

> Studies of technology have suggested that technologies necessarily embed assumptions about users (Woolgar, 1991) (and sociologists embed assumptions about readers (Latour, 1988)), constructing their particular public. So experts, when dealing with questions of public engagement, might be seen as (re-)constructing their publics as they (re-)construct science-in-public.
>
> (Stilgoe, 2007, p. 47)

If, as Wynne suggests, the contemporary scientific imagination "embodies deep and persistent concerns over public mistrust in science" (2005, p. 68), then the ways scientist-communicators construct scientific complexity, uncertainty and risk in public may assume the presence of mistrust; configuring their relationship with their audience and affecting how audiences engage with their work. The remainder of this section (1.2) is dedicated to exploring definitions and conceptualisations of scientific complexity, risk, and uncertainty.

### *1.2.1 Complexity*

Complexity can mean different things to different people. As such it is "notoriously hard to define and measure" (Nowotny, 2005, p. 15). In a scientific context complexity may refer to the 'complexity sciences': a broad term used to capture a variety of scientific disciplines that focus on the analysis of self-organising 'complex' systems and the emergent behaviour thereof. To a non-scientist, or indeed a science communicator, 'complexity' may be synonymous with 'complicated'—a barrier to be overcome in the service of understanding. Te Pūnaha Matatini conducts research into complex systems consistent with the former definition, but their focus on public engagement means investigators also often encounter situations in which the latter definition is applicable.

Scientific complexity exists simultaneously within multiple dimensions of scientific knowledge. Firstly, and most intuitively, scientific knowledge itself can be technically complex. It is not always possible, in everyday life, to process all of the information required to understand a given scientific topic (Nowotny, 2005). Secondly, scientific information exists in complex institutional and political contexts. From a constructivist perspective, scientific reality is not solely dictated by the rational observation of nature, it is also negotiated and constructed through the communal work of scientists and institutions. Scientists are not isolated rational observers, they construct scientific knowledge in conjunction with technical experts, sponsors,

stakeholders, funders, users, policy makers, regulators, and their peers. Scientific knowledge is therefore created in particular local contexts, and its claim to truth is contingent upon the specific technical, social, economic and political conditions of that context (Zehr, 2012). Members of the public are not necessarily blind to this context. Using the setting of a 'consensus workshop' to examine how the lay public processes complex scientific information for decision making, Lach and Sanford (2010) observed that participants spent "as much time discussing the institutions in which science and scientists are embedded as they did considering the 'scientific facts'" (p. 141).

There is also complexity in the way scientific knowledge is constructed and communicated. First, scientific claims about what is true are often exclusively privileged over other claims. This can be called epistemic authority—an exclusively authoritative or privileged right to make claims about what is true. Secondly, the knowledge represented by these claims is often more complex than its, often simplified, representation. As above, scientific knowledge is created in, and contingent upon, local contexts. Nevertheless, scientific knowledge achieves a universal authority through its standardisation, reproduction and global distribution (Jasanoff & Wynne, 1998) as this knowledge travels from the local context of a laboratory to more formal structures of universal scientific claims (Zehr, 2012). While scientific knowledge may be presented as certain or 'factual', this often obscures the network of contingencies, contexts and institutions that have constructed such a claim to epistemic authority. Thus, complexity and uncertainty are interrelated: claims of certainty obscure complexity. Simultaneously, claims about certainty and uncertainty can be complex, especially when they overlap. This is epistemic complexity—complexity about what is and is not known.

Gustafsson (2017) observed that people in the monarch butterfly conservation community, including scientists, downplay complexity and emphasise certainty in service of maintaining a

collective narrative—one that presents the need for conservation efforts as an objective, scientific truth. These actors acknowledge complexity but de-emphasise it, configuring it as a contributing part of the big picture, but immaterial to the credibility of the greater whole. This enables individuals to prioritise a single threat to the butterfly—for example milkweed habitat destruction—and act on it, confident they are contributing to the collective conservation effort without acting in "denial of other aspects of the narrative" (p. 504). By downplaying scientific complexity, scientists encourage specific actions. According to Gustafsson the converse is also true: actors avoid emphasising complexity because they fear it will provoke a counternarrative that discourages action.

Wynne (2005) argues that a dominant cultural assumption within science is that scientific knowledge has the capacity to be predictive or to enable control over natural phenomena. They argue this assumption transforms how scientific complexity is represented to the public, specifically epistemic complexity. According to Wynne, the possibility for emergent, unpredictable behaviour within complex systems is 'deleted' from authoritative public representations of science. Wynne highlights this "institutional (mis)representation of 'science' for 'society' is more than simply skilled scientific distillation—identification of 'the essence'—[of the science] for non-specialist users such as policy-makers and public audiences" (2005, p. 70). Institutional representations contain two other components:

1. The 'deletion' or removal of dimensions of complexity that cannot be domesticated into promises of prediction or control.
2. Scientists' confusion of 'science' through the insertion of social assumptions and commitments into authoritative public representations of science. For example, through the assertion of benefits as though they are purely rational, completely

> objective and undeniably true—as though bestowed by nature rather than a product of subjective-humanness.

Wynne argues the removal of complexity from public representations of science is an example of public science. Complexity is removed because the dominant cultures of science imagine the public to be "incapable of respectable reasoning" (p. 4) about scientific complexity, unless it is subject to scientific prediction or control.

For Wynne, this constitutes a reinvention of the deficit model that defines the public as incapable of dealing with the provisional nature of scientific knowledge (2005, p. 70). More precisely, they argue the dominant framing of the public by science embodies deep and consistent concerns about the credibility of science in the eyes of the public (2005, p. 68). With respect to deleting complexity, they write:

> Simplification is justified by the need to translate essential truths to the public, but is actually the systematic deletion of any indications of a lack of control or lack of knowledge beyond tractable imprecision. What scientists choose to share with the public is thereby influenced by a background concern about social control and authority.
>
> (Wynne, 2005, p. 84)

Complexity is often deleted from authoritative representations of science, made to the public, where those acting to translate scientific information see it as troublesome to their relationship with an audience who is imagined to be mistrusting. The scientific information presented therefore encodes assumptions about the actual audience's capacity to reason about complexity.

This perspective on complexity is relevant to scientist-communicators. In their representations of complexity (or lack thereof), scientist-communicators may perpetuate a linear, deficit model relationship with the public. In addition, excluding public audiences from knowledge about

scientific complexity limits the information available to them for decision making. This potentially externalises costs and consequences of science, particularly new technologies, onto the already marginalised—it restricts visibility and critical examination of complexity to those who traditionally have access to the institutions of science. On the consequences of removing complexities that cannot be predicted or controlled from public representations of science, Wynne says:

> [T]his significant, but silent epistemic move also constitutes a—perhaps inadvertent, but no less ethically weighted—so far unaddressed politics in its seamless externalization of the costs that may occur from this neglect, onto future or otherwise marginalized potential victims, human and other…
>
> (Wynne, 2005, p. 70)

One example of what this externalisation might look like in practice comes from the literature on feminist science. Sharra Vostral, writing on Toxic Shock Syndrome and feminist movements to regulate tampon absorbency in the 1980s, notes that science (up until that point) had "detached menstruation and tampons from [menstruators'] embodied experiences by instrumentalizing them for lab purposes" (Vostral, 2017, p. 23). Specifically, scientists used blue saline to test tampon absorbency and tested with a standardised synthetic vagina, thereby eliminating from consideration the differences between menstruators' bodies. This reduction of complexity, in service of greater control and predictability through the elimination of variables, produced results that meant "tampons might be miscategorized as less absorbent than they actually were" (p. 18). This was a potentially serious risk to health as either leaving the tampon inserted for too long, or removing before it was full (potentially leaving behind fibrous material), could increase the user's risk of Toxic Shock Syndrome. This was demonstrated by an alternative feminist science, conducted using heparinised blood, which showed tampons absorb much more blood than saline. Despite increasing complexity, the use of blood yielded

robust and useable results, avoiding the externalisation of cost (in the form of risk to menstruators' health) from science's reduction of dimensions of complexity.

Notably, Wynne (2005) suggests that the reduction of "complex understanding and its epistemic foundations" may be the result of intensifying commercial influence on science: what is predictable and controllable is "potentially exploitable" (p. 78). That claim is reflected in Vostral's account (2017); they note the adoption of scientific methodologies that account for the significance of menstrual fluid would support regulatory reform, and, "industries resisted changes to tampon packaging and product design since they threatened profitability" (p. 22). Defending instrumentalised and disembodied science both maintained control and protected commercial interests. Whatever the motivating impulse, by eliminating complexity from public representations of science, scientific actors avoid taking responsibility for the potential consequences of that complexity. In other words, they externalise risk. Complexity is conceived of in the PES and social construction literature as something hidden from public representations of science to maintain the impression of control and authority, while potentially externalising risk silently onto non-experts.

### *1.2.2 Risk*

Risk, like complexity, is a concept so broad it can sustain definitions that diverge significantly. Fischhoff and Kadvany (2011) describe the scientific study of risk as founded in decision theory: risks threaten things we value, and one decides which action one takes in response depending on available options, possible outcomes, and relevant uncertainties. The study of risk from this perspective involves modelling risk-based decision making with abstract rules—what would a fully informed, rational person fully in-touch with their own values and priorities do? These are then complemented by behavioural studies examining how real people make decisions in context. Decision theory takes a mechanistic approach to risk: it attempts to

quantify factors that contribute to decision making, model an ideal decision-making process, and measure the ways in which human behaviour differs from that ideal. This definition of risk is narrow, tractable and quantifiable. It differentiates between the technical-scientific measurement of risk and cultural perceptions of risk—presenting experts and the public as having fundamentally different, sometimes opposing, understandings of risk. From this perspective the 'problem' of risk communication is achieving "greater concordance between cultural and technical assessments of risk" (see Krimsky, 2007, p. 157).

A much broader definition of risk that critiques this overly mechanistic formulation is Ulrich Beck's idea of the 'Risk Society'. In *Risk Society: Towards a New Modernity* (1986/1992) Beck argues the industrial society of the early 20th Century has transformed from being organised around the distribution of wealth and goods into a society dominated by the logic of distributing the risks and consequences of production. The risks once viewed as latent side-effects of industrial production have become irreversible threats to life, and society is becoming structured and defined by their management. According to Beck, the risks of modernisation are systematic, pervasive, and irreversibly harmful. These risks are often invisible (though their effects are felt) without professional expertise because they are large, complex, and easily misdiagnosed as local phenomena, as opposed to the consequences of global systems that require political solutions. It is easier to blame increasingly prevalent forest fires on arson than to acknowledge the impact of global climate change.

This puts scientists and science communicators in a position of power—the visibility of these risks on this scale is dependent on expert scientific knowledge. As such, these risks can be "…changed, magnified, dramatized or minimized within knowledge, and to that extent are particularly open to social definition or construction" (Beck, 1986/1992, pp. 22–23). If science has epistemic authority over risk, then science also has an exclusive ability to define risks. Beck

argues, the risk society reveals the scientific claim to objectivity and rationality to be false—scientific attempts to express risk as quantifiable, or reduce it to technical manageability, only serve to hide social expectations and values that underly such calculation (1986/1992, p. 29). This 'deletion' of complexity may legitimise unknown risks that have not been accounted for, enabling the selective distribution of their consequences. Not all risk positions are equal.

There are commonalities between Beck's definitions of risk and Wynne's analyses of scientific complexity. They both locate science as a centre of power and imply a concomitant responsibility: scientists, scientific institutions and those involved in the production and representation of public science, must be conscious of the assumptions, biases and socio-political implications of their work. If they fail in this duty, they divert the potential costs and consequences of hidden assumptions, unanticipated risks and otherwise invisible hazards onto already marginalised people.

The relevance of engaging with risk for science communicators is that experts with a technoscientific definition of risk are put in an asymmetrical relationship of power—able to define risks and therefore unilaterally impose their assumptions about/on the public (Beck, 1986/1992; Ofori-Parku, 2018). This occurs alongside increasing evidence that risks are socially constructed (Ofori-Parku, 2018; Rayner, 2012; Wynne, 1989, 2001; Zinn, 2008). Consequently, scientific definitions of risk are prioritised, while informal and local experiences and definitions are side-lined (Rayner, 2012). The credibility of scientific experts and scientific institutions are thereby damaged as their expressions of certainty and universality—assumptions of authority and control—contradict lay-people's nuanced and pluralistic knowledge (Wynne, 1989).

Wynne (2001) argues that public resistance to technologies such as nuclear power and GMOs is as much a response to scientific institutions' implicit representations of the public as it is to

the risks per se (2001, p. 450). Here the distinction between ‘real’ and ‘perceived’ risk, located respectively within science and the public, is a “self-destructive fallacy” (p. 450). This fallacy is deeply embedded in modern scientific, policy and risk-management cultures (see Fischhoff & Kadvany, 2011). It assumes that public concerns about risk are by definition an irrational and subjective distortion of ‘real’ risk—the public must therefore be educated using simplified, technical information. Wynne argues that this construction marginalises non-expert knowledge by ignoring public concern unless it is based on a misunderstanding of scientifically defined risk. This hides uncertainty by totally and silently excluding ‘unknown unknowns’ as valid components of risk. Upholding quantifiable risk as the only relevant definition presents a façade of certainty and control that can appear disingenuous: representing scientific institutions as capable of controlling risk while ignoring that they are incapable of controlling unanticipated consequences. The focus on technical definitions of risk can also construct ethical concerns as unscientific: treating them as highly personal, subjective choices individuals can make after they have properly assimilated the objective risk analysis.

Publics respond to these elements of scientific institutions and their culture as much as they respond to the risks themselves (Wynne, 2001, 2005). Scientific institutions double down on explanations of objective risk because they misinterpret the public’s lack of trust as a lack of understanding and a demand for greater certainty. In doing so they reinforce the very cultural features that cause mistrust. Failure to reproduce the dominant scientific definition of risk is tacitly characterised as emotional, irrational, and lacking intellectual substance. Scientific institutions thereby undermine their own credibility because public concerns about risk are not purely emotional or value-based decisions—they are rational, pragmatic and calculated decisions based on a recognition of the inherent uncertainty of science (2001, p. 456). The public is dependent on scientific knowledge and its institutions to perceive and manage many

modern risks; the trustworthiness of expert institutions is therefore central to the public evaluation of risk.

It is in this way, Wynne argues, the dominant cultural attitudes about science and rationality— the particular ways in which risk is socially constructed by scientists— can alienate publics. The solution, they suggest, is reflexivity:

> The limitations in these representations of risk and the public, that explicitly decouple objective risk from any ethical element (which is seen as an individual and highly personal decision based on objective risk), inhibits any reflexive or critical self-examination from the dominant scientific institutions and thereby go on to shape so called 'rational' thought.
>
> (Wynne, 2001, p. 456)

Wynne thereby argues scientific institutions must apply scientific rigour to their own assumptions about the public, and reflect on and critique their own cultural values.

### *1.2.3 Uncertainty*

Like complexity and risk (as outlined above), uncertainty is also an integral part of science. For example, an experiment may produce an unexpected or unintended result: should it be disregarded? Were the experimental techniques applied incorrectly? Was the data collected reliably? Were our expectations wrong? Do we have enough resources to investigate the result? Somewhere between observation and publication, however, these uncertainties are minimised (or removed) and the data presented as certain (Star, 1985). A central theme of the production of scientific knowledge (as a universal claim about what is real) is the process of managing, transforming, and removing local uncertainties (see Shackley & Wynne, 1996; Star, 1985; Stilgoe, 2007).

Scientists do not only make claims about what is known, they also make explicit claims about what is *not known* and use these claims to justify that something should or should not be done (Stocking & Holstein, 1993). "Ignorance" writes Stocking (1998), "…is not simply a 'given' in people or nature, but it is (at least in part) a construction embedded in diverse social interests and commitments" (p. 168). Uncertainty, as with ignorance, is actively constructed by scientists (see Smithson, 1993; Stocking & Holstein, 1993). The construction, management, and transformation of uncertainty is fundamental to scientific endeavour, as it is the means by which scientists collectively transform contingent, local knowledge into universal claims of truth (Star, 1985; Zehr, 2012). Scientists construct uncertainties as a cultural practice, but not necessarily as a deliberate (or disingenuous) act. The way uncertainty is constructed nevertheless serves as a discursive tool embedded in social interests and commitments.

Shackley & Wynne (1996) describe the social construction of uncertainty in interactions between policymakers and the scientists advising them. They argue that scientific advisors must adopt flexible and ambiguous representations of uncertainty in order to maintain credibility among their scientific peers (by meeting demands for accuracy), while simultaneously meeting policymakers' expectations that science can clarify a policy response to a scientifically defined problem. Specifically, these representations do not "challenge the notion […] that the risks are tractable and manageable by practices and institutions that are similar to those currently in existence" (Shackley & Wynne, 1996, p. 280). Correspondingly, policymakers must participate in negotiating uncertainties so as not to be seen as out of touch or misrepresenting scientific information. These authors argue flexible constructions of uncertainty have two effects. Firstly, they facilitate discussion and negotiation between the scientific and policy communities, creating a common discourse and a shared culture. Secondly, they argue this discourse has direction: it orders the social relationship between the science and

policy communities, helping scientists maintain the cultural authority of science. This is an example of boundary work.

Boundary work is a concept developed by sociologist Thomas Gieryn, defined as the "[…] attribution of selected qualities to scientists, scientific methods, and scientific claims for the purpose of drawing a rhetorical boundary between science and some less authoritative residual non-science" (Gieryn, 1999, pp. 4–5). Geiryn demonstrated that, when the authority of science or scientists is challenged, a common response from scientists is to demarcate the realm in which their expertise is autonomous (Gieryn, 1983, 1999). In other words, they draw a line between science and other areas of expertise, sorting knowledge and practices onto either side of the line and claiming an exclusive right to make authoritative statements about whatever they designate to be within the scientific domain. Shackley and Wynne (1996) extend the idea of boundary work and introduce the concept of 'boundary-ordering devices.' Boundary-ordering devices are approximate 'shorthands' used to enable shared understanding across different realms of expertise, institutions, or circumstances. For example, scientific advisors may use a simplified representation of uncertainty that does not accurately represent the scientific understanding of uncertainty, nor a policy maker's understanding. Instead, it is a third, hybrid understanding built to bridge the boundary between the two domains.

Shackley and Wynne (1996) describe six ways uncertainty is rhetorically deployed to enable understanding between scientists and policy makers while also preserving science's cultural authority. First, by claiming to *manage or clarify uncertainty*: defining which uncertainties are relevant (providing certainty about uncertainty). Second, promises to *reduce uncertainty* in areas relevant to policymaking are also promises to increase the effectiveness of knowledge, and thereby the effectiveness of policy. This is often sufficient to justify additional funding. Third, *transforming uncertainty* is a means by which scientists may be seen to reduce

uncertainty: transforming ignorance (unknown unknowns) and indeterminacies (known limits to the parameters of a system) into more tractable representations such as a quantified risk. Fourth, scientists may recognise the presence of multiple types of uncertainty (e.g. ignorance, indeterminacy, embedded assumptions) in their work, but *condense* that uncertainty into a single, undifferentiated category or simplified quantification. Fifth, scientists can *schedule* the reduction of uncertainties into the future, presenting a timeline for reducing uncertainty—presumably when data, technology, and knowledge have improved—and promising to provide robust information in future, tacitly reinforcing their own authority in the present. Lastly, scientists may *displace* uncertainty by locating its source wholly within the domain of a specific discipline, social world, or policy domain other than science. By claiming uncertainty arises from social or political forces, scientists defer responsibility for reducing that uncertainty and preserve the authority of science.

These representations of uncertainty work to sustain the privileged, authoritative position of science. Thus, representations of uncertainty "intended for consumption outside of the [scientific] community" (Shackley & Wynne, 1996, p. 284) tend to transform uncertainty into something that does not threaten a given scientific methodology as capable of robust predictions. An example of the way uncertainty can be rhetorically 'managed' by scientists comes from Gustafsson (2017) and their study of the shared conservation narrative around monarch butterflies. They noted a boundary was constructed between science and conservation: uncertainty was "relegated to the backstage practices in the scientific sphere" (p. 507) until a threshold of certainty necessitated communication to other actors. Scientists acknowledged uncertainty, but assumed that once clarified, uncertainties should not threaten the already established scientific narrative. Uncertainty was constructed as immaterial to the assertions of certainty that compelled conservation action.

In another example of the transformation of uncertainty, this time in the context of Aotearoa, Palliser and Dodson (2019) describe how researchers estimating the total abundance of Hector's Dolphins—inherently high in uncertainty—would update research methods between successive surveys, leading to incompatible methods over time. This methodological context and the uncertainties associated with estimating populations were "not disseminated widely, yet are generally significant for understanding the research findings" (Palliser & Dodson, 2019, p. 13). Often median values were presented publicly, rather than a full range of possibilities, presenting scientific knowledge as more certain than it was. They conclude that a lack of transparency around scientific uncertainty, including its transformation into limited quantifiable representations, and combined with cultural assumptions about science's objectivity and reliability, contributes to an increasing mistrust in science in Aotearoa where science can be rhetorically deployed to silence public concern (Palliser & Dodson, 2019). As Mellor (2010) demonstrates, scientists have persisted in creating condensed numerical measures and simplified communication protocols for uncertainty because through quantification, they expected to control public discourse.

Finally, the way scientists construct uncertainty can impact their relationship with publics. Stilgoe (2007) demonstrates that constructing uncertainty exclusively in the domain of scientific expertise can prevent public engagement with science, in turn constructing the public as 'cognitively deficient' with respect to uncertainty. Examining public concerns about the potential health risks from mobile phones, Stilgoe demonstrated that experts relied on the scientific basis of regulatory guidelines to dismiss public concern about the adequacy and relevance of those guidelines. In doing so, public consideration of scientific uncertainty was "seen as unwarranted"; the public was considered "not cognitively equipped to make judgments about the contingencies of scientific knowledge" (p. 51). Stilgoe suggests that the study of scientific uncertainty is part of a broader project that must consider how scientists

"*construct their publics* as part of the process of doing public science" (p. 56, emphasis in original). Scientists can maintain boundaries between themselves and non-specialist publics, ordering those boundaries such that they maintain authority over uncertainty. Even attempts to facilitate understanding of uncertainty can, depending on the specific construction, reinforce scientists' presumed authority.

### *1.2.4 Conceptualising complexity, risk and uncertainty*

Complexity and risk are often hard to extricate from uncertainty. In this thesis, I consider the commonalities between them. To that end, I draw on Gieryn's concept of boundary work to consider the ways that complexity, risk and uncertainty are mobilised by scientists working in public engagement to reinforce, or transform, boundaries between science and publics. Gieryn (1999) argues that science does not have "essential or universal qualities" (p. xii) with which to identify its boundaries, and its borders are fluidly defined through the cultural practice of boundary work. Gieryn demonstrates how scientists rhetorically demarcate the realm in which their expertise is autonomous, thereby claiming an exclusive right to make authoritative statements about whatever they designate to be within the scientific domain. This—combined with repeated claims within the PES and constructivist literature that complexity, risk, and uncertainty are constructed for public consumption in simplistic ways that serve to protect the epistemic authority and privilege of science—highlights the position of power held by scientist-communicators. For example, when scientist-communicators construct these features of scientific knowledge in public, on which side of the boundary do they lie? Are they relegated to the backstage practices of science or exposed to the public? Who has access to define, examine, and challenge these elements of scientific knowledge if scientists unilaterally define them as for expert eyes only? If these elements of knowledge are restricted to the scientific domain, what does that say about public engagement? Does it lie within the boundary of science,

or do scientists consider it a process other than science, a social process applied to scientific knowledge after the fact(s)?

As such, the concept of boundary work is a useful tool with which to interpret scientist-communicators' representations of complexity, risk and, uncertainty. As scientist-communicators represent these concepts in (and to) public(s) they implicitly define boundaries between science and non-science as they decide what and how to communicate to (presumed) non-specialist audiences. By deciding which elements of scientific complexity, risk, and uncertainty should be communicated publicly, or how they should be represented, scientist-communicators construct a relationship between themselves and their audiences according to embedded assumptions about what that audience wants, needs, or is capable of. As such, complexity, risk, and uncertainty can be important vectors by which scientist-communicators construct their publics, which in turn impacts the way science is communicated and interpreted. This project explores whether the practices of participating scientist-communicators in Aotearoa align with the PES and scientific constructivist literature described here. If, as Helga Nowotny argues, we are "in a period where the relationship between science/society is being renegotiated" (2016, p. 83), social constructions of complexity, uncertainty and risk in science communication will play a key role in defining that relationship.

## *1.3 Methodology and scope*

This research is both funded by Te Pūnaha Matatini and focuses on Te Pūnaha Matatini researchers as a case-study. This group is, to an extent, self-selecting: Te Pūnaha Matatini has a strong culture of highly engaged and motivated science communicators, many of whom had expressed interest in research-informed science communication practice. This group of scientists is not comprehensively representative of science communication in Aotearoa, but they offer examples of how individual scientists come to be involved with public engagement activities, develop their own engagement practices, and configure their own relationships with various publics. In order to highlight this, the project has both analytical and descriptive elements.

The first element of this project is analytical—to examine how complexity, risk, and uncertainty, as qualities of scientific research, are constructed within the public engagement activities of these scientist-communicators and to assess the extent their experiences reflect PES literature. A secondary focus of this project is to describe the experience of individuals working in public engagement with science. This is in service of 'disaggregating the monolith of science'—a challenge made by the authors of "The Reflexive Scientist" who noted that Science and Technology Studies (STS) and PES literature often represented science homogenously and with little attention to its specific political-economic and institutional contexts (Salmon et al., 2017). The project seeks to document the experiences of these scientist-communicators, who they are and how they practice, with particular attention paid to their institutional, social and political context.

### *1.3.1 Participants*

Participants were selected using selective convenience sampling. I made an initial list of twelve potential participants from Te Pūnaha Matatini's cohort of Principal and Associate

Investigators. This initial list was selected under the assumption that as members of Te Pūnaha Matatini—a Centre of Research Excellence (CoRE) focused on the study of complex systems—complexity, risk, and uncertainty would be integral to their research. Each potential participant was approached because they were both scientific researchers and involved in various forms of public engagement or science communication activity. Careful attention was paid to ensure the list represented a diverse range of scientific disciplines, personal backgrounds, and types of public engagement.

These 12 potential participants were contacted by email and asked if they wished to participate. Eight responded in the affirmative and interviews were scheduled. Of those eight, three interviews never eventuated, either because the participants pulled-out or because of scheduling difficulties. The remaining five interviewed were: Professor Shaun Hendy, Director of Te Pūnaha Matatini; Dr. Daniel Hikuroa, Co-Deputy Director of Public Engagement and Principal Investigator; Dr. Dion O'Neale, Principal Investigator; Dr. Izabelle Sin, Principal Investigator; and Associate Professor Siouxsie Wiles, Co-Deputy Director of Public Engagement and Principal Investigator. Between them they have research expertise in, among other things, physics, mathematics, complex systems, earth systems science, mātauranga Māori, economics, and microbiology. During the interview process Sin, who is a Research Fellow at Motu Economic and Public Policy Research, recommended I talk with their Communications Director, Ceridwyn Roberts. They became the sixth participant in this research, providing the perspective of a science communication professional who is not a research scientist.

### *1.3.2 Research design*

Each participant was interviewed in a semi-structured, conversational manner to allow flexibility in exploring their unique experience of communicating complexity, risk, and

uncertainty.[2] They were each interviewed in their place of work, except Wiles who was interviewed via video conference. Interviews lasted between 60 and 90 minutes, were recorded with a dictaphone, and transcribed for thematic analysis and coding. Participants were asked to describe their careers as scientists and communicators; how complexity, uncertainty, and risk were relevant to their scientific research; how they included such information in public engagement activities; and how that affected their relationship with their audiences. The generic interview guide I used as the basis for each interview is included as Appendix 1. Before the interview I asked each participant to send me a publication from/about their work that they felt demonstrated complexity, risk, and/or uncertainty. Having read these publications, I hand annotated each interview guide with new questions and modifications, focussing the interview on the specific details of each participant's work. All participants agreed to remain fully identifiable throughout the research.

The interviews were collaborative and participant-led in an attempt to adopt a methodology that is both informed by, and reflects the values of, kaupapa Māori.[3] Each participant was asked to articulate what they want from the project, to provide feedback on the way the research is/should be conducted, and to establish boundaries around what they were willing to discuss. I chose to adopt a methodology that reflects the values of kaupapa Māori because I was aware from the outset that this research could potentially engage with mātauranga Māori, or with public engagement that involved Māori communities. As a Pākehā researcher, I wished to avoid perpetuating the colonial relationship between research and indigenous peoples that has served

[2] Participants were interviewed under Victoria University of Wellington human ethics application #0000027389.

[3] I am grateful to Dr Pauline Harris (Ngāti Kahungunu, Rongomaiwahine), Centre for Science in Society, Victoria University of Wellington, for their advice in this.

to privilege Western knowledges while denying validity to Māori knowledge, language, and culture (See Smith, 2012). In particular, I want to ensure those generous enough to share their knowledge and expertise with me are also those who benefit from it.

There were two other avenues of inquiry built into this research. First, participants were asked to consider if there were any documents or texts related to their research (and communication thereof) they considered it both possible and appropriate to make available to me. The texts volunteered by the participants augmented those I could find publicly available online and included presentation slides or scripts, draft documents, media articles and press releases. They provided another vector for analysis through close reading of their representations of complexity, uncertainty, and risk.

Also, I invited all participants to a roundtable discussion several months after the initial interviews. This was an opportunity for me to report on my provisional findings and to facilitate a discussion that draws connections between participants. It was also an opportunity for the participants to share their experiences of public engagement, and of communicating about complexity, risk, and uncertainty, with each other—an opportunity to share knowledge that is rarely prioritised by research institutions. This was a mechanism for dialogue and feedback and was intended to be supplementary to the interviews, which were the primary means of data collection. The roundtable was recorded with the consent of the participants, to capture any salient insights. An explicit goal of this project was to develop practical tools to aid the public engagement efforts of Te Pūnaha Matatini researchers with respect to complexity, risk and uncertainty. Facilitating a discussion between participants who each have substantial knowledge in this area, but rarely have the opportunity to share among themselves, was an achievable output within the scope of this research project.

### *1.3.3 Methodology*

Each interview was transcribed verbatim using the software NVivo. In order to become familiar with the material I read each transcript and document in full, noting connections between interviews and documents, potential themes, and points of interest. Below is a table of interviewed participants, the duration of the interview, the length of the final transcript, and the number of documents volunteered by each participant.

Table 1.

List of participants

| **Participant** | **Interview Duration** | **Transcript wordcount** | **No. Documents provided** |
|---|---|---|---|
| Dr. Isabelle Sin | 1:05:24 | 11,085 | 23 |
| Dr. Daniel Hikuroa | 1:08:33 | 9,594 | 5 |
| Dr. Dion O'Neale | 1:14:23 | 10,272 | 2 |
| Professor Shaun Hendy | 1:25:19 | 11,822 | 2 |
| A/Prof Professor Siouxsie Wiles | 1:29:36 | 15,541 | 6 |
| Ceridwyn Roberts | 1:08:54 | 9,231 | 14 |
| Totals | 7:32:09 | 67,545 | 52 |

Each interview was coded and analysed according to themes emerging from the data. Initial codes included concepts relevant to the literature review (e.g. risk perceptions, uncertainty regulates action, deleting complexity), emergent themes (e.g. hostile publics, civic responsibility, ethical and moral considerations), and contextual points of interest (e.g. time pressure, social media, commercial imperative, overwork). These codes were then iteratively reviewed, reassessed, and categorised into broader themes. Each document was analysed for representations of complexity, uncertainty, and risk, as well as constructions relevant to the themes that emerged from the interviews. Throughout each stage the theoretical framework

established above informed the analysis. Direct quotes from the interviews and documents have been lightly edited for clarity and readability.

### *1.3.4 Key themes and chapter outlines*

The following chapters in this thesis are organized thematically. In this first chapter I have drawn on interpretive literature describing the social construction of scientific knowledge to establish an understanding of how scientific complexity, risk and uncertainty may configure the relationship between scientists and society. In the chapters to come I attempt to address the following research question:

> **To what extent do the experiences of scientist-communicators engaged in communicating scientific complexity, risk, and uncertainty align with the literature on public engagement with science?**

Chapter two—in an effort to 'disaggregate the monolith of science' and be attentive to the particular politics of research fields and the institutional contexts of scientists who are interacting with the public (per Salmon et al., 2017)—introduces participants, describes their scientific and public engagement expertise, and situates them each within the broader context of science and public engagement in Aotearoa. Chapter three examines the ways in which participants conceive of complexity, uncertainty, and risk, and the factors they consider when constructing these elements of scientific knowledge in public. Chapter four examines participants' defensive thinking about public representations of complexity, uncertainty and risk. Participants tended to focus on ways publics could misunderstand, dismiss or actively misuse such representations in ways that might challenge the epistemic authority of science. In doing so they also construct the publics with which they engage, including their scientific peers, Finally, chapter five describes the ways in which some participants are attempting to transform public engagement with science in Aotearoa, increasing transparency and accessibility around

complexity, risk and uncertainty. Participants do so by treating transparent public engagement as a responsibility of science, by expanding the boundaries of science and acknowledging other ways of knowing, and by telling the narratives of research that make explicit what science does not know.

Together these chapters demonstrate that while participants' practice largely reflects the body of PES literature reviewed for this thesis, some are also resisting systemic and cultural barriers that act to entrench science as an inaccessible, exclusive, and unilateral arbiter of knowledge about the world. In doing so they attempt to adopt research and engagement practices that change the ways they construct complexity, risk and uncertainty in public.

# Chapter #2 Background

This section contains a brief introduction to each participant and the scientific work discussed in their interview. Each participant operates in different contexts, possesses different expertise, and came to science communication along a different route. The analysis in this thesis benefits from those differences and is enriched by those contexts. Below is a table summarising details about participants as scientists and science communicators within the institutions of Aotearoa (see Table 2). Following the introductions, this chapter examines the context within which these scientist-communicators operate, at least those elements the participants chose to highlight themselves, and examines how these contextual features might influence participants' practice.

## *2.1 Participants*

Professor Shaun Hendy is a professor of physics at the University of Auckland and the director of Te Pūnaha Matitini—a Centre of Research Excellence focused on studying complex systems and networks. Hendy began communicating about science as a PhD student because they enjoyed teaching astronomy and physics to retirees in Canada. Upon returning to Aotearoa, following completion of their PhD, they developed those skills further; presenting cosmology lectures to the Wainuiomata Lions club from a beer-spattered laptop. Now a well-recognised public scientist who appears regularly in the national media, Hendy is the recipient of two science communication prizes. When asked for an example of their communication work to discuss, Hendy chose a *New Zealand Herald* article profiling Te Pūnaha Matatini and Hendy's work on complex systems (see Morton, 2015). Over the course of the interview we also discussed Hendy's books *Silencing Science* (Hendy, 2016), their year eschewing flight, and the resultant (then unpublished) book *#NoFly: Walking the Talk on Climate Change* (Hendy, 2019).

Table 2.
Participant details

| **Participant** | **Institutional affiliations (2019)** | **Core discipline** | **Communication roles and awards** |
|---|---|---|---|
| Professor Shaun Hendy | Te Pūnaha Matatini<br>University of Auckland | Physics, Applied mathematics | Prime Minister's Science Media Communication Prize (2012)<br>Callaghan Medal (2012) |
| Associate Professor Siouxsie Wiles | Te Pūnaha Matatini.<br>University of Auckland | Microbiology | Prime Minister's Science Media Communication Prize (2013)<br>Member of the New Zealand Order of Merit (2019)<br>Callaghan Medal (2013)<br>NZAS Science Communicators Award (2012)<br>Co-deputy director of public engagement, Te Pūnaha Matatini |
| Dr Dion O'Neale | Te Pūnaha Matatini.<br>University of Auckland | Applied mathematics, Network science | |
| Dr Isabelle Sin | Te Pūnaha Matatini.<br>Motu Economic and Public Policy Research | Economics, Econometrics | |
| Ceridwyn Roberts | Motu Economic and Public Policy Research | Science communication, Theatre studies | Vice-President, Science Communicators Association of New Zealand<br>Producer, Story Collider<br>Communications Director, Motu |
| Dr Daniel Hikuroa | Te Pūnaha Matatini<br>Te Wānanga o Waipapa, University of Auckland | Earth Systems Science, Geology, Mātauranga Māori | Co-deputy director of public engagement, Te Pūnaha Matatini<br>Previously: Community Earth Systems Science Programmes Manager, Institute of Earth Science & Engineering |

Associate Professor Siouxsie Wiles is a microbiologist and describes themselves as a 'bioluminescence enthusiast' in online biographies. They are co-deputy director of public engagement for Te Pūnaha Matatini, and lead the Bioluminescent Superbugs Lab at the University of Auckland. They are recipient of numerous awards for their science communication work, including being appointed to the New Zealand Order of Merit for

services to microbiology and science communication. Wiles began communicating about science in the UK, providing transparency around the use of animals in scientific research. Upon moving to Aotearoa in 2009 they started blogging for the Science Media Centre about health research which, after an outbreak of Escherichia coli in Germany that caught New Zealand media attention, led to media appearances. Now with a regular column on the website *Stuff* and a regular radio slot on RNZ's *Nine-to-Noon*, Wiles is one of Aotearoa's most prolific and visible public scientists. In our interview we discussed Wiles' research at the Bioluminescent Superbugs Lab, which is driven by the antibiotic resistance crisis. "We are running out medicines to treat infections" (Wiles, personal interview, 24 July 2019). We also discussed their burgeoning Open Source Period project, which aims to use 'open science'— transparency and scrutiny of processes and data— and crowdsourcing to fill the gap in research around menstrual cups (Wiles, 2019).

Dr Dion O'Neale is a complex systems and networks science researcher in the Department of Physics at the University of Auckland. An applied mathematician by training, O'Neale has worked for Industrial Research Limited (IRL), now called Callaghan Innovation, and is now a Principal Investigator for Te Pūnaha Matatini, interested in how networks affect the dynamics and properties of complex systems. O'Neale worked with Hendy at IRL and both moved to the University of Auckland, a move that preceded the formation of Te Pūnaha Matatini. O'Neale's science communication activities have largely focused on interested publics and 'enthusiastic amateurs' in the format of Café Scientifique. During our interview we discussed O'Neale's research combining archaeology and network analysis to explore early Māori communities' relationship with sources of obsidian (see Ladefoged et al., 2019). We also discussed O'Neale's work talking data analysis with industry as part of a team at the New Zealand Food Safety Science Research Centre, and providing general expertise on algorithms, artificial intelligence, and the future of labour automation for government workers.

Dr Isabelle Sin is a principal investigator for Te Pūnaha Matatini and senior fellow at Motu—a small, independent (and not-for-profit) economic research institute based in Wellington. For Sin, communicating about their economic research is an important part of the job at Motu:

> We do academic type research, but we are not a university; we do need to be funded. Part of what we are trying to do is influence policy debates and that means we really need to get knowledge about our research, and what we find, out to the public—to policy makers, but also [people] who it might be relevant to.
>
> (Sin, personal interview, 26 June 2019)

Sin nominated two of their working papers as focal points for our conversation about their communication activities. Firstly, "What Drives the Gender Wage Gap? Examining the Roles of Sorting, Productivity Differences, and Discrimination" (Sin et al., 2017) which interrogates the extent to which the gender pay gap is a product of discrimination. Secondly, we discussed "Parenthood and Labour Market Outcomes" (Sin et al., 2018), a working paper examining the effect of parenthood on wage disparities in Aotearoa.

Ceridwyn Roberts is the Communications Director at Motu Economic and Public Policy Research. Roberts comes from the world of communications and is the only participant not a member of Te Pūnaha Matatini or with scientific training. A self-described 'science brat'—the child of a Department of Science and Industrial Research (DSIR) nuclear chemist—Roberts has an academic background in Theatre Studies and professional experience in communication from a variety of fields, ranging from Toyota's corporate communication to Rape Crisis New Zealand. As Motu's Communications Director, Roberts writes "pretty much everything other than the papers that come out of this place" (Roberts, personal interview, 26 July 2019). We discussed the executive summaries, media releases and other communications that Roberts wrote concerning Sin's two working papers listed above. Roberts is also the vice-president of

the Science Communicators Association of New Zealand, a professional organisation promoting and fostering science communication in Aotearoa, and a producer for Story Collider New Zealand, a non-profit organisation dedicated to telling true, personal stories about science.

Dr Daniel Hikuroa is an earth systems scientist and senior lecturer in Māori Studies, Te Wānanga o Waipapa, University of Auckland. Much of Hikuroa's work focuses on weaving together systems of knowledge, for example science and mātauranga Māori. They publish and communicate about the philosophical and methodological process of weaving these knowledge systems, but also apply that new knowledge to their own research. Hikuroa's communication activity emerges from a desire to learn how to communicate effectively but is also, in their view, a responsibility as "a beneficiary of society" (Hikuroa, personal interview, 1 July 2019). During our interview we discussed Hikuroa's paper "Mātauranga Māori—the ūkaipō of knowledge in New Zealand", which describes Māori systems of knowledge and how they are often disregarded by scientific communities despite utilising techniques consistent with the scientific method and producing knowledge that can be accurate and precise (Hikuroa, 2017). This led to a discussion of Hikuroa's work with the Environmental Protection Authority that has led to the creation of a new body of work, the Mātauranga Programme, in which the EPA is creating a framework to test the veracity of mātauranga as evidence (Hikuroa, Personal Interview, 1 July 2019).

I use a number of terms throughout this thesis to collectively describe participants and the professional groups they belong to. Participants in this research are described as scientists, science communicators, or scientist-communicators depending on context. For the sake of clarity, I have endeavored to use 'scientists' to describe participants in their capacity as scientific researchers, 'scientist-communicators' to describe participants engaged in science communication work in addition to scientific research, and 'science communicators' to be

inclusive of those who do science communication but do not have a formal scientific training. For the purposes of this thesis ‘science’ encompasses the scientific investigation of complex economic data performed by Dr Sin at Motu.

### *2.2 Public scientists, generalist science communicators and Paul Callaghan*

Sir Paul Callaghan was a huge influence on Hendy. “One of the first generalist science communicators in New Zealand” (Hendy, personal interview, 5 July 2019), Callaghan was the first director of the MacDiarmid Institute for Advanced Materials and Nanotechnology, a CoRE, and established communication and outreach as part of the organisation’s ambit. Callaghan was mentor to Hendy: originally one of Hendy’s physics lecturers at Massey University in the early 90s, Callaghan inspired and encouraged Hendy’s work on measuring innovation when they worked together through the MacDiarmid Institute. They co-authored a book together—*Get off the Grass: Kickstarting New Zealand’s Innovation Economy* (Hendy & Callaghan, 2013), published after Callaghan passed away in 2012. “I got to see how seriously he took science communication and how much of an impact it was possible to have as a scientist in the media” (Hendy, personal communication, 18 February 2020).

When the MacDiarmid Institute was “declared a big success” around 2006 (Hendy, personal interview, 5 July 2019) it became a default model for how CoREs would operate, including a mandate for some element of public engagement. The influence of Callaghan can be seen in Te Pūnaha Matatini’s focus on public engagement, and in Aotearoa’s science communication community more generally. “People used to say there’s an unwritten rule” said Hendy, “that you shouldn’t talk about things outside of your area of expertise. You’d hear people saying that, but then they’d say ‘But it’s OK that Paul is. Paul’s allowed to. Paul’s good at it’” (personal interview, 5 July 2019). For Hendy it was influential to have someone speaking about science

generally who had "been given permission to, by virtue of [their] stature within the science community" (personal interview, 5 July 2019).

Today, both Hendy and Wiles fit the mould of a public scientist established by Callaghan. Each has license within the science community, though not comprehensively so, to speak publicly about science generally, including topics about which they are informed but are not within their area of explicit scientific expertise. Wiles notes that this status is also partially the product of being a useful resource for the mainstream-media:

> I'm in a small country, I'm a vocal person who has been working hard at learning how to communicate to different audiences—both written and oral. Then you become what is known as 'talent'. Journalists know you will respond to them. They can talk to you.
>
> (Wiles, personal interview, 24 July 2019)

Of the participants in this research these two are most commonly seen on TV and heard on the radio, communicating about science and scientific issues to the public. As Wiles points out, Aotearoa is a small country. One influential person's practice can make space for others or change the focus of an industry. The science communication space in Aotearoa, while growing, can also be a precarious, under-resourced, and politically challenging place to work.

### *2.3 Communicating science in neoliberal institutions*

All participants are primarily, though not exclusively, publicly funded. The systems, institutions, and funding apparatus of New Zealand's science sector, within which these scientist-communicators work, are the result of significant neoliberal restructuring in the early 1990s. In 1992 the government's Department of Scientific and Industrial Research (DSIR) was dissolved and replaced by 10 Crown Research Institutes (CRIs). These 'commercially focused' organisations compete for funding from a centralised foundation. Critics have pointed out this

limits opportunities for "curiosity-driven science without an immediate commercial goal" (Priestley, 2010, p. 486). The DSIR, structured as a public service, was responsive (if reactive) to public need: scientists would respond to phone calls and letters, the organisation ran open days, tour groups and public talks, and the scientists were encouraged to give media interviews—all this without a media or communications plan (Priestley, 2016). By contrast, the CRIs, with their mandate to "promote and facilitate the application" of research and technological developments (Crown Research Institutes Act 1992, section 5), moved to a model of public engagement that was closer to marketing, corporate public relations, or science promotion. Communication became about ensuring general public support, which put strain on scientists to provide content for outreach efforts which increasingly reframed their audience as 'clients' (Priestley, 2016). This neoliberal turn in public science funding shaped the landscape in which scientist-communicators work, incentivising commercial and industrial priorities over exploratory science. Such context, as discussed later, cannot help but influence the practice of the scientist-communicators embedded within its systems.

Hendy and O'Neale previously worked for CRIs which, in Hendy's experience, have an ambivalent relationship with science communication:

> Crown Research Institutes had a funny relationship with science communication in New Zealand: they run hot and cold at times. [It] depends very much on the senior management team and the board's philosophy on how CRIs should operate. You know there was a high profile case a few years ago where a Crown Research scientist was fired for talking to the media … There was a period where we were absolutely tied down, we weren't even allowed to be on the web.
>
> (Hendy, personal interview, 5 July 2019)

The extent to which CRIs value the public engagement efforts of individual scientists are dependent on the political proclivities of their leadership. Since the DSIR was dissolved those

priorities have always had to contend with the commercial imperative placed on these semi-independent, business focused, and funding-competitive institutions. The State considers CRI funding to be partially mission-led, in service of particular policy aims, and partially industry led and therefore "expected to result in measurable benefits to firms and the economy" (Ministry of Business Innovation & Employment, 2015, p. 28). The ever-present consideration of measurable economic benefits can shift focus away from public engagement for societal benefit, and towards a commercial model of communication that emphasises promoting public acceptance of science or managing the institution's public relations. In this way, the commercial emphasis of New Zealand's scientific institutions can encourage a particular type of public engagement with science that treats people like consumers.

Another key feature of the public science landscape in Aotearoa are the Centres of Research Excellence (CoREs), which, alongside other mechanisms, allow for "investigator-led" scientific research "undertaken to acquire new knowledge" (Ministry of Business Innovation & Employment, 2015, p. 27). First established in 2002, CoREs provide a mechanism for establishing collaborative research networks between CRIs, universities, and other academic and research institutions. Hendy, Wiles, O'Neale, and Hikuroa each hold academic positions in the University of Auckland across three different departments but come together as members of the CoRE Te Pūnaha Matatini. Sin, also an investigator at Te Pūnaha Matatini, works at Motu alongside Roberts, Motu's Director of Communications. CoREs allow for investigator-led scientific research where funding is primarily allocated based on scientific excellence, which may insulate them somewhat from the need to promote their work with an eye towards commercial priorities. It is worth noting that, at the time of writing, CoREs were engaged in an intensive rebid process in which active and outward-facing engagement was a criterion by which to justify further funding.

There is, however, little in the *National Statement of Science Investment: 2015-2025* (2015) about public engagement with science. It is only mentioned once, in the context of a continuing commitment to engage New Zealanders through *A Nation of Curious Minds: He Whenua Hihiri i te Mahara* ('the Plan'). 'The Plan' places emphasis on young people and science education, highlighting the importance of "science literacy" to enable students to "compete, both at home and internationally"; to upskill in order to secure "future economic development and wellbeing" and to produce "more science- and technology-competent learners, and more choosing STEM-related career pathways" (Ministry of Business Innovation & Employment, 2015, p. 62). This focus on young people and economic development embedded in Curious Minds initiative (and its Participatory Science Platform) neglects the adult and community focussed science communication and media engagement that science communicators, such as those in this study, might do to encourage public engagement with their research. It also demonstrates an explicit neoliberal ethos in the foundations of science investment and the (considerably smaller and separate) investment in public engagement with science in Aotearoa.

This neoliberal ethos is worth considering given multiple participants reported doing public engagement work while in precarious non-permanent working arrangements, or on 'soft money'. Soft money is used colloquially to signify a precarious working situation in which an academic role is fixed term and dependent on external funding. Workers hired on soft money will often only be hired for a fixed term, but some may persist so long as the person in that role, or doing that work, can find further external means to fund it. Hikuroa recalls doing meaningful, community focused public engagement on such a contract:

> The title was: Community Earth Systems Science Programmes Manager. It was very accurate. It meant I was working with communities on sort of earth systems scale problems, or challenges, or opportunities, and then trying to turn those things into research contracts, or teaching, or even contract work.

> As part of doing that role I was applying to government funds, I was applying to philanthropic [funders], I was hitting up iwi trusts for work.
>
> (Hikuroa, personal interview, 1 July 2019)

Reliance on soft money to fund public engagement work puts those doing such work in a precarious position, despite their apparent scientific authority. They have little job security if it is their main source of income and it creates an additional workload if they must pursue this work in addition to more secure work arrangements.

Participants also spoke of doing high-profile science communication in the mainstream media while fighting for a permanent position within their university; or how the work they do to imagine and implement innovative means of public engagement, beyond the dominant model of promoting science, must happen in addition to meeting the obligations of their 'actual' academic jobs. In-depth, public engagement that invites active public participation still occurs, but without dedicated and robust institutional support it is often the responsibility of individuals. That work, therefore, often relies on the enthusiasm and unpaid labour of the scientists and communicators who see its value and importance. As Hendy noted, these conditions can be harder on early-career researchers than those with established credibility and public profiles.

Motu operates independently of CRIs, CoREs and universities. As an independent organisation doing academic research, its researchers bring in funding on a project-to-project basis. Roberts describes how Motu maintains its independence and remains non-partisan with a commitment to open publishing:

> When we have a paper, even if [the funder] didn't like what we found we would still put out that paper. All of our contracts have that in it and I really like that independence and have come to find that that's actually really quite rare.

(Roberts, personal interview, 26 July 2019)

Roberts goes on to describe how this independence, and the publishing freedom that comes along with it, is not the norm for researchers and communicators in Aotearoa:

> Talking to other science communicators: there is a lot of having to make adjustments for what the funders want and need. Even in the CoREs and the National Science Challenges. And even in universities. We like to say that we're a university without the bureaucratic bullshit.
>
> (Roberts, personal interview, 26 July 2019)

Roberts noted that, when a government department commissions research from Motu, the amount of support they receive for public engagement efforts differs depending on how the relevant government Minister feels about the research. Roberts recounted an incident where a Minister "went completely ballistic" (Roberts, personal interview, 26 July 2019) when Motu released research commissioned by that Minister's department. In contrast, Sin's work on the gender wage gap (and subsequent engagement efforts) was well supported because the funder, the Ministry for Women, "was really keen to get the message out there and wanted to work with us on it" (Roberts, personal interview, 26 July 2019). While Motu's researchers retain independence, the reach and impact of that research is still somewhat dependent on the proclivity of those who control the money.

Whether a science communicator works at an independent organisation, a semi-independent CRI, or at a university, the necessity of funding encourages communication practices that align with funders' expectations. Given public engagement that tends towards partnership or co-production, as opposed to unilateral declaration or promotion, is often treated as supplementary to scientific research and dedicated funding is therefore scarce, science communicators will be incentivised to represent knowledge in ways that conform with funders' expectations for how that knowledge will be used. If the most significant impulse is towards the commercialisation

of scientific research, then it follows communication practices that enable commodification will more likely attract funding, thereby influencing the direction of public engagement with science in Aotearoa.

### *2.4 Social media and social networks*

Participants indicated they learn about public engagement and science communication through informal means, despite being professionally involved in that domain. Many noted they were exposed to new information on the subject through colleagues, peers, or family. Sometimes information came from colleagues studying public engagement with science, but most came from fellow practitioners of science communication, both inside and outside of science. Additionally, many participants pointed to social media—particularly Twitter and blogs disseminated there—as a source of informal learning. Dr. Dion O'Neale describes where they read about science communication and public engagement:

> People's blogs, people's little write ups, stuff that comes up through Twitter and through conversations. We've had this informal sort of salon style irregular meetup in Auckland—The Data Poet's Society—which is mostly an excuse for having the name. It's kind of getting people who are interested to come together and talk about data visualisation and using visualisation to communicate data and tell stories and all the rest of it.
>
> (O'Neale, personal interview, 5 July 2019)

This sentiment was echoed by others. Small informal groups of scientists with an interest in communication, chance encounters with colleagues, the occasional person of interest followed on Twitter (and blogs about communication shared through such networks) were their main source of knowledge. Engaging with academic literature on communication and public engagement happened sporadically, usually distilled through practical workshops from local organisations such as The Workshop or The Science Media Centre. Three participants had

completed the Science Media Centre's 'Science Media SAVVY' workshop which aims to develop confidence and media skills for researchers. Often participants engaged with the academic side of public engagement because an individual paper was specifically recommended by peers over social media. Social media, for some participants, was both a resource and an opportunity.

Hendy and Wiles are both active Twitter users and have been regular contributors to Sciblogs.co.nz, a local online hub for "scientists who want to reach out to a general audience" (*Sciblogs | About Us*, n.d.). These platforms allow them to publicise scientific information, weigh in on public discussions as both experts and science generalists, and add their expertise when other scientists may be silenced by institutional and political restrictions (Hendy, 2016). For Hendy social media presents an opportunity for a more democratic mode of science communication:

> Suddenly we had these other means of communication and other ways of connecting with journalists. It used to be the big professors who would have the hotline to the *[New Zealand] Herald* editorial and those kind of senior connections. Then there were people like Siouxsie who are connecting with journalists on Twitter right? And putting stuff up on blogs that's useful to journalists. There was this sort of new way of communicating—we were able to take the debate to social media, use blogging, and then that got on radio and that led to the book which got it on TV.
>
> (Hendy, personal interview, 1 July 2019)

For Wiles it is also a way to humanise the scientists behind research. Speaking about acknowledging values and bias in scientific contexts:

> We should be able to justify our existence and this is how I am on Twitter: I'm going to bring my whole-self to this so you can see what my life is like, who I am, why I think the way I do, and why I act the way I do.

(Wiles, personal interview, 24 July 2019)

They both recognise this approach makes some scientists, particularly those of older generations, uncomfortable. By making their expertise freely available through informal channels, these scientist-communicators disrupt the structures of control and authority that traditionally mediated which scientific information—and which experts—were made available to the media, and thereby the wider public.

## *2.5 Growing into science communication*

For many scientists, their transition from a career in scientific research to one including science communication resulted from a mixture of opportunity and self-improvement. Maybe a colleague was looking for someone with interesting stories to present at a Café Scientifique; maybe they were invited to talk to a government department about their general area of expertise. Whatever the reason, few scientists interviewed deliberately set out to become science communicators.

Hendy got their opportunity when Industrial Research Limited oscillated out of its restrictive approach to communications under a Chief Executive who was amenable to scientists appearing in the media:

> There was a period where things were opening up and our comms manager said: we've been asked if we've got anyone who could go talk about the Large Hadron Collider on Radio New Zealand. "Is it going to create a black hole and destroy the world?" was the interview pitch. So I had a 40-minute interview on Radio New Zealand Nights—the first live piece of media I had done. Then they invited me back as a regular after that. So that changed, suddenly having done that this kind of window opened up. This is something I enjoy; this is something I see as valuable; and those opporunities started opening for me, having sort of stepped over the threshold.
>
> (Hendy, personal interview, 1 July 2019)

After crossing that threshold Hendy made a concerted effort to make themselves available to comment for journalists: “there’s been, I suppose, a strategic element to what I am doing but also a little bit of opportunism” (Hendy, personal interview, 1 July 2019). This mirrors Wiles’ experience of becoming ‘talent’ for the media. By getting an opportunity to make a media appearance, proving to be capable, reliable, and useful to journalists, scientist-communicators can establish themselves as a resource and more opportunities will flow. This presents an opportunity for scientist-communicators to communicate outside their area of expertise—as representatives of science more broadly.

When living in the United Kingdom, Wiles would speak in schools about ethical use of animals in research as part of an outreach campaign that followed their winning the UK National Centre for the Replacement, Refinement & Reduction of Animals in Research (NC3Rs) inaugural ‘Three Rs’ award. After moving to Aotearoa, they looked to continue that work, but couldn’t find an organisation willing to fund similar outreach. They began looking for other opportunities to continue communicating:

> That really came when I met Peter Griffin from the Science Media Centre who said: we have SciBlogs, would you like to blog for us, we don’t really have anybody who is doing health research stuff. I was like: “I’ve never done this before it’s mostly been just talking.” But I thought it was a really cool opportunity to learn how to write better, like write more succinctly and just write for a different audience, because I’m really good at writing in the passive voice and that’s not very engaging. I thought that’s kind of like just a good opportunity. And then essentially everything just sort of exploded from there.
>
> (Wiles, personal interview, 24 July 2019)

Part of the opportunism here is accompanied by a desire to develop and diversify skills. For Wiles, blogging led to further opportunities in broadcast media. For Hendy it happened the other way around:

> I made a very deliberate attempt to start blogging. I'd been a blog reader. I don't think it had occurred to me that I would have anything interesting to blog on. I heard that the Science Media Centre was setting up SciBlogs and so I volunteered to be one of their first bloggers and that was kind of a strategic thing. I wanted to [link] the stuff I was saying through the broadcast media, I wanted to back that up with blogs. It was partly, you know to get better value out of the things I was doing. … Adding the writing, I guess, was a strategic choice. A lot of the broadcast stuff has just been opportunistic.
>
> (Hendy, personal interview, 1 July 2019)

The fact many participants gravitated toward science communication as their careers progressed is partly the result of participant selection. This research focuses on scientist-communicators, which generally involves being a scientist first and then developing skills and interest in public engagement along the way.

Roberts comes to science communication from the other direction. Science-curious but not science-trained, Roberts is a professional communicator who came to science communication after stints in the private sector:

> I've been at Motu since March 2015. It was here that I first heard that there was such a thing as science communication and realised: well, here are my people. The thing that interests me most about science communication is that I really like working with clever, passionate people; but I'm a generalist. I'm never going to sit down and do a PhD in one particular thing because my flypaper brain would go nuts. So, this is the perfect opportunity to just pick up bits and pieces and explain it.
>
> (Roberts, personal interview, 26 July 2019)

No participants set out to become science communicators, but each discovered it has value and importance along the way. For Hikuroa, public engagement is a responsibility inherent to scientific research:

> So when I was doing the PhD, even at that point I was very aware that, you know, effectively what I was doing—well, the science part of it—was being funded by the New Zealand taxpayer. I felt there was a yearning to learn how to communicate better as well as a responsiblity as a beneficiary of society that I should communicate my work.
>
> (Hikuroa, personal interview, 1 July 2019)

That many participants came to science communication obliquely may contribute to Salmon et al.'s (2017) observation that public engagement activities in Aotearoa have "generally developed based on 'what feels right' and personal or institutional motivations" (p. 62). That scientist-communicators "are neither informed by theory nor informing research in this field" (p. 62) makes sense given they are not trained science communicators with a history of study in that field. They are people with other expertise who have applied themselves to public engagement because they think it is important.

One recent book that influenced this network of scientist-communicators is *A Matter of Fact: Talking Truth in a Post-Truth World* (Berentson-Shaw, 2018)—it was recommended to me, independently and without prompting, by most participants interviewed. The book collates and summarises a variety of scientific literature about effective science communication, often focusing on psychological studies, into a broad discussion of challenges and potential solutions. It is "…a discussion on how we can get more traction on our evidence and science; on evidence-based ideas and how those engaged in communicating evidence can do so effectively and engagingly" (p. 18). The book argues people use a variety of mental shortcuts—including feelings, emotional and social experiences, as well as judgements of narrative or causal sense,

and assessments of a communicator's credibility—to reduce the cognitive load presented by new information (Berentson-Shaw, 2018). This book has influenced the thinking of many participants, particularly in relation to 'values', and the importance of narrative in public engagement with science. Throughout the following chapters I will refer to this book as an example of how participants interact with and interpret literature on public engagement. Some participants reproduced ideas from this book in our interviews, often framing them as useful tools for effectively communicating complexity, risk, or uncertainty.

The participants in this research operate in a variety of contexts, but they are all situated in a system of public science funding defined by a neoliberal turn in the early 1990s. This system is competitive and more concerned with the commercial application of scientific knowledge than public utility. Within this context each participant has come to work as a communicator of science in their own way, but most continue to develop their skills and interact with public engagement theory through small, informal networks across social media and professional organisations. Where Wiles and Hendy have established profiles in the mainstream media as generalist scientific experts, others, such as O'Neale and Sin, engage with the public about their specific area of expertise—giving talks to enthusiasts at a Café Scientifique, being invited to speak to government departments, or keeping stakeholders informed as part of general research practice. Roberts, primarily a science communicator, produces communication materials for the researchers at Motu, but is also involved in the Science Communicators Association of New Zealand (SCANZ). Hikuroa has a slightly different focus from the others in that their work with mātauranga is often directed at scientists—encouraging them to broaden their definitions of what constitutes reliable knowledge. It is with this range of expertise, and situated within these contexts, that these public representatives of science construct complexity, risk, and uncertainty for publics.

# Section II: Results

## Chapter #3 Constructing complexity, risk, and uncertainty

The science communication career of Professor Shaun Hendy, winner of the Prime Minister's Science Media Communication Prize and Callaghan Medal for outstanding contributions to science communication, had modest beginnings: as a PhD student, debating climate change deniers on Usenet.[4] Speaking about their first exposure to STS literature and, in particular, theories about the social construction of scientific knowledge, Hendy said:

> [T]his was being flicked back at me that, actually, well your science is just a social construct, and how can you predict the future it is just ridiculous. There's no way you can be certain about climate change. That was my entry into that. I think that is often how scientists are confronted with [STS/PUS literature]: as a tool for undermining authority, and so our reaction is quite defensive. My particular reaction was to start reading about it, find something they got wrong and then go "aha!" … Classic confirmation bias, right?
>
> (Hendy, personal interview, 5 July 2019)

This quote encapsulates some common themes from interviews with participants: an uneasy relationship with literature that describes scientific knowledge as socially constructed, a concern for maintaining scientific authority that may manifest in defensiveness, and a suggestion that maybe their contemporary understanding of the social dimensions of science

[4] Usenet is a precursor to contemporary internet forums, allowing users to read and post messages in threaded discussions online.

has developed beyond that initial, defensive, reaction. These themes will each be explored in more detail in the coming chapters. This chapter will focus on the ways participants conceive of and construct complexity, risk, and uncertainty; what factors participants consider when deciding how to construct such things in public, and how they conceive of the publics they engage with throughout this process of construction.

Uncertainty was the most extensively discussed topic among participants and was often presented as a definitive and integral part of science generally. Dr Hikuroa, for example, framed uncertainty by "recognising, of course, that science is not about certainty; science is about reducing uncertainty" (Hikuroa, personal interview, 1 July 2019). Dr O'Neale echoed that sentiment "there is always uncertainty in everything we measure but uncertainty doesn't invalidate what has been observed" (O'Neale, personal interview, 5 July 2019). Some participants, such as Associate Professor Wiles, discussed uncertainty as part of the process of doing science—sometimes research has desirable outcomes that may not eventuate. Speaking about their research to discover new compounds with antibiotic properties, they said:

> [The significant] uncertainty is whether this is going to work. We know now that we have identified some things that have never been seen by science before. The uncertainty is we still don't know if they are actually going to make good drugs. The uncertainty is that they might not work… that's most of the uncertianty: whether we've been doing all this stuff and nothing will come out of it.
>
> (Wiles, personal interview, 24 July 2019)

In this chapter, after exploring participants' perspectives on complexity and risk I examine a significant theme that emerged from participants' discussions about scientific uncertainty: uncertainty can encourage or discourage audiences to act. This influences how scientist-communicators represent uncertainty publicly, depending on the actions they wish their

audiences to take. This demonstrates that participants are cognisant of the ethical and moral decisions they make when constructing science in public. These decisions are a means by which science communicators can make transparent, or obscure, elements of scientific knowledge production based on their assessment of potential audience responses. Such decisions can either reinforce the elements of privilege, authority, and presumed control criticised by PES scholars as characteristic of science/society relationships, or resist those tendencies in service of building something new.

### *3.1 Constructing complexity and risk*

Participants responded to questions about complexity and risk succinctly, often with little elaboration. Among the participants in this research, complexity was largely conceived of in terms of the scientific paradigm of complex systems, or as a synonym for the technical intricacy of scientific research. Hendy makes the distinction between the two positions: "I don't think my research is complex as such, but I'm studying things that are complex" (Hendy, personal interview, 5 July 2019). For both Hendy and O'Neale 'complexity' is largely synonymous with complex systems: "Coming from a maths background I like the sort of the traditional complex systems thing" (O'Neale, personal interview, 5 July 2019). Hendy presents complex systems, both in their work as a physicist and as a research focus for Te Pūnaha Matatini, as a means for simplifying complicated phenomena:

> I like to build simple models. One aspect of a complex system is that you've got many entities interacting in some way. Those elements could be people, they could be atoms, they could be animals or companies. [In physics] I'd be doing computer simulations of atoms interacting through various forces and then I'd be trying to come up with simple models to explain what was going on. … A simulation is just a simulation: it's one realisation of a particular system. Really to generalise, to gain an understanding and to make

> predictions about something that you have learned from a simulation you need some kind of simplifying model.
>
> (Hendy, personal interview, 5 July 2019)

The simplification described here is descriptive; seeking to build a generalised model of a given phenomenon to predict how it will behave. It takes mathematical principles often used to describe physical phenomena, such as the behaviour of atoms, and applies them to the social world to, for example, model pedestrian behaviour. Hendy's interest in using complex systems in this manner first arose when a lunchtime conversation inspired them to apply mathematical techniques from material science to a patent database. "That was kind of a real 'ah ha!' moment. Some of the techniques I might use to understand a complex system in the atomic world might actually be useful for understanding businesses or people" (Hendy, personal interview, 5 July 2019).

For Sin there is a technical component to complexity. Sin describes their work as complex because they use the Integrated Data Infrastructure (IDI)—an agglomeration of de-identified data collated from various public services and held by Statistics New Zealand. This means their data sources are never 'clean' as they were never conceived of as a single data set. The data is often incomplete and rarely describes exactly what researchers are looking for, meaning they have to make inferences from the available data. This layer of technical abstraction and intricacy complicates the already complex economic activity that Sin researches. Sin speaks about the economy as a complex system in similar terms to those used Hendy and O'Neale, but considers the research process itself to be complex as well:

> I guess I think of the economy itself as a complex system. You've got all these actors with different incentives acting in various ways with imperfect knowledge and bumping into each other and somehow economic activity

> happens from this. So we're dealing with this really complex system and the data is sort of coming from all these different places in it.
>
> (Sin, personal interview, 26 June 2019)

As the communications director for Motu, Roberts is responsible for representing this complexity to various audiences. For them the technical complexity of economic research—the toolbox of methods, regressions and formulae econometricians use to transform raw data into knowledge about the economy—is, echoing the words of Latour and Woolgar (1979/2013), an impenetrable 'black box' to many. This can be a barrier to effective communication:

> It is very difficult to explain: "here is a black box and you put some things into it and out will pop options". People don't understand how that happens, so I am trying to tell the story of what happens in that black box without actually going through every equation.
>
> (Roberts, personal interview, 26 July 2019)

They describe producing two-to-four-page executive summaries (for busy policy professionals) or media articles (for a wider audience) as distillation and simplification; a process of summary throughout which they are guided by their own lack of economic expertise:

> The decisions that I go through are basically: I am not an economist, I also do not have an economics brain at all. Most economic theory seems crazy to me, which is very useful and I hold on to that. You know, I have had various textbooks recommended to me and I have never read any of them.
>
> (Roberts, personal interview, 26 July 2019)

This process involves trying to understand and describe the research in their own words first, and then negotiating accuracy with the economic experts.

The technical and systemic complexity described by Sin, combined with the process of simplification and distillation performed by Roberts, produces a level of epistemic

complexity—complexity about what is and is not known. Sin describes a complex dynamic between research and data availability not apparent in simplified external representations:

> We almost never measure exactly what we want to measure… That is one of the major tricks of this sort of research—how do we find out about the things we care about based on the data that exists? Generally, you are figuring out how to wrangle things that have been collected for some other purpose.
>
> (Sin, personal interview, 26 June 2019)

These specific constraints and complexities of data sources, and any uncertainties they may produce, are to an extent made invisible when presented with authority in external representations. On a small scale, this reflects the process of obscuring local contingencies and contexts by which science constructs epistemic authority (see Jasanoff & Wynne, 1998; Zehr, 2012).

Dr Dan Hikuroa speaks of complexity differently. For them, the complexity of their work is that they are trying to weave together two systems of knowledge which is "not always technically a complex process" (Hikuroa, personal interview, 1 July 2019) but may be socially complex as it proves a challenging topic for scientists:

> I wouldn't say what I am doing is complex as a physicist might describe complexity, or a mathematician might describe complexity, or an economist might describe complexity, but nevertheless what I do is to demonstrate to my fellow researchers that, for example, we all have a worldview. And the reason they've never thought about it is because their worldview is more or less the dominant worldview. The default worldview. The one that is so ubiquitous that it becomes invisible. It's not until you're exposed to other ways of knowing and being that you recognise 'Oh gosh, actually I do have a worldview.' To me that is the complexity of the work I do.
>
> (Hikuroa, personal interview, 1 July 2019)

This is a different conception of complexity from that expressed by the other scientists interviewed. It seems, at least partly, to arise from Hikuroa's unique positioning: they are an expert introducing mātauranga, often excluded from western definitions of science, to an audience of scientists. For scientists, this may be a challenging inversion of their usual position of epistemic privilege. The complexity here is less about the knowledge itself, and more the social power dynamics at play.

When asked how risk manifests in their work, many participants discussed the risks they face personally, for example the risk their research might be misinterpreted, or the risk that their experiments do not produce useful results. Sin represented risk in terms of economic actors and decision theory: "Risk is used in terms of people's economic decision making. Do I prefer this certain outcome, or do I prefer taking this risky gamble?" (Sin, personal interview, 26 June 2019). They did not discuss risk as a concept to be communicated to publics. Hendy, Hikuroa, and Wiles each talked about communicating risk to audiences, their descriptions often entwined with discussions of uncertainty. The concepts are closely related: the divergent conceptions of risk presented by Fischhoff and Kadvany (2011) and Beck (1986/1992) each acknowledge uncertainty as an inherent aspect of risk. Hikuroa's descriptions of risk refer to cultural narratives that inform decision making under uncertain conditions and are therefore discussed below under 'Constructing uncertainty to (dis)incentivise action' (section 3.2). Hendy's descriptions of risk focus on interviews conducted with scientists after the 2011 Christchurch earthquake and are examined below under ethical and moral decision making (section 3.3).

Wiles discussed communicating about risk of infection in both their research into antibiotic resistance, and menstrual cup safety. They constructed risk very differently in each scenario. The menstrual cup research is at an early stage of development and is therefore currently focused on finding inclusive ways to generate useful research questions. Their risk

communication in this scenario is limited to detailing what experts do not know: “what I’m trying to communicate is just that we don't know anything [about the potential health risks of menstrual cup use] and how might we learn those things?” (Wiles, personal interview, 24 July 2019). In this situation, Wiles is explicit about scientific ignorance instead of excluding ‘unknown unknowns’ from consideration as a valid component of risk. This avoids presenting the scientific definition of risk as a certainty, thereby marginalising non-expert definitions (as discussed by Wynne, 2001).

In contrast, Wiles represents risk as absolute with respect to their work on antibiotic resistance:

> I’m trying to convey to people that this is something you can’t ignore. Most people will have had an infection and taken antibiotics. So, to be able to communicate to somebody: these organisms, you have had them, you have taken antibiotics. What happens when those antibiotics don’t work? Because that is what is going to happen, right? So your risk of getting an infection is 100% it’s just what it is and how serious it is that we don’t know.
>
> (Wiles, personal interview, 24 July 2019)

Wiles frames the risk of infection as a ‘not if but when’ proposition. This shifts emphasis from the probability of infection to qualified factors such as type and severity of infection. In the process uncertainty is displaced from scientific assessment of risk (which is assumed to be certain) to the hypothetical experience of being infected. This displacement constructs infection as a certainty, which Wiles uses to encourage people to reflect on when they last used antibiotics, and what might have happened had those antibiotics been ineffective because they encountered an antibiotic-resistant superbug. This is analogous to the displacement of uncertainty described by Shackley and Wynne (1996): the scientific capacity to predict infection goes unquestioned; instead there is uncertainty about how individuals will respond to the risk of infection. Wiles uses this constructed certainty to encourage action: “The people I

speak to are mostly older people who are starting to need hips and stuff replacing and it's like: 'get them done now!'" (Wiles, personal interview, 24 July 2019).

### *3.2 Constructing uncertainty to (dis)incentivise action*

Sin noted that if they had been worried their research might cause harm "uncertainty would have been [centred]" in their public representation of their research (Sin, personal interview, 26 June 2019). A common consideration among participants, reflected in this quote, is that representations of uncertainty can have consequences: they can incentivise (or disincentivise) audiences to take certain actions. Emphasising uncertainty might discourage an audience from taking action in favour of a cautious approach. For example, one might emphasise a high degree of scientific uncertainty to discourage policy makers from prematurely committing investment to a solution that may prove ineffective. Conversely, eliminating uncertainty from representations of science has the potential to encourage, even to demand, action as a necessity. Hendy took this into account when embarking on their #NoFly year:

> … part of it was actually to demonstrate the strength of my belief in climate change. By not flying I am downplaying the uncertainty in climate change—I really think that this is on its way, the evidence has convinced me, I no longer think there is uncertainty, I think it's going to be a big problem. The uncertainty is almost completely cut out of how I'm communicating about climate change by doing that communication through action.
>
> (Hendy, personal interview, 5 July 2019)

Hendy, by demonstrating a commitment to action based on scientific evidence, also demonstrates their confidence in that evidence. This minimises the visibility of scientific uncertainties to a potential audience, and simultaneously exemplifies a desirable response—in this case avoiding air-travel or, more generally, acting to reduce greenhouse gas emissions consistent with the scientific evidence on climate change.

Hendy goes on to discuss how this projection of certainty and trust in scientific evidence was done with a particular audience in mind:

> There are people that perhaps have a reasonable trust in science or are somewhere towards the middle but who maybe aren't sure about whether we need to act or not: how clear is it? Is this really coming? How sure are the scientists that this is happening? That was the group of people, kind of on the sceptical side of things [for whom] I felt I could move the needle slightly.
>
> (Hendy, personal interview, 5 July 2019)

Hendy is targeting a persuadable audience: those who may accept scientific evidence but require a strong expression of confidence to act on it. By minimising uncertainty, scientist-communicators can 'move the needle' for those who are on the 'skeptical side of things'. In addition, these projections of certainty serve to protect against audiences who would exploit perceived uncertainties to fuel counter-narratives:

> Those [uncertainties] have been magnified by the climate change denial community—some of whom are scientists, a lot are not. That climate change denial group have very much understood the link between uncertainty and action so they have massively played up the uncertainty in climate science to undermine the possibility of action.
>
> (Hendy, personal interview, 5 July 2019)

Particularly in the context of climate change communication, scientific evidence is used to emphasise the reality of climate change as an issue requiring action. Doing so can serve to encourage specific individual actions—such as minimising flying—or more generally to build awareness and consciousness that might translate into political will for mitigatory action. Uncertainty is deployed strategically here; its construction changing depending how a communicator wishes their audience to behave in response or based on who they believe they are communicating to. It is advantageous, from this perspective, to minimise public visibility

of scientific uncertainty. Doing so limits a potentially hostile audience's access to information they can use to undermine scientific authority and simultaneously makes a convincing case, to those who may have previously been unconvinced, that action on climate change is necessary. The priority is to convince people to accept evidence, or to act on evidence, but not necessarily to understand that evidence, uncertainties and all.

This bears similarities to Gustaffson's (2017) observation that scientific actors acknowledge complexity and uncertainty inherent to scientific evidence, but de-emphasise it—configuring it, instead, as contributing to a broader narrative, but immaterial to the credibility of that narrative. As Gustaffson says:

> Uncertainty is relegated to the backstage practices in the scientific sphere, while conservation and policy work is based on what is known, which is presented to be enough to recognize that there is a problem in the case of the monarch that needs to be addressed and acted on… When uncertainty becomes known, these unknowns will not substantially change the general understanding…
>
> (Gustafsson, 2017)

Gustaffson is describing boundary work whereby scientists claim autonomy over uncertainties, presenting them as something to be managed within professional scientific circles. This rhetorically reinforces the broader narrative (that action is required to address issues they have described) as reliable. Hendy does similar work with the science of climate change, relegating uncertainty to the scientific domain in order to support the collective narrative that mitigation is urgently necessary. This also avoids provoking a counter-narrative from the 'climate change denial community' who seek to discourage mitigatory action.

According to Hendy, this relationship between uncertainty and action creates an ethical dilemma for scientists and particularly scientist-communicators. They point out that,

historically, discussions about climate change have been influenced by economic arguments that mitigation is only possible when it is known where the costs of climate change will fall. These arguments are often accompanied by the assertion that we are too uncertain about the costs, and therefore cannot act. For Hendy:

> …this is kind of an ethical trap for scientists right because now anything you say about uncertainty is tied to action and that adds ethical dimensions to even very simple statements about uncertainty. You've got to then weigh up well does this mean we're gonna act now? I think for a lot of scientists that has meant that they have focused on worst case scenarios. They have perhaps chosen to downplay the uncertainty.
>
> (Hendy, personal interview, 5 July 2019)

Hendy connects their tendency to downplay uncertainty with personal values:

> My personal belief is that we should be acting, we should be doing more than we have. But I also recognise that that is a moral and ethical choice. It reflects my values and there are a number of scientists that have very, very different views and that has led to some really strong and quite bitter debates within the science community.
>
> (Hendy, personal interview, 5 July 2019)

Here the choice about how to represent uncertainty is constructed as personal rather than scientific. The public representation of scientific knowledge is thereby differentiated from the knowledge itself: the knowledge is scientific, the manner of representation a subjective choice. For scientists, representations of uncertainty can influence action and action requires ethical and moral consideration. This means that representations of uncertainty will, in part, be contingent on what a scientist or communicator perceives as the societal role of the scientist. Is it to be a dispassionate arbiter of knowledge, as advocated by Roger Pielke (2007)? Or is it to encourage change based on that knowledge?

Hikuroa, speaking about mātauranga Māori encoded in pūrākau [5] demonstrates how the connections between uncertainty and action can also be used to enable decision making about risk. Hikuroa points to a pūrākau warning of a taniwha, living in a stream near Matata, whose tail would flick back and forth:

> So, in that way the knowledge of the taniwha—acting because you knew about the taniwha—it acted as your kaitiaki. It kept you safe. To me that was a fascinating idea. It's both a risk management strategy and… I'd never really thought about this in terms of uncertainty. I suppose if I thought about my natural hazards training, what are the things you need to know? What's the hazard? How big is it? How often does it happen? The knowledge of the taniwha, of the lizard, tells us what [the danger] is; tells us the magnitude; but it doesn't tell us when it's going to happen. So that is a level of uncertainty there, but that isn't super important if you have nothing to be impacted—if you build out of harm's way.
>
> (Hikuroa, personal interview, 1 July 2019)

This is an example where acknowledging the uncertainty of knowledge and enabling people to judge uncertainty for themselves, instead of limiting its exposure to expert consideration, allows an audience to make an informed decision about how to act. It presents an alternative to minimising representations of uncertainty and demonstrates potential disadvantages of doing so. Projecting certainty to those who might not accept scientific evidence must be balanced against excluding other audiences from accessing uncertainty where it may have utility in decision making, particularly with respect to risk. Unfortunately for the people of Matata, badly

[5] Pūrākau are 'a traditional form of Māori narrative, containing philosophical thought, epistemological constructs, cultural codes and world views,' and 'deliberate constructs employed to encapsulate and condense [knowledge] into easily understood forms' (Hikuroa, 2017b).

damaged by flooding and debris in 2005, the people who decided where houses could be built "were not familiar with these taniwha" (Hikuroa, personal interview, 1 July 2019).

### *3.3 Ethical and moral decision making*

A theme running through the previous discussion of uncertainty is that, if constructions of uncertainty or risk can influence whether people act, scientist-communicators must make conscious ethical and moral decisions about how those discourses are constructed. Many participants made decisions about how to represent complexity, risk, and uncertainty, informed by their personal systems of belief and not strictly as dispassionate scientific experts.

According to Hendy, the way scientists communicated about risk following the 2010 and 2011 Christchurch earthquakes has significantly influenced science communication in Aotearoa. After the magnitude 6.3 quake on 22 February 2011, according to Hendy, seismologists had to think hard about how to present aftershock forecasts and the associated risks to the residents of Christchurch. In the end they hesitated:

> There is a moral calculus in deciding how you are going to talk about particular types of risk. If we kind of downplay the risks of aftershock forecasts, then people are going to go into buildings that they shouldn't and an aftershock is going to come along and people are going to die. So that's the one hand, so if you undercook the risks people are going to put their lives at risk based on that information. On the other hand if we overcook them—if we really, really want people to be cautious and not expose themselves to damaged buildings—then the insurance industry is going to collapse, because people are going to pull their money out of the insurance companies. [The seismologists] were weighing these two things up in their minds and in that situation their decision was to not do anything; was to not prioritise that communication.
>
> (Hendy, personal interview, 5 July 2019)

It seems evident that scientist-communicators must make decisions about how to represent scientific risk and uncertainty in public; decisions that require judgment about social, economic and political information, and cannot be made based strictly on scientific expertise. As Beck (1986/1992) points out this puts scientific experts and communicators in a position of power: they are in the privileged position of being able to perceive the scientific dimensions of these risks, and thereby define and represent them. Beck argues this epistemic privilege allows scientists to impose social expectations and assumptions unchallenged, but, as Hendy illustrates, it can create a moral calculus that results in paralysis. In this situation, the seismology community eventually, after much discussion and effort, pushed through that paralysis by adopting more transparent practices: "They're much more about just putting the information out there and trying to talk people through it without doing that calculus in their heads before doing it. They are not self-censoring as much anymore" (Hendy, personal interview, 5 July 2019)[6].

The understanding that communicating about uncertainty and risk has an ethical or moral dimension is mirrored by Sin when they ask: "if policymakers act on this information that I am providing without taking in all the caveats is there a chance this could make things worse?" (Sin, personal interview, 26 June 2019). Similarly, Roberts says they "only tend to [include] stuff where we've found high significance" in media releases, because they work with "extremely data and detail focused people" who "wouldn't let a media release out that they thought was going to [get] confused" (Roberts, personal interview, 26 July 2019). Together, these examples suggest some participants tend to respond to the moral and ethical dilemmas by attempting to limit public exposure to uncertainty and risk. This is an example of science

[6] For a more detailed description of this process see *Silencing Science* (Hendy, 2016)

communicators constructing a boundary between scientists and publics: empowering scientists to contend with uncertainty and risk where non-scientists are excluded from doing so.

Part of Hendy's goal as director of Te Pūnaha Matatini is for the organisation to set themselves apart from the traditional cultural norms of science by more explicitly engaging with ethical and moral dimensions of science and science communication:

> I think that scientists must be much more engaged with the ethics around communication and most scientists don't go there. If you ask most scientists they will say 'well, it's not for me to make an ethical judgement.' I'm generalising a lot. I hope you won't find this a lot in Te Pūnaha Matatini because I think we're a selecting bunch of people that actually are much more explicit about our values and do put ourselves in positions where we are making these choices explicitly.
>
> (Hendy, personal interview, 5 July 2019)

Hendy acknowledges that avoiding an ethical judgement under the pretence of remaining scientifically detached is, in effect, "an ethical choice in itself, but it is also a very simple and easy choice to not think too hard about" (Hendy, personal interview, 5 July 2019). The scientific norm, according to Hendy, is to avoid engaging with the ethics of communicating about risk and uncertainty, in doing so making an implicit ethical decision. Such a decision may keep discussion of uncertainty and risk within the bounds of scientific practice, privileging scientists over publics when it comes to decision making. By minimising the public exposure of uncertainty and risk to avoid making ethical and moral decisions about social consequences (as seismologists did immediately following the 2011 Christchurch quake) scientists make an implicit ethical decision that maintains their authority over definitions and disclosure of relevant uncertainty and risk.

The dominant cultural norms and assumptions of science discussed here—that scientists should avoid engaging with the ethical issues of communication (as described by Hendy), and scientific knowledge must maintain public confidence in both its predictive ability and potential to exert control over natural phenomena (Wynne, 2005)—both exert influence over scientist-communicators. This is the culture of the systems in which scientist-communicators are embedded. Such influence, exemplified by Sin, Roberts, and the immediate response to the Christchurch earthquake, encourages restrictive representations of complexity, risk, and uncertainty by default. As Wynne (2001, 2005) suggests, if scientists mistakenly assume that typical publics expect certainty from science then "science as public knowledge is obliged to delete any open reference to unpredictability and unknowns" (2005, p. 71). This maintains scientific authority, reinforces a culture that assumes it has capacity to exert control, and potentially alienates publics. It is not, however, the only way complexity, uncertainty and risk are represented.

The seismologists' response to the Christchurch earthquakes eventually moved towards transparency of information, and Te Pūnaha Matatini looks to explicitly engage with the ethical and moral dimensions of science communication. By explicitly and visibly engaging in moral and ethical decision making—abandoning a rhetorical commitment to scientific norms of disinterest and objectivity—there is potential to construct complexity, risk and uncertainty in ways that enable, rather than restrict, access; allowing the boundary between science and publics to become more porous. Such constructions challenge dominant assumptions and expectations of scientific culture. By constructing science in public, science communicators might also exert influence over the culture of science itself—influence flows both ways.

### *3.4 A reductionist influence*

As scientist-communicators are embedded in and influenced by the culture of science, it is worth noting here that some participants expressed concerns about an increasing reductionist influence on scientific research. Wiles describes the dominant scientific approach in their discipline as the 'hypothesis driven reductionist approach' (Wiles, personal interview, 24 July 2019). This approach is iterative and highly technical, focusing on fundamental, low level phenomena; advancing disciplinary knowledge without, necessarily, a focus on direct application. It resembles Jasanoff & Wynne's (1998) description of scientific positivism. Specifically, it derives certainty from the fact it is based on the strict observation of natural phenomena, and it assumes the advancement of science itself can produce societal development. Speaking about their own solution-focused 'fishing expedition' approach to finding new antibiotic compounds, Wiles notes:

> The thing I find a bit bonkers is that the work that everyone else gets funded to do, is the way no antibiotics have been discovered. It's the more 'I want to know how this thing binds to that thing and then we could potentially exploit that as a drug.' That is the stuff that gets funded and it has never, ever made a good drug for bacterial infections.
>
> (Wiles, personal interview, 24 July 2019)

For Wiles, a reductionist approach to science sacrifices societal benefit and issue-focused thinking in favour of a technocentric desire to be at the cutting edge of scientific thought. Wiles feels their proven method of drug discovery is overlooked because it does not push new or exciting theoretical boundaries and it is therefore less fundamentally interesting, even if it may lead to practical results. Wiles comments that their research, a proven method for finding antibiotic compounds with which to produce new drugs, is characterised as "what [scientist] did in the forties, fifties, sixties, so it's not [thought of as] exciting, interesting science. What

we need are drugs that will kill the bugs that kill people … I find that [attitude] very frustrating" (Wiles, personal interview, 24 July 2019). That frustration pushed Wiles into crowdfunding their antibiotic discovery research which, as discussed later, significantly transforms the way they think about public engagement.

Wiles saw the reductionist approach to science as limiting practical research focussed on material outcomes. They turned to alternative funding mechanisms because their research does not conform to the reductionist paradigm. This recalls Wynne's observation that an intensifying commercial influence on science may lead to a reduction in complex representations of science because that which is presented as predictable and controllable is "potentially exploitable" (2005, p. 78). Those funding scientific work, whether governments or private companies, are, to an extent, buying scientific knowledge on the assumption it will provide certainty or control—on the assumption they can use it to achieve a particular outcome. This perception of certainty can be achieved through a reductionist approach to science which removes complexity from public representations (Wynne, 2005), through the transformation of uncertainty into something tractable and manageable by existing governmental institutions (Shackley & Wynne, 1996), or by relying on reductive and technical (and thereby predictable/controllable) assessments of risk (Wynne, 2001). By presenting their work as such, scientists potentially make themselves more attractive by conforming to the expectations of those who decide how funding is distributed.

The commercial incentive may encourage conservative representations of complexity, risk, and uncertainty—thereby protecting financial and property interests—but it also encourages a specific flavour of scientific thought. This reductionist technoscientific approach can order the relationship between science and publics such that authority over complexity, uncertainty, and risk remains in the scientific domain, rarely exposed to public scrutiny. Because scientist-

communicators are embedded in the institutional funding structures of science, they too are subject to the cultures and behaviours encouraged by funding practices. If the thrust of funding pushes scientific knowledge production to serve commercial interests, then a similar force may influence science communication practice.

# Chapter #4 Defensiveness: constructing publics

The focus of this chapter is a theme that emerged strongly across all interviews: defensiveness. This frequently influenced the way participants represented complexity, risk, and uncertainty. These scientist-communicators pay significant attention to the fragments of (real and imagined) publics who will misunderstand, dismiss, or actively misrepresent their representations of complexity, risk, and uncertainty. While they do not believe the majority of their audience is antagonistic, they do pay significant attention to the ways in which publics may be predisposed to misinterpret their messages. It is, of course, necessary to consider the ways in which one might be misunderstood when trying to communicate expert information accurately. The distinction to explore here, however, is how public engagement—and in particular constructions of complexity, risk, and uncertainty—might be affected when a dominant concern of the communicator is avoiding misuse and misinterpretation of their message, as opposed to encouraging understanding.

## *4.1 Misinterpretation*

Participants each anticipated the ways in which they might be misinterpreted, and this influenced their choices about how to represent scientific information. They were conscious of the ways in which the public might be deficient in their understanding of complexity, uncertainty, and risk in scientific contexts; and in their understanding of the scientific method more generally. The specific deficiency of understanding assumed by scientist-communicators varies by audience, but the anxiety about misinterpretation persists regardless. This encourages a conservative approach when deciding which research is exposed to public scrutiny and the construction of a façade of scientific certainty that does not accurately represent the state of scientific knowledge.

Dr Sin often presents their research findings to government and policy audiences, such as the Ministry for Business and Innovation (MBIE), and tailors the representation of complexity and uncertainty to suit that audience. Presenting the results of "What Drives the Gender Wage Gap?" (Sin et al., 2017), Sin made it clear that the results had a substantial 'error band' around them. The actual gap in pay between genders could be smaller or larger than the figure presented. They highlighted that the important takeaway for their audience, irrespective of the margin of error, was that they could confidently exclude the possibility that men and women were paid equally for performing the same work. They quantified the uncertainty involved as a way of emphasising which conclusions should be properly excluded:

> It's more about thinking what do I want them to take away from it? What do I need to be careful of them falsely concluding? And then trying to help them to not falsely draw that conclusion. Then, partly, what do I want them to confidently say that this research was saying.
>
> (Sin, personal interview, 26 June 2019)

This anticipates misinterpretation as a response from the audience and makes defending against it a priority—ensuring the audience has a confident grasp of the key conclusions is secondary.

Sin's focus on misinterpretation is motivated by concern over potentially damaging consequences: "How badly could things go if people misinterpreted what I'm saying, or didn't pay sufficient attention?" When presenting the results Sin felt uncertainty need not be a central concern in their engagement activities because results were in line with the general understanding that women are not paid as much as men. If, however, the results had been less conclusive (or inverted) then the potential for damage would be much higher: a respected expert presenting counter-evidence could jeopardise attempts to address pay disparity. If incorrect, such claims would entrench the conditions that already disadvantage women. In this hypothetical situation Sin felt it would be beneficial to emphasise uncertainties:

> I didn't talk about the uncertainty as much as I might have if I'd been really worried that I was going to cause damage. In that case the uncertainty would have been [centered] … but in this case I guess I was confident enough to give the caveats but not excessively hammer them.
>
> (Sin, personal interview, 26 June 2019)

Uncertainty here is emphasised (or not) depending on the communicator's confidence in the results, but also the potential consequences of the audience misinterpreting the research. Sin also suggests they would emphasise uncertainty where their results contravened scientific agreement in ways that might lead to harm.

Misinterpretation was also a concern for Roberts who, in their capacity as Communications Director at Motu, helped coordinate and prepare engagement activities for Sin's research. Roberts suggested that, when writing media releases, Motu prioritises research projects that have clear and unambiguous results:

> I only tend to do stuff where we've found high significance, well, depending on what it is. Honestly, where it's something that, you know, the big meaty issue is over here and we sort of half found this and half found this, I tend to ignore that because it will get confused.
>
> (Roberts, personal interview, 26 July 2019)

This suggests that, for these participants, research with ambiguous results, or indeed research that produces complex results for complex or controversial issues, is deprioritised for public engagement. Such research may receive less public exposure or be communicated to expert, rather than non-expert, audiences. Roberts says media releases from Motu are tightly focused on results because they cannot assume a more non-expert audience has a sufficient understanding of the scientific process: "I don't think I can assume that people understand that we have a hypothesis and work through it" (Roberts, personal interview, 26 July 2019). The

public imagined here has a deficient understanding of the scientific research process, making them predisposed to misinterpreting uncertainty or complex information:

> [My colleagues] wouldn't let a media release out that they thought was going to be confused … any time something is confused I have to jump right on it. I am extremely careful not to put anything [out] there, because it would distress them.
>
> (Roberts, personal interview, 26 July 2019)

The potential consequence of this approach is that only research with both high confidence and unambiguous results is exposed to the public; restricting any acknowledgement of nuance and ambiguity to experts and erecting a public facing façade of certainty that does not accurately reflect scientific knowledge. This is analogous to critiques levelled by the PES literature that public representations of scientific knowledge can exclude unknown-unknowns, thereby projecting certainty which can appear disingenuous and alienate publics (Wynne, 2001); or, do not accurately reflect that the scientific claim to truth is contingent upon the contextual technical, social and political conditions within which knowledge is generated. These contexts are stripped away in service of a greater perception of certainty (Zehr, 2012). Scientist-communicators anticipate that they may be misinterpreted and this, potentially, has a chilling effect on public engagement, encouraging a defensive approach to exposing complex or uncertain information to public scrutiny.

### *4.2 Dismissing evidence: values, perceptions and subjectivities*

Defensiveness also manifested in the way participants discussed the influence of audience values on their science communication. Quantitative research has shown the uptake of scientific information, irrespective of its apparent neutrality or impartiality, is interpreted via personal values held by an audience (see Kahan, 2010). This is emphasised in *A Matter of Fact: Talking Truth in a Post-Truth World* (Berentson-Shaw, 2018)—a text read and recommended

by many participants. Participants were not, however, specific about the values their audiences held. Participants took the social science concept of values and subsumed it into a science-centric perspective, distorting it such that it became a stand in for subjectivity generally. Values were not discussed as the product of discursive, social, or political contexts. Rather 'values' were often presented as a nebulous, ill-defined thing *out there*; something inherent and innate to people and publics, applied *to* scientific knowledge after it is produced and communicated: a personal filter through which knowledge must pass before being accepted, but not an inherent part of scientific knowledge production or communication.

Sin provides the clearest explanation of how audience values were conceptualised by some participants and their colleagues:

> The people who were talking about [What Drives the Gender Wage Gap?] sort of liked my message and so they were willing to take on the research. Usually when I talk about research to non-technical audiences I find there are two sorts of people: one is the people who like what you are saying and they'll agree with it no matter how you got there, and one is people who don't like what you are saying and will disagree with it no matter how you got there. It's not about evaluating how you got there it's just about: do I like what they are saying and therefore believe it or do I dislike it and therefore disbelieve it.
>
> (Sin, personal interview, 26 June 2019)

From this perspective, members of an audience bring pre-existing beliefs to scientific information that predispose them to either accept or reject their findings outright. In such a scenario the communicator must anticipate resistance or dismissal from segments of their audience no matter how articulately or carefully they communicate. The concept of 'values' is linked with an inability to comprehend the facts. It is presented as a mechanism individuals use to process scientific information because they cannot understand complexity or uncertainty in

the way trained scientists do. This framing also suggests an assumption on the part of scientist-communicators that some publics will always be incapable of accepting scientific research because of some pre-existing, nebulous (yet inherent) value-set. Such an assumption, true or not, reinforces that scientist-communicators' perception of their audience is, to an extent, influenced by expectations of dismissal and scepticism—the ways in which the audience might fail to accept scientific knowledge.

Sin went on to describe how, when they presented caveats to an audience, the audience was predisposed to either ignore uncertainty—accepting the research—or fixate on it. This reaction mirrors the relationship described above with respect to values: audience members are (perceived to be) predisposed to accepting or rejecting scientific conclusions and may use uncertainty as a tool to justify their pre-determined position:

> I think research should be presented with caveats, but caveats are really hard for people who are not researchers to take on board. They hear a caveat and they either decide 'I don't understand that and it doesn't matter—I believe the research.' Or else they say: 'OK so that is a reason not to believe the research', and they disregard the research. It's hard to communicate and get people to take on the nuance of: 'OK here is the best we can do, and we think there is something to it, but it's not perfect. It is not the final word on this matter'. I don't know that I have ever had any success in convincing anyone to take that middle line of taking it with the caveats. Either they accept what you are saying or they don't.
>
> (Sin, personal interview, 26 June 2019)

Notably, this quote implies that non-experts' use of value-systems, to evaluate the veracity of scientific knowledge, suggests they are not able to engage productively with the nuances of scientific uncertainty and complexity. Specifically, Sin identifies difficulty communicating to an audience that scientific research is 'not perfect', its conclusions nuanced and contingent on

specific contexts, without some audiences dismissing the research outright. This constructs an audience to whom science communicators feel they should not make the inherent uncertainty and complexity of scientific knowledge visible. Those willing to accept the research will do so regardless of uncertainty, and those inherently predisposed to dismissal because of their 'values' may emphasise uncertainties to justify their position—in doing so publicly contesting the veracity of the knowledge and authority of those producing and representing it. On this framing, being transparent about uncertainty risks audiences dismissing evidence outright by undermining scientific authority, and potentially enabling counter-narratives.

The construction of the public as unable to productively engage with the complexities of scientific research also manifested in the way some participants discussed audience perceptions of uncertainty and risk. Asked if the public perceives risk differently to scientists and researchers, O'Neale responded "Almost certainly; definitely with uncertainty" (personal interview, 5 July 2019). For O'Neale, scientist-communicators must navigate a tension between publics' need for actionable simplicity and their own complex understanding of scientific uncertainty. The public "want simplicity, I think. We all kind of want simplicity of information, and certainty lets you make things simple" (O'Neale, personal interview, 5 July 2019). Scientists acting as communicators, however, often hedge and provide conditional statements because they do not wish to over-generalise and lose precision:

> There is very rarely just one factor that clearly explains all of everything. There is always uncertainty in everything we measure but uncertainty doesn't invalidate what has been observed. [If] you have a bunch of different tests, each of which might not be very strong, but they all point in the same direction, you say "it's likely that things go in this direction" as opposed to "we know nothing at all". But when it comes to communicating this outside researchers in your own area, probably you can't. Yeah that uncertainty

> means you would not bother to try and say, you know, things will point in this direction.
>
> (O'Neale, personal interview, 5 July 2019)

This positions scientific uncertainty as so complex it cannot be accurately conveyed to non-experts. It constructs the public as unable to understand that scientific research is a process of managing uncertainty which can nevertheless produce robust conclusions. Instead, the public is constructed as preferring definitive statements which they can directly apply to their own lives, and which scientists are often unwilling to provide unless they are "arrogant enough and confident enough; or maybe their results are clear enough" (O'Neale, personal interview, 5 July 2019).

Presenting scientific uncertainty as uniquely complex, and thereby incomprehensible to publics, reinforces the idea publics and scientists have different perceptions about uncertainty and risk. This reflects the mainstream position in decision theory and risk science which differentiates between the technical-scientific measurement of risk and cultural perceptions of risk—presenting experts and the public as having fundamentally different, sometimes opposing, understandings of risk. From this perspective the 'problem' of risk communication is achieving "greater concordance between cultural and technical assessments of risk" (see Krimsky, 2007, p. 157). This framing of 'perceptions', as well as the framing above of 'values', mirrors the concept of motivated and unmotivated audiences discussed earlier—each framing constructs an audience with predetermined characteristics that cause them to either accept or reject evidence outright.

O'Neale recounted a situation whereby a member of the public perceived a statement made by O'Neale and other scientists as a claim to certainty, when the statement was intended to be one of loose correlation. O'Neale and colleagues, working on a project that mapped historical

networks of Māori obsidian sourcing, published an article in which they described how obsidian sourcing practices differed based on geographical area. These areas, they said, roughly matched the rohe (territory or boundaries) of some iwi and hapū in the Auckland area. A member of the public objected to this because other iwi and hapū are also present in those areas and they argued O'Neale and colleagues were erasing the presence of those groups. According to O'Neale:

> This person perceived a huge risk that we were going to destroy research relationships and we were going to terribly offend various iwi and hapū who might [have relationships to those areas]. Lots of people have lots of links to lots of pieces of land and this research wasn't at all trying to say what those links were.
>
> (O'Neale, personal interview, 5 July 2019)

For O'Neale this disagreement was about a difference in perception. The scientists did not believe they were making an empirical claim about the relationship between local iwi, hapu and land—they were simply pointing out that two sets of data 'roughly correspond' and as such indicate a potential direction for future research (O'Neale, personal interview, 5 July 2019). The member of the public, however, perceived their article to be making claims of certainty, even if they thought such claims were incorrect, and perceived risk (to research relationships) where scientists saw none.

These ideas about how publics perceive uncertainty and risk reproduce the dichotomy between 'real' and 'perceived' risk Wynne described as a "self-destructive fallacy" (2001, p. 450). By positioning scientists as arbiters of 'real' knowledge (in O'Neale's case as exclusively capable of understanding uncertainty and its complexities), public concerns are constructed in opposition as 'perceptions'—which may be assumed to be an irrational, emotive, or value based distortion lacking scientific rigour (Wynne, 2001). Such assumptions reproduce a deficit-

model relationship that encourages communicators to double down on reductive, technical representations of risk and uncertainty, potentially alienating publics who, like the person who responded to O'Neale's article on obsidian, have concerns that are not accounted for by scientific definitions.

Compare this framing of values and perceptions to the one expressed in *A Matter of Fact* (Berentson-Shaw, 2018), which many participants indicated influenced their understanding. Berentson-Shaw defines values as: "(a) concepts or beliefs, (b) about desirable end states or behaviors, (c) that transcend specific situations, (d) guide selection or evaluation of behavior and events, and (e) are ordered by relative importance" (from Schwartz & Bilsky, 1987). They argue that values are "universal concepts about what matters most to us" (2018, p. 93); they are complex and often contradictory, with everyone holding multiple values simultaneously and changing which they emphasise depending on circumstance. Drawing on the concept of cultural cognition (see Kahan, 2010), Berentson-Shaw argues that values shape people's perceptions of risks and beliefs and that assimilation of 'neutral' scientific information will always be filtered through pre-existing value sets. They point out that the scientific fixation on neutrality (and by extension objectivity and rational apoliticism) can undermine effective communication by ignoring the importance of values. In response, they suggest taking values seriously and using approaches that enhance trust will lead to more effective communication of scientific evidence.

The importance of values, as expressed by Berentson-Shaw, was not lost on participants, however they often adopted a narrow interpretation of this work that did not fully represent its complexities. They tended to locate values as inherent to individuals or publics without acknowledging their presence in science or science communication. In this way, both audience 'values' and public 'perceptions' were discussed by participants in ways that reproduced a

dichotomy between science and publics. In their view publics are characterised as relying on personal, subjective shortcuts ('values') to assess the validity of research—compensating for an inability to adequately engage with the nuances of complexity and uncertainty inherent to research—or, similarly, where public concerns about risk ('perceptions') are dismissed because they do not align with scientific assessments of risk. This reinforces a scientific cultural norm that characterises public opinion as emotional and values-driven, and scientists as objective and rational (Wynne, 2001). This draws a rhetorical boundary between scientists and publics by attributing qualities like subjectivity and emotional motivation to publics exclusively, leaving unchallenged the dominant presumption scientific authority is objective. This resembles boundary work—rhetorically differentiating between science and a less authoritative non-science, making public concerns easier to dismiss as irrational. Such characterisation potentially elides that members of the public may reject scientific evidence, not because their values conflict with the evidence, they perceive risk differently, or they are irrational; but because of legitimate, rational, non-scientific concerns such as mistrust of the institutions producing evidence (Wynne, 2001).

### *4.3 Misuse: complexity and uncertainty undermining authority*

The concern that uncertainty or complexity might be actively misused against scientific evidence was common among participants. Associate Professor Wiles describes a formative experience in their science communication career: receiving media training after winning the first NC3Rs 'Three Rs award'. At the time there was a loud and concerted anti-vivisectionist movement in the UK who, among other things had "…even dug up the body of a woman who was related to somebody who bred guinea pigs for research" (Wiles, personal interview, 24 July 2019). Wiles suspects that they were awarded the prize, at least in part, because their work showcased that researchers were trying to use animals in a necessary and humane manner. In that context, they relate the experience of being awarded the prize:

> [The NC3Rs] were like ‘so this is a big deal and we are going to put out some media around it and your name will be associated with this,’ and so I completely freaked out because of the climate of what things were like in the UK. So they basically organised for me to have a whole day of media training, which was the most terrifying thing because it was just this BBC journalist barking at me: ‘So you’re torturing animals?’ and I was just like ‘Ahhhhhhh, noooo!’ And at the end of the day he was like ‘Meh, I’m not sure how you’re going to do actually.’ Just because I kind of fell apart.
>
> (Wiles, personal interview, 24 July 2019)

If a scientist’s first experience of communicating to the public on a large scale is one that presents the public as aggressive, hostile and antagonistic, it follows that they would develop a defensive orientation when it comes to public engagement—one that may be hard to discard.

Hendy, who began their career arguing with climate change deniers on the internet, continues to be conscious of the influence that audience has on public engagement. Speaking about disagreements between scientists on how climate change should be addressed, Hendy said:

> Those [disagreements] have been magnified by the climate change denial community—some of whom are scientists, a lot are not. That climate change denial group have very much understood the link between uncertainty and action, so they have massively played up the uncertainty in climate science to undermine the possibility of action.
>
> (Hendy, personal interview, 5 July 2019)

Hendy continues, referring to the work of Dr Amelia Sharman (2015), to elucidate how the relationship between antagonistic audiences and scientists in a contested space constrains science communication:

> Unfortunately, [vocal climate change deniers] buttoned down the science so the scientists are less likely to want to communicate. [Scientists] are much

> more constrained on the error. They are focused on narrowing down the error bars. They are much less likely to explain what the uncertainties are. It has really buttoned down the climate scientists and the skeptics are like: 'that was our goal; to keep climate scientists out of [the public] arena.'
>
> (Hendy, personal interview, 5 July 2019)

This is a conscious acknowledgement that emphasising the potential impact of antagonistic audiences on communication can lead to conservative representations of uncertainty and complexity. As discussed previously, these conservative representations can be deployed in order to encourage action consistent with scientific evidence, or to avoid counter-narratives that discourage action by undermining scientific authority (as in Gustafsson, 2017).

For both Hendy and Wiles, however, antagonistic backlash has not always eventuated, even when it was expected. When information about Wiles' NC3Rs prize hit the media:

> They [released the information] and then nothing happened. Absolutely nothing happened. There was a small article in the newspaper but it was just like nothing happened. And so [NC3Rs] said OK, we want you to start talking about this stuff to other people and we're going to start with schools. They started getting me to go into schools and talk about my research and about using animals.
>
> (Wiles, personal interview, 24 July 2019)

Rather than being subjected to aggressive retaliation, Wiles' experience with public engagement set them on a trajectory that helped them gain experience and develop as a science communicator. It is clear that the scientist-communicators' assessment of who their audience is, and how they might react, does not always accurately represent reality. For Hendy, eschewing flight for an entire year had some unintended benefits:

> [My No-Fly year] definitely annoyed some climate change deniers. You know that was a side benefit: occupying them, other than being disingenuous in public.
>
> (Hendy, personal interview, 5 July 2019)

This demonstrates that the antagonistic misuse of scientific information is not a certainty, nor is the undermining of scientific authority the only possible response from potentially antagonistic communities. Hendy, by refusing to fly and demonstrating a commitment to action on climate change, drew the attention of an antagonistic audience away from scientific uncertainty; their disapproval instead redirected at Hendy's action. What this suggests is that a pre-emptive focus on managing hostile audiences may not be a productive premise or frame—it shifts the focus away from receptive audiences. This encourages public engagement that is defined, not by its target audience, but by those who wish to disrupt the efficacy of such engagement. This framing is tactically advantageous to those who wish to undermine public engagement with scientific evidence, and it seems the defensive preparations of science communicators can anticipate antagonism that never eventuates.

### *4.4 Defensiveness within the academy*

Defensiveness in science communication also manifests within the academy. Shackley & Wynne (1996) demonstrated that scientists communicating about uncertainty had to represent it such that it conformed with audience expectations while, crucially, keeping representations "flexible and/or ambiguous enough to satisfy peer-group scientists' demand for accuracy" (p. 280). Among participants in this research, it was clear their public audience was not the only group whose reaction they considered when communicating about complexity, risk, and uncertainty—they were also wary of the reactions of their scientific peers. Wiles, asked if their credibility as a public scientific expert had been affected by transparency about scientific uncertainty in their research, or by explicitly exposing their personal values, responded:

> I know that within my peers in academia I have people who think I'm awesome and who see what I do and just go 'we are so glad that you exist and do what you do,' and then I have others who are just hate everything I stand for and everything I do.
>
> (Wiles, personal interview, 24 July 2019)

There is a division within the scientific community about how transparency in public engagement—which inherently exposes uncertainty, epistemic complexity, and the limits of quantitative definitions of risk—should be managed. For Wiles, transparency conflicts with the cultural norms in science because it reveals the personal subjectivities that underly scientific objectivity:

> The more people understand that [scientists have values], and we are transparent about what [our] whole self is and what our conflicts are, and our biases are: I think that makes a lot of people really uncomfortable in science. They [think scientists] should be on a pedestal because we are special.
>
> (Wiles, personal interview, 24 July 2019)

They describe how scientists can be 'uneasy' about telling the public too much and 'lifting the curtain' on how scientific knowledge is generated. This defensive framing suggests scientists are cautious about being too transparent as it might jeopardise scientific authority by lifting the curtain too high. A potential consequence is that scientist-communicators seeking to engage the public by building relationships based on trust and reciprocity—exposing the inner-workings of science beyond the boundary of the scientific community—may have their work at the interface between science and society characterised, by scientists, as unscientific. By divorcing public engagement from scientific knowledge production—dismissing it as a social process applied to scientific knowledge after it is generated—scientists potentially ignore the impact public engagement, and its construction, has on producing scientific knowledge for publics.

The aversion to transparency among some scientists may be cultural but it has political and institutional roots. Asked whether it is important to be transparent about the political and institutional context of scientific knowledge production, Hendy offered the following:

> There was a journey out of the institutional barriers that I had to take. If you are in a CRI it's still very difficult to communicate, you've got to navigate some complicated internal politics. You know, it is less explicit in the university, but there will be how your colleagues look at what you are doing and that can be quite punishing, especially when you are starting out.
>
> (Hendy, personal interview, 5 July 2019)

Scientist-communicators, particularly those in their early career or transitioning from scientific research into a more public facing role, must defend public engagement as valuable work within institutions that do not always see it as such. Hendy notes such institutional peer pressure lessened as they became more experienced, and more senior:

> It's funny that I have stopped talking about that [institutional context], I've moved away from that because I have unhitched myself. You know at some point it becomes less important to you. You've just sort of been given license once you've been doing it long enough. So for people like Siouxsie and me there are little frustrations that perhaps our institution doesn't value what we are doing, that perhaps our colleagues don't.
>
> (Hendy, personal interview, 5 July 2019)

Even established, experienced, and respected science communicators (with multiple awards) feel like their engagement work can be undervalued by their peers and institutions.

Dr Hikuroa's audience is often scientists and scientific institutions. Specifically, Hikuroa weaves together science and mātauranga Māori, challenging the scientific community to accept mātauranga as precise, accurate, generated through rigorous practice, and epistemically valid

even though it incorporates "culture, values and world view" (Hikuroa, 2017, p. 6). This requires scientists to reframe mātauranga—"hitherto mostly ignored or disregarded by the science community because it seemed to be myth and legend, fantastic and implausible" (Hikuroa, 2018)—as a system of knowledge, just like science, with its own way of expressing uncertainty and complexity. For Hikuroa, a significant challenge in this process is demonstrating to scientists that:

> We all have a worldview. The reason they've never thought about it is because their worldview is more or less the dominant worldview. The default worldview. The one that is so ubiquitous that it becomes invisible.
>
> (Hikuroa, personal interview, 1 July 2019)

This is an inversion of the typical relationship between scientists and other knowledges—Hikuroa is speaking from a place of expertise about a system of knowledge *to scientists* who have no such expertise. Additionally, Hikuroa is also speaking to their scientific peers and advocating those peers recognise their own epistemic worldview, including its position of privilege, particularly over indigenous knowledges. Hikuroa initially presented these arguments using defensive language, anticipating resistance from their scientific colleagues, but has since transitioned to a more assertive framing. Take, for example, the following slides presented by Hikuroa to scientists and board members of the Environmental Protection Authority (EPA). The slides are from two versions of the same presentation, the first presented in 2016 and titled 'Mātauranga Māori – Science or Superstition?', and the second simply 'Mātauranga Māori'.

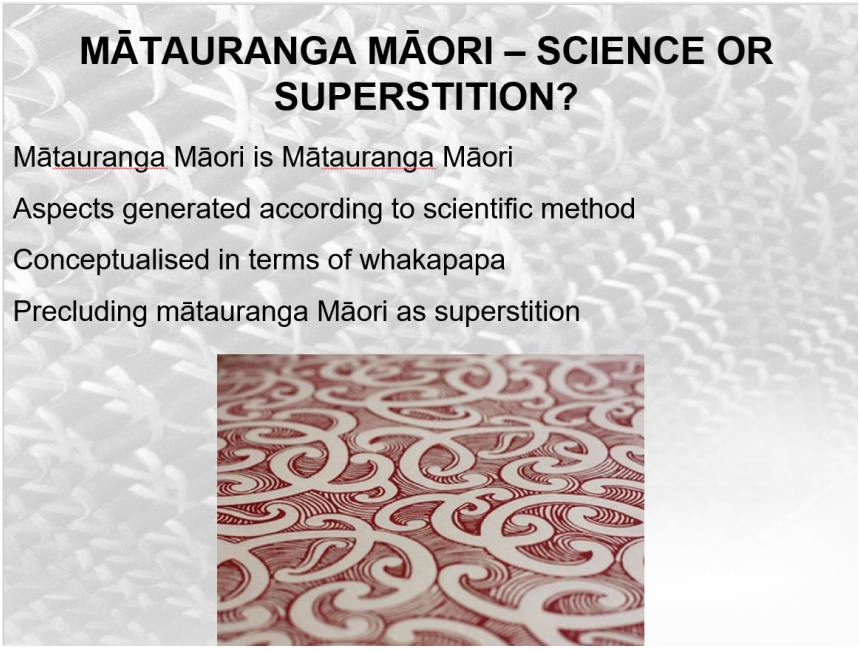


*Figure 1. Slide describing mātauranga Māori as a system of knowledge. From "Mātauranga Māori – Science or Superstition?" by Hikuroa, D., 2016.*

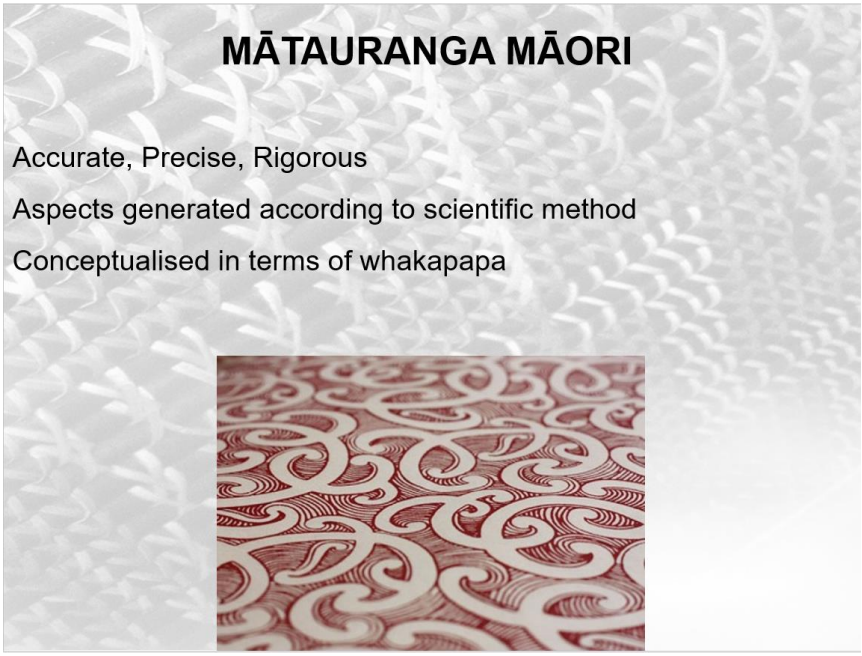


*Figure 2. Slide describing mātauranga Māori as a system of knowledge. From "Mātauranga Māori" by Hikuroa, D., 2018.*

In the latter presentation the defensive framing of 'superstition' is dropped in favour of affirmative statements about what mātauranga is, as opposed to what it is not. The earlier slide demonstrates an anticipation that scientists will dismiss work related to indigenous knowledge

as unscientific, and therefore that work must be justified in traditionally scientific terms. While the dynamics of power are different, there are similarities with the experiences of Wiles and Hendy: these defensive orientations anticipate that *scientific* colleagues and institutions will perceive the work of scientist-communicators as *unscientific* because such work involves engaging with values and forms of knowledge that do not conform to restrictive definitions of (explicitly western) science: a social process applied to science after the fact. As discussed earlier, reductive definitions of science are often encouraged by commercial interests while, as we will see later, mātauranga Māori may present an alternative way to communicate about uncertainty and risk.

### *4.5 Constructing publics*

Most participants, when asked what their audience knew about science, distinguished between publics with a general understanding of the scientific method and research process, and those without. Roberts and Sin both distinguished between policy audiences and the general public. "The [policy analysts] that I am writing for understand that there is a scientific method" says Roberts, "and that what we do is present a hypothesis and then test [it]" (Roberts, personal interview, 26 July 2019). Speaking about the media releases they prepare for a wider audience, they said: "I don't think I can assume that people understand that we have a hypothesis and work through it" (Roberts, personal interview, 26 July 2019). Sin makes a similar distinction:

> I think that this is probably less of a concern in policy audiences and more of a thing with the general public: a lot of people don't really understand how research works. Their understanding of the world comes from basically anecdotes.
>
> (Sin, personal interview, 26 June 2019)

This illustrates a presumption that wider public audiences (ie not policy professionals) may not have sufficient scientific literacy to differentiate scientific claims from anecdote or rhetoric.

This presumption is potentially a means by which scientist-communicators could reinvent the deficit model—constructing publics as "incapable of respectable reasoning about science" (Wynne, 2005, p. 4)—thereby justifying a defensive orientation that restricts public visibility of scientific complexity.

Hendy and O'Neale framed their audiences by distinguishing between motivated and unmotivated audiences. Hendy pointed out that an audience motivated to engage with scientific research does not always do so because they are sympathetic. Sometimes they are hostile:

> There's two groups of people that are very highly motivated in the climate change debate. There's people with environmental concerns [for whom] it is in their interest to learn everything they can particularly around the downsides. They will be motivated to do that. And where there is a bunch of skeptics, who again are very motivated to learn about it in order to try and discredit the science … convince themselves it's not right.
>
> (Hendy, personal interview, 5 July 2019)

For Hendy there is risk in representing uncertainty to hostile audiences, discussed in section 4.3, but also to audiences who are not strongly motivated to engage with scientific evidence. Such audiences "are going to pick up the soundbite, right? They are going to join their own impressions [with] it and they are not necessarily going to go back and deeply educate themselves" (Hendy, personal interview, 5 July 2019).

A motivated, not explicitly hostile, audience may educate themselves about the complexities and uncertainties of scientific evidence appropriately, but hostile audiences will do so with intent to undermine that evidence. Unmotivated audiences, however, lack the will to develop a sufficiently accurate understanding. This framing of an 'unmotivated audience' locates public misunderstanding of science in an unwillingness to put in work:

> Over the 50 years that we have been talking about climate change the motivation has not been high for the public to really get into the details and to put the effort into understanding the risks and uncertainties. This audience in Canterbury [after the earthquakes] they were really, as a whole, much more motivated to get in—to put the work in to understand what was being said to them.
>
> (Hendy, personal interview, 5 July 2019)

Such framing limits hypothetical audiences to whom science communicators feel they can be transparent about complexity, risk and uncertainty; but also obscures the ways scientists and science communicators may be responsible for public misunderstandings by placing the blame solely on publics.

O'Neale recounted how speaking exclusively to motivated audiences can be a largely unfulfilling experience for a scientist-communicator:

> I used to do more of the 'directly to interested public' type stuff. So that I would consider things like talking at a Café Scientifique. Things where you don't know who is going to show up in the room, which generally I've found turns out to be a bunch of elderly ex-scientists or science enthusiasts—people who might otherwise be called enthusiastic amateurs. I don't do so much of that anymore, I don't seek it out so much anymore. Partly because it got a little bit unfulfilling. I was speaking to the same sorts of people, the same demographic of people all the time.
>
> (O'Neale, personal interview, 5 July 2019)

This response suggests a desire to convince the unconvinced, yet throughout this chapter I have outlined how participants demonstrated a tendency to focus on reasons why publics might not be convincible: whether it is a public's lack of understanding about research methods; a lack of motivation; or, a public's inherent, immutable subjectivity. Barriers to effective public engagement are often located in the audience and not the communicator or the institutions they

represent. Such a construction encourages communicators to relegate complexity, risk and uncertainty to the background practices of science (where they are dealt with by experts) rather than presenting them publicly (where they may be misinterpreted). This defensiveness may alienate publics who feel they are not being told the whole story. It produces a tension which, I think, is characteristic of science communication in general; trapped in a liminal space between a scientific culture characterised by a strict adherence to objectivity and the subjectivities of the public sphere. Science communication is, therefore, more likely to succeed in reaching publics where its practitioners can lean into their own subjectivities and resist a dominant culture of the scientific structures within which they are embedded—structures that potentially alienate non-scientists.

Scientist-communicators—even those who are successful, self-reflective, and innovative—still think defensively when engaging publics. Parts of their audience, both real and imagined, are framed as prone to misinterpreting, dismissing, and actively misusing the information they represent. Scientist-communicators can emphasise or minimise the significance of complexity, risk, and uncertainty in their representations of scientific knowledge, either making them publicly accessible or drawing a boundary and sequestering them within background practices of science. Complexity, risk, and uncertainty can be constructed in ways that either lift the curtain on scientific knowledge production, or keep it firmly drawn.

A defensive orientation towards the public encourages a conservative approach to representing complexity, risk and uncertainty; perceived as potential tools for undermining the authority of science if exposed too freely. By minimising the outward appearance of uncertainty, by reinforcing quantitative definitions of risk as supreme, by removing complexities in simplistic representations of knowledge, scientists can protect their own privileged position of epistemic authority. The potential for publics to interpret research undesirably, intentionally or not, is

often attributed to some deficiency or inability to understand the scientific method, to grapple with the nuances of uncertainty, to accept scientific authority, or to make rational (non-emotive) decisions. By consciously imagining the ways in which the public is deficient, communicators make decisions about how to represent science, and which science to represent, possibly alienating publics who may not be deficient in the ways imagined. These assumptions about public deficiency are embedded in scientific culture and entrenched by scientific institutions, making it difficult for science-communicators to challenge dominant practices because their work may not be valued by their peers or rewarded in their workplaces.

This prevalence of defensive thinking among scientist-communicators—and the consequent inclination towards conservative representations of complexity, risk and uncertainty—is not always unnecessary. It may be a prudent or practical tool for minimising the spread of misinformation; it may be well supported by research; it is certainly supported and shaped by the experiences of science communicators. It is also not the only consideration communicators make when communicating about scientific research—it may not even be the most prominent. Its presence, however, makes it worth interrogating what influence it may have on the relationship between science, science communicators, and various publics. Whatever the benefits of a cautious approach that anticipates misinterpretation, dismissal, and misuse, it is also worth asking: what are the costs?

## Chapter #5 Transforming a scientistic status quo

> "We are not special. We are actually fucking privileged to do what we do."
>
> (Wiles, personal interview, 24 July 2019)

The literature engaged with for this thesis is largely critical of scientists' contribution to public engagement. It identifies a lingering positivist influence that, for example, holds scientists should adhere to strict objectivity and that uncertainty is inexorably reduced (often exclusively) through the advancement of scientific understanding. This is largely in line with Wynne's assessments of science as an institution dominated by a culture of protecting its own authority and characterized by assumptions about its own capacity for universality or to exert control (Shackley & Wynne, 1996; Wynne, 1989, 2001, 2005). Together such observations identify a scientistic component to contemporary scientific culture.

Scientism is "the belief that science, especially natural science, is much the most valuable part of human learning" often because it is either "the most authoritative, or serious, or beneficial" (Sorell, 1994, p. 1). Such an attitude encourages behaviours that preserve scientific knowledge's position of epistemic privilege. It is, I think, unsurprising such a culture would leave its mark on most scientist-communicators, influencing their defensive constructions of complexity, uncertainty, and risk. Participants, however, were not wholly defined by that culture—they often transcended it. In this chapter I examine the ways that participants suggested or demonstrated that public engagement with science could be transformed; challenging the scientistic components of the status quo. I focus on how representations of complexity, risk, and uncertainty can be used to expand the boundaries of science, negotiate barriers to accessibility, foster a relationship of reciprocal trust, and move towards engagement rooted in a genuine partnership between scientists and publics.

### *5.1 Public science, public funding: a sense of responsibility*

Many participants talked about public engagement as a process of bringing scientific knowledge into the public domain. This process involved promoting understanding and negotiating trust with publics but was distinct from the act of science itself. It happened afterwards; a process applied to scientific knowledge but not part of it. Both Associate Professor Wiles and Dr Hikuroa demonstrated a more integrated view of public engagement with science: as part of a broader system of public knowledge production. Both considered public engagement to be a responsibility inherent to the process of doing science.

> As someone who is publicly funded, I have always felt the obligation to communicate our results back to the people who fund our research... People pay taxes and those taxes go to the government and then the government allocates them to the research councils who people apply to [for grants]. There is a massive disconnect, most of my colleagues do not see that money as taxpayer money. … I'm publicly funded and the public have a right to know what is happening with their money right? … [Scientific research] is a public good and it is a long-term investment. I think every academic, frankly, has that responsibility but very few, I think, really understand that and take it seriously.
>
> (Wiles, personal interview, 24 July 2019)

By configuring their relationship to the public as a duty or responsibility, Wiles acknowledges public influence as both a legitimate part of the scientific process and a mechanism for democratic accountability. In doing so they recognise science, not as 'pure' knowledge, generated free from context and applied to society after the fact, but as an inherently public act.

Hikuroa demonstrates a similar sense of responsibility: "I felt a yearning to learn how to communicate better as well as a responsibility, as a beneficiary of society, that I should communicate my work" (Hikuroa, personal interview, 1 July 2019). They also present that

responsibility as a necessity, at least in part to avoid assuming the epistemic privilege and assumed authority of science is unimpeachable:

> It is just not good enough to say: 'Give us the money. Trust us. We know best.' I'm really keen to share what I'm doing. I think it's exciting; it's interesting. But there's a responsibility to [communicate]. That's what drives my communication work. I need to be doing it.
>
> (Hikuroa, personal interview, 1 July 2019)

Hikuroa presents the responsibility for public engagement as being in tension with (explicitly neoliberal and technocratic) attitudes that 'scientists know best' and should therefore be afforded public trust. A technocratic perspective, and the assumptions therein, is fundamental to a deficit model relationship between science and society. This tension suggests that, while not the norm, treating public engagement as both a responsibility and a necessary component of good science can be a means of resisting scientistic tendencies. By acting as though all scientists have such a responsibility, science communicators can, potentially, put pressure on scientific institutions to treat public engagement as an inherent part of science and thereby begin to bring such a world into existence.

For Wiles, the exclusivity of science is perpetuated by funding structures that selectively fund scientific projects such that they do not sufficiently reflect the diversity of publics providing funding through their taxes. According to Wiles, in microbiology these funding structures both favour a 'hypothesis driven reductionist approach' to science, but also embed systemic failures that limit who is able to define scientific research priorities:

> It has really made me think about the process of research. In my area we need money to do stuff, right? The money we do or don't get is based on us writing grants, and so the money people get [determines] what [research] questions people get to ask. Who are the people, like me, who are in the position to ask

> a question? Is that question deemed important enough by their colleagues to then get funded? Then, do they have the capacity to do it? And that is how you get a racist vaccine, right? By having a not particularly diverse set of people asking questions, and a not particularly diverse set of people giving an even smaller set of people the money.
>
> (Wiles, personal interview, 24 July 2019)

The 'racist vaccine' Wiles refers to was an early iteration of the HPV vaccine, which claimed to protect women from strains of HPV that caused 90% of cervical cancers. "It turns out that that was only true if you were basically a white woman in North America or Europe", says Wiles (personal interview, 24 July 2019). There are many varieties of HPV and the two used to create the vaccine were those most commonly found in white American and European populations. For Wiles this demonstrates how decision-making power about scientific funding and research priorities is entrenched in a homogenous group of—largely white, male, affluent—people through systemic barriers that prevent broader access to the institutions of science. Frustration with such funding apparatus, and an increased consciousness of these systemic barriers, led Wiles to turn to crowdfunding to support their search for new antibiotic compounds. This brings them into a much more direct funding relationship with the public, which has implications for their public engagement initiatives; the way they represent complexity, uncertainty, and risk; and the way they aim to involve the public in research going forward.

Wiles' research at the Bioluminescent Superbugs Lab is driven by the antibiotic resistance crisis. Wiles and their team are testing a collection of 10,000 fungi for antibiotic properties, but funding for such research has been hard to come by: "the only organisation that essentially took a punt on us was a charity called Cure Kids" (Wiles, personal interview, 24 July 2019). Cure Kids funded a pilot programme in which 300 samples were tested, then launched a

crowdfunding effort in 2017 aiming to raise $250,000 to progress the project and test a further 1000 samples (Cure Kids, 2017). Wiles says that the crowdfunding effort started small, with people at public talks offering to help out:

> Before we even started the big crowdfunding I was asked to give talks all the time. I don't even know how this came about … maybe it was giving a talk and somebody saying "Well, can I help? Can I give you some money?" I went to the University [of Auckland] and I said "somebody has offered to give me some money, how do we make this happen?" [The University of Auckland] put up a page on their website. We made these little forms that we give out [at public talks]; they have all the details about donating. And we kind of came up with a figure: for this project we think it costs about $250 to to take a fungus all the way through our screening. You know, we were kind of desperate and this project is really important, and we have not enough funding and you know any little bit helps. Twenty dollars buys us some petri dishes, you know that kind of thing.
>
> (Wiles, personal interview, 24 July 2019)

Donors who contributed $250 or more would 'adopt' a fungi, receiving a certificate and picture of their adoptee along with regular updates on progress (*New Medicines to Kill Superbugs Fund*, n.d.).

For Wiles, receiving money directly from the public, rather than indirectly through grants, made the relationship between publics and researchers much closer. It "actually fundamentally affects not just how we communicate but actually everything about our science" (Wiles, personal interview, 24 July 2019). The duty of care researchers owe to publics is much clearer under these conditions, no longer obscured by grant applications and funding bureaucracies. Wiles felt this was an opportunity to demystify the process of scientific research:

> We had a responsibility to those donors to let them know what we were going to do with their money and what progress was. I wanted them to come on the

> journey with us, and I wanted them, fundamentally, to understand what research is like and how the process works and how long it takes. You know, the fact that we have been working on this project for like four years and have a a handful of [novel] compounds now. I wanted them to understand that it wasn't just: "oooh I want to do this idea" and then five minutes later you've got a drug. I wanted them to understand how long and frustrating [it was] … and that most of the time it didn't work. I wanted them to understand what this was like. What this process was like.
>
> (Wiles, personal interview, 24 July 2019)

By making the process of scientific research more visible, there is an opportunity to actively expose complexity—technical, institutional, and epistemic—and uncertainty. In particular the epistemic complexity of scientific research can be made visible as repeated failures are surfaced to donators alongside any potential successes. Wiles sees this as a process of relationship building and notes the trust in that relationship has not been compromised through exposing the inherent uncertainties of research:

> People seem fine [with uncertainty]. For the people that have sponsored a fungus we've gone back to them at the end of the year and said, you know "Bugger! Yours didn't do anything" or, "It did do something but that's not actually the kind of drug that we're looking for." We've had people with the means go: "Oh crap, I want another one then!" and basically donated again. It's great that part of it worked.
>
> (Wiles, personal interview, 24 July 2019)

According to Wiles' experience, making the scientific process more transparent, with all its uncertainties and failures, has not undermined confidence in science, if anything it has produced a relationship where some people are motivated to continue materially supporting the research. This suggests that a defensive orientation towards publics that is protective of complexity and uncertainty may be counter-productive. In Wiles' responses it was clear that,

while they have mobilized defensiveness to bolster certain claims about scientific knowledge in public, they were also constantly working to move beyond that defensiveness. Other participants displayed, and worked to overcome, similar tensions. Perhaps being transparent about the complex and uncertainty features of scientific knowledge will do more to foster a relationship of trust than it will to undermine scientific authority. In this case, visibility of the scientific process is, however, partially limited to those with the capacity to contribute financially, bringing into focus the issues of access that come with crowdfunding.

While crowdfunded science provides an interesting case study for exploring alternative, more direct relationships between researchers, publics and science communicators, it is not a desirable means of funding science. Crowdfunding only encourages direct engagement and transparency with publics who can afford to buy in, and those publics are self-selected in that they voluntarily donate and therefore have a pre-existing level of interest and trust in the project. As such crowdfunding neither democratises research, when compared to existing systems, nor is it an effective means of engaging with publics who are, to use Hendy's term 'unmotivated'. If anything, reliance on crowdfunding is evidence of the systemic failures of public funding apparatus; as is the case in the United States of America where one in three campaigns on the crowdfunding site GoFundMe are for medical costs (Martinez, 2019)—demonstrating the systemic failure of the American medical system and health insurance industry.

Wiles notes that any potential benefits for public engagement from crowdfunding are contingent on the efforts of those running the campaign. Wiles is not convinced they fully delivered on the promise of keeping donors informed about the process:

> I'm disappointed in myself that I haven't had the time and energy to put into that relationship. I'm trying to figure out ways to do it but its been quite hard doing it alongside all the projects that I'm actually doing and the job I actually have. So that is something for the fungi project that I've been

> thinking quite hard about: how do we share our data? How do we let people know where we are in the process? That is something we are working on but we haven't got fixed yet. But that kind of leads on to the menstural cups project…
>
> (Wiles, personal interview, 24 July 2019)

Wiles' menstrual cup research project, Open Source Period, is in an early conceptual stage of development. It provides an indication of how Wiles imagines the future of public engagement with science in Aotearoa. In Wiles' words "the menstrual cup project is about rethinking the whole idea about how we do [scientific research] in the first place" (Wiles, personal interview, 24 July 2019).

### *5.2 Expanding boundaries and challenging scientific norms of 'objectivity'*

Open Source Period is a research project, established by Wiles, that seeks to apply the principles of 'open science'—transparency and scrutiny of processes and data—to the largely under-researched topic of menstrual cups (Wiles, 2019). When a study published in 2018 (Nonfoux et al., 2018) suggested that menstrual cups may not be as safe as first thought, Wiles' phone started ringing "off the hook" (personal interview, 26 July 2019). Menstrual cups as an alternative to other sanitary products were increasing in popularity, partly due to the promise of being sustainable, environmentally friendly, and cost-effective. Wiles found they were not in a position to address concerns being raised by journalists because "we don't know if [menstrual cups are] safe or not because fuck all research—at least that's been published—is available" (Wiles, personal interview, 24 July 2019).

Wiles recalls that, as they began trying to contextualise the study in various editorials (see Wiles, 2018a, 2018b), they received numerous emails from concerned members of the public alongside the expected requests for comment from journalists:

> I basically set up a Google doc and said "well, if you've got a question pop it down." And all these type of questions, things that as I'm not a menstrual cup user I'd never thought about, I was like "wow"! If I was the person writing the research grant I would not think of any of these things. So that led to: how could we use this as an example or as a test case for bringing people together, as a community, to say what are the things this community is interested in researching. What are our questions?
>
> (Wiles, personal interview, 24 July 2019)

Opening question generation to a broad audience immediately raised further concerns: How to fund research based on these questions? Could one ensure the researchers on such a project understood they were working for a community with whom data must be shared? Can it be published somewhere with no paywall? Is it possible to "change the way we do the research and the way we communicate the research at every stage of it to make sure the community can see what is going on?" (Wiles, personal interview, 24 July 2019).

Wiles' efforts to increase transparency lead towards a process of co-production: one that attempts to use science as a tool to address publicly defined needs not being met by existing funding structures. In Wiles' words the project is:

> …the culmination of all my thinking of how do we fundamentally change the way we do research, the way we think about the questions we ask, who gets to ask the questions, and how we fund it. How do you fund stuff that no funding agency is interested in? … Half of our population bloody menstruate for most of their lives—how is it acceptable that we wouldn't know that they were safe or what was the best way to clean them? But it's not something that any funding agency seems interested in. So yeah, I'm just kind of interested in this for the subject it is, but also as a test case for whether we could do things really differently.
>
> (Wiles, personal interview, 24 July 2019)

Wiles' efforts at a more inclusive research paradigm has parallels with attempts to regulate tampon absorbency as described by Vostral (2017). The study that prompted Wiles to investigate menstrual cup safety (Nonfoux et al., 2018) tested the growth of dangerous bacteria on various sanitary products by placing them in a plastic bag with a growth medium; notably not human blood. This mirrors Vostral's account, where a process of techno-scientific abstraction (using synthetic analogues instead of human blood) in service of a controlled experiment has divorced the object of study from the bodies of menstruators. This reduction of complexity potentially exposes menstruators to risks, unforeseen by science, because the research does not account for the complexities of diverse human bodies and conditions. In this way, scientists' decisions about how to conduct experiments can implicitly define risks. Public representation of that research as definitive and comprehensive (as with the racist HPV vaccine referred to by Wiles) would exemplify Wynne's suggestion that the removal of complexity from public representations of science represents a "so far unaddressed politics in its seamless externalization of the costs that may occur from this neglect, onto future or otherwise marginalized potential victims, human and other…" (Wynne, 2005, p. 70).

This potential externalisation of risk onto marginalised communities highlights that scientists hold a position of power–they can define what is or is not a valid risk. Such definitions will be based on social assumptions, and scientists can thereby unilaterally impose such assumptions about/on the public (Beck, 1986/1992; Ofori-Parku, 2018). Combined with systemic barriers preventing a plurality of perspectives within scientific institutions and funding structures, this can distort scientific research in materially harmful ways, simultaneously damaging the credibility of scientific experts and institutions as their expressions of certainty and universality—assumptions of authority and control—contradict lay-people's nuanced and pluralistic knowledge (Wynne, 1989).

This position of power held by scientists is reliant on access to material resources—labs, equipment, personnel, grants. Vostral described how access to science in the feminist push to regulate tampon absorbency was asymmetrical. Manufacturers possessed "a depth of scientific know-how with engineers, biologists, animal labs, and money to run any number of tests," while consumer advocates "were at the mercy of manufacturers and data produced by in-house scientists who chose whether or not to share" (Vostral, 2017, pp. 11–12). This suggests those with access to capital have the power to most easily deploy science and thereby define what comprises a valid risk, even if those risks primarily affect others. It is a similar asymmetrical relationship to resources, science and power that Wiles is attempting to circumvent by co-producing research into menstrual cup safety with affected members of the public.

Wiles' Open Source Period project makes many promises. In theory, the co-production of research questions, followed by an open-source and radically transparent research process maintaining an informed community of public partners, could circumvent many of the criticisms levelled at scientists by PES scholars. It takes the concerns of publics seriously by including them in the foundations of research, rather than leaving it to a (limited) demographic of experts to determine what risks and questions are important. It makes explicit that to science there are uncertainties and unknown-unknowns, allowing non-scientists to fill in the gaps of scientific expertise. It is a model that could (potentially) sacrifice some scientific authority in favour of a relationship of mutual trust where complexity, uncertainty and risk are as much subjects for public discussion as they are for discussion by scientific experts. It thereby trusts that publics have the capacity to understand scientific complexity, uncertainty and risk. Crucially, it also empowers them to define their own relevant risks and uncertainties, to make decisions about them, and, ideally, creates conditions whereby those concerns will be treated seriously by scientific experts.

It is yet to be seen whether this potential will become a reality. For Wiles, the intention behind this project is to address what they see as the failures of their public engagement efforts with respect to fungi research where they didn't "put enough time and energy into that relationship" (Wiles, personal interview, 24 July 2019). They are still "trying to figure out ways to do it" but have to do so in addition to "all the projects that I'm actually doing, and the job I actually have"—their full-time academic role (Wiles, personal interview, 24 July 2019).

Hikuroa is also working to challenge the privileged and exclusive positioning of science within society by asking scientists to reflect on their own subjectivity. As discussed earlier, Hikuroa challenges other scientists to acknowledge their worldview, particularly when it is '…the default worldview. The one that is so ubiquitous that it becomes invisible' (Hikuroa, personal interview, 1 July 2019). For Hikuroa this involves asking scientists to acknowledge their own biases and to question whether their scientific process is, in fact, value-free.

> Depending on the audience I will push them on how free of values their process might be, and how free of bias. If I am feeling bold and I am feeling the audience will benefit from it, I'll say: "Every single one of us is biased. I think the most honest approach is to try and think about what your bias is and try to put it down on paper." And some people get really upset with me for saying that, others are like: "Yes! finally someone is confronting the elephant in the room."
>
> (Hikuroa, personal interview, 1 July 2019)

As Hikuroa continues, one's worldview defines "what you think of as being possible, or actual, or impossible" (Hikuroa, personal interview, 1 July 2019). Acknowledging one's own subjectivity allows for the possibility of appreciating other perspectives, and thereby expanding the realm of what one considers possible. The goal of this exercise, it seems, is to challenge the cultural norms and structures that have led to western scientific thinking holding an exclusive

position of epistemic privilege over other systems of knowledge, particularly when it comes to decision making. In doing so, Hikuroa is challenging institutions that make decisions based on evidence, like the Environmental Protection Authority (EPA), to expand their definitions of what makes reliable evidence, and thereby what is possible within an evidence-based framework. Hikuroa notes that "for too long mātauranga had been disempowered and trumped by science in all sorts of decision-making processes. I wanted to provide a basis to challenge that situation" (Hikuroa, personal interview, 1 July 2019).

Specifically, Hikuroa is challenging the exclusive scientific claim to objectivity from two angles: asking scientists to acknowledge their subjectivities, and by highlighting the precision, accuracy and robustness of mātauranga:

> Pūrākau and the maramataka are very sophisticated bodies of knowledge or examples of knowledge. In particular, the maramataka which I feel is remarkable, that it's accurate and precise after centuries. I have no doubt in my mind that it will have adjusted through time as natural systems are variable. So I was very clear about wanting to show … that it was a system of generating knowledge developed independently of the scientific method but completely consistent with it.
>
> (Hikuroa, personal interview, 1 July 2019)

This perspective challenges any exclusive claim to objectivity science might assert. It also suggests an alternative model for communicating about complexity, uncertainty, and particularly risk, that avoids the conditions by which scientific representations can alienate publics. It makes risk explicit and trusts the audience to make their own intuitive judgements about how to respond. Take, for example, the pūrākau about the taniwha living in a stream near Matata whose tail would flick back and forth (section 3.2). This narrative is based on observation, interpretation and then "you put a Māori worldview in, and you have a taniwha that explores some geomorphologic features of a river" (Hikuroa, personal interview, 1 July

2019). Hikuroa points out this story is an effective risk management strategy—it specifies a danger and its magnitude, but it is not specific about timing. There is a level of uncertainty that encourages caution. This provides a counterpoint to the criticisms both Beck (1986/1992) and Wynne (2001) level at scientific communication of risk.

Beck argues the scientific claim to objectivity and rationality is false because expressions of risk as quantifiable and technically manageable hide social expectations and values, potentially legitimising unknown risks. Pūrākau, by contrast, communicate risk with no pretension to objectivity—they are narratives that interpret observations through Māori cultural codes and world views (Hikuroa, 2017). By clearly encoding a system of values pūrākau meet their audience halfway, avoiding the scientific tendency to alienate publics through unilateral declarations of fact that may appear unreliable. Similarly, Wynne argues a reliance on quantifying risk can project a false certainty that constructs scientific institutions as in control of risks they are incapable of controlling, or anticipating all possible risks. Again, pūrākau present an alternative means of communicating—a qualitative approach that communicates necessary information and trusts audiences' intuitive understandings of uncertainty and risk. Far from marginalising non-expert knowledges, as science is wont to do, pūrākau make a case for engaging publics' values and intuition in risk communication.

Hikuroa sees value in science communication that is more explicit and transparent about the values and biases of its scientists:

> Scientists probably need to learn that, although we strive to be values-free and unbiased, I think that in the way we communicate our science, or even do our science, we need to be more explicit and transparent with that. People get freaked out about bias, but all I'm saying is think about it. Put it out there. Then at least people know where you are coming from.
>
> (Hikuroa, personal interview, 1 July 2019)

The implication here is that reflexivity can make for more effective science communication. A scientific culture that does not affect objectivity in order to privilege itself over others, and other systems of knowledge, has a better chance of forming meaningful partnerships with publics. Hikuroa has had some success convincing decision-makers to take mātauranga seriously:

> As a result of that paper [(Hikuroa, 2017)] the EPA have now put significant resource into funding a mātauranga programme. It starts from the position that mātauranga can be precise and accurate and is rigorously generated, and hence those are the criteria we have for evidence and the EPA is all about evidence-based decision making.
>
> (Hikuroa, personal interview, 1 July 2019)

In order to be convincing, however, Hikuroa had to make their argument conform with the prevailing cultural frame of contemporary scientific institutions. That means highlighting the predictive capacity of mātauranga and making their argument "as value-free, as apolitical, as unbiased as I could possibly make it" (Hikuroa, personal interview, 1 July 2019). While Hikuroa pushes for science to expand its boundaries, both by challenging its exclusive claim to objectivity and demonstrating the value of other knowledge systems, such expansion only occurs when marginalised knowledges can justify themselves as appropriately scientific.

### *5.3 Telling a story, specifying the unknown*

A strong theme that emerged from all participants is that an effective method for communicating scientific complexity, risk, and uncertainty is to tell stories. This was a strategy that worked to overcome defensive defensiveness. Hikuroa describes pūrākau in a way that presents an alternative model for how complexity, uncertainty and risk, might be communicated—embracing values, metaphor and intuition, as opposed to prescribed, quantified scientific representations. Roberts, speaking about their experience doing public

engagement for Rape Crisis New Zealand, noted that a report combining statistics with contextualising narratives was more impactful than either statistics or stories had been in isolation:

> …we had a five year report that looked at everybody who'd been through Rape Crisis and asked them several questions around ethnicity, how long it had been since they had been sexually assaulted, what sort of sexual violence it had been, what they'd done about it et cetera. It was a really interesting report and it was pretty horrendous. It took an average of seven years, I think it was, before people would go to the police and only about 10% [of survivors] did … I didn't realise [at the time] that what I was doing [in this report] was basically adding stories to the statistics, which is what we did and is why it kind of worked.
>
> (Roberts, personal interview, 26 July 2019)

This sentiment, that narrative is an effective means of communicating about science, was repeated, to varying extents, by other participants. O'Neale, for example, said "I guess I try and present research as a narrative just because I think it makes… well it's easier. It flows that way" (O'Neale, personal interview, 1 July 2019). Sin describes translating the black box of economic formulae and regressions into a description of "the intuition behind what I am doing" (Sin, personal interview, 26 June 2019). Roberts characterises narrative as means of humanising science:

> I think as humans story is the thing that connects us. I think it is the easiest way to make people human, and if you believe that somebody is human and can see their humanity then it is easier to accept what they tell you.
>
> (Roberts, personal interview, 26 July 2019)

Wiles makes a similar connection when they discuss telling their own personal narratives as part of their science communication practice:

> People relate to stories and they relate to people more than they relate to hard facts … I've been thinking about that when I communnicate. Now I have this column [on Stuff.co.nz] and I thought about the columnists whose columns I most enjoy and they are the ones where you feel like they've given you a glimpse of who they are and what their lives are like. I decided to do [my column] as Siouxsie Wiles, mother, lego enthusiast. This is who I am.
>
> (Wiles, personal interview, 24 July 2019)

Here there is a convergence between Wiles' and Roberts' descriptions of narrative as a means for effectively communicating about science, and Hikuroa's efforts to promote reflection, by scientists, on values and bias. By telling the story of scientific research, the presence of personal values and biases are exposed for public scrutiny, but also naturalised as a normal part of scientific process. This inherently makes visible the complexities of science as a social, constructed, and contested space; the product of the communal work of many.

Wiles makes an explicit connection between telling their personal story and the Māori concept of whakapapa—commonly reduced to 'genealogy', but also a means of situating oneself within an interconnected ecosystem of all that exists:[7]

> I think [personal narrative] connects more with the public. I mean this is something that our indegenous population knows very well right, that people want to know who you are and where you are from. People want to know what your whakapapa is. And so [being] really clear [about]: this is who I am, this is why I think the way I do—I don't think it has affected my credibility at all. Well, with most people.

[7] Whakapapa demonstrates an interconnectivity between everything as a "cognitive genealogical framework connecting creation of the universe to everything within it via descent from ancestors" (Hikuroa, 2017).

(Wiles, personal interview, 24 July 2019)

Wiles seems to be suggesting that by approaching public engagement as an individual, rather than as a figure of epistemic authority, people are more willing to engage and there is little loss of credibility. Hikuroa also made comments that suggest they are thinking about how telling the narrative of scientific research can change the relationship between science and publics, particularly by setting realistic expectations around complexity and uncertainty:

> One question that I always bring up in these conversations is about communicating the knowledge that you generated using the scientific method versus communicating the inherent uncertainty and bias and complexity of doing science. What can we hope to know about this? There are some things we can never know. I think we need to be communicating that more, and more, and more to the public so that they have reasonable expectations of scientists as opposed to saying "tell us the answer." … That's what I'd like to see more of: communicating the uncertainty, the complexity part [of science] as opposed to communicating the findings of your work.

(Hikuroa, personal interview, 1 July 2019)

Together these participants seem to be advocating that telling the story of scientific research (and researchers) leads to a more effective public engagement with science because it demystifies the process. It begins to make visible elements of science, such as complexity, risk, and uncertainty, that were otherwise hidden from public view, even if it does not surrender control of them completely. This begins to shift the boundary between science and non-science: scientists relinquish the exclusive power to define and manage complexity, uncertainty and risk, redistributing it, at least partly, to the people. The boundary of science expands to acknowledge the reliability and robustness of other systems of knowledge, such as mātauranga Māori, and other ways of knowing.

Participants seem to be coalescing around a vision on what public engagement with science could look like in Aotearoa. This constellation of ideas—the importance of transparency, a commitment to debiasing, a resistance to overly rationalistic scientific thinking, and the value of narrative as a tool for effective communication—requires that complexity, risk and uncertainty become transparent elements of scientific knowledge production and thereby open to public scrutiny and definition. This vision recalls Nowotny et al.'s (2001) concept of contextualisation: when society is given the opportunity to speak back to science in a public space it transforms science from reliable knowledge to socially robust knowledge, in the process distributing expertise. "Reliable knowledge can become socially robust knowledge only if society perceives the process of knowledge production to be transparent and participative. This, in turn, depends upon a reciprocity in which the public understands how science works but, equally, science understands how the public works" (Nowotny et al., 2001, p. 248).

# Section III: Discussion

## Chapter #6 Defensiveness and transformation: tensions in public engagement

As I have shown above, the participants interviewed for this thesis, as both scientists and science communicators, put a lot of thought into the ways they construct complexity, risk, and uncertainty in public. Often, such constructions serve to draw boundaries between scientific experts and publics; at other times they work to transcend those same boundaries. A significant influence on this social construction of public engagement was participants' defensive orientation towards publics, which anticipated the ways in which publics might misinterpret, dismiss, or misuse representations of complexity, risk, and uncertainty, thereby undermining the presumed authority of science. This can encourage scientist-communicators to approach public representation of complexity, uncertainty, and risk conservatively; relegating them to the background practices of scientific experts where they feel making them public is too risky. These results largely reflect PES literature, which identifies scientistic elements of the culture of science, and its relationship with society, that can alienate publics—working against building science/society relationships founded on trust and reciprocity.

Scientist-communicators, however, consciously work to transform scientistic elements of scientific culture. The participants in this study, as a cohort of scientist-communicators in Aotearoa, are collaboratively constructing a vision for what public engagement with science could look like. This potential future begins to make visible elements of science, such as complexity, risk, and uncertainty, that are otherwise hidden from public view. It begins to shift the balance of power, surrendering some of science's exclusive claim to authority and

objectivity, in doing so legitimising the expertise of publics, and acknowledging the validity of other systems of knowledge. In this discussion I want to examine the tension between defensiveness and transformation in this cohort of participants and consider three things that may have influenced it: a local book that takes an accessible, interdisciplinary look at scientific literature on effective science communication, the commercial imperative underlying science and engagement in Aotearoa, and the PES literature reviewed for this thesis.

### *6.1 The influence of A Matter of Fact*

*A Matter of Fact: Talking Truth in a Post-Truth World* by Dr Jess Berentson-Shaw (2018) was recommended to me, independently, by most participants. Wiles, for one, made a conscious decision to start changing the way they did public engagement and "that was a really deliberate thing based on Jess Berentson-Shaw's stuff" (Wiles, personal interview, 24 July 2019). The book, by a local author, seems to have significantly impacted the way participants thought about public engagement. Given these scientist-communicators tend to learn about public engagement through informal networks of peers, or through social media, it makes sense a short, accessible book by an author active in Aotearoa's science communication community[8], would be influential. The constellation of ideas expressed by participants, as a desirable future for public engagement with science, is largely coherent with arguments made in *A Matter of Fact*. Participants, however, had varying interpretations of the concepts therein—particularly with respect to 'values'. The book also tends to frame successful public engagement in terms

[8] Dr Jess Berentson-Shaw is a Co-Director of The Workshop, a Wellington based 'think-and-do tank' seeking to bring about evidence-based, social change in Aotearoa by, among other things, changing how experts communicate (*The Workshop*, n.d.)

of the effective assimilation of scientific narratives, which is in tension with PES literature that is critical of the contributions scientific culture has made to public engagement.

The book draws heavily on quantitative scientific studies of public engagement, with a particular focus on psychological studies, health sciences, and risk management, supported occasionally by references to more interpretive or sociological scholarship. Berentson-Shaw is careful to note that the book's advice about effective communication must be accompanied by a commitment from scientists (and science communicators) to actively debias themselves, and to adopt "technologies of humility" (Jasanoff, 2007) that "cultivate ways of knowing that are currently pushed aside in the accepted 'rational scientific model'" (Berentson-Shaw, 2018, p. 145). This call to action parallels Hikuroa's efforts to make scientists conscious of their own worldview, to make bias explicit, to demonstrate the utility of mātauranga, and challenge the rational scientific model's exclusive claim to producing reliable, evidence-based knowledge. It is telling, however, that Hikuroa's argument must conform to the scientific language of rationality, disinterested objectivity, and apoliticism in order to make scientists change their practices.

One particular area where it is useful to place participant's responses in conversation with *A Matter of Fact* is the conversation about public 'values' (discussed in detail section 4.2). Berentson-Shaw (2018) argues that values are often complex and contradictory, that people hold multiple values simultaneously, and choose which to emphasise depending on circumstance. These values can shape perceptions of risk and 'neutral' scientific information will always be filtered through these values and perceptions. As such, the scientific fixation on neutrality can undermine effective communication by ignoring the importance of values. Compare this to the way some participants conceived of values in section 4.2: as a mechanism

individuals rely on to interpret scientific evidence where they lack sufficient understanding of complexity, risk and uncertainty.

This demonstrates a dichotomy evident in the way some participants discussed values: they were located as inherent and exclusive to the public and personal sphere; not part of scientific knowledge production or communication. Values were discussed as abstract—not arising from political interests, social structures or material conditions, but innate and immutable personal qualities. Whether an individual accepts scientific evidence or not was presented by some participants as an arbitrary personal decision disconnected from scientific evidence and those communicating it. This constructs a boundary between scientists and publics: individuals rely on arbitrary personal values to interpret science, but science (and its communicators) do not. It reinforces a scientific cultural norm that characterises public opinion as emotional and values-driven, as opposed to objective and rational scientists (Wynne, 2001). Drawing boundaries between scientific 'facts' and personal 'values' absolves practitioners from considering the ways in which the institutions, culture and values of science are complicit in constructing a relationship with publics built on mutual mistrust.

Not all participants reproduced this science/values dichotomy. For example, Wiles framed values, drawing on the work of local activists, as a tactical consideration. Speaking of creating social change through public engagement with science, they said:

> So there is always those people who fundamentally disagree with your values. … I don't actively engage with those who fundamentally stand opposed to everything that I stand for. Because that's it. There is no common ground. But [with] everyone else you have some common ground.
>
> (Wiles, personal interview, 24 July 2019)

This closely reflects Berentson-Shaw's (2018) argument that public engagement should be directed at "the persuadables": those who do not agree with you, but are not so far entrenched in oppositional values as to be a lost cause. This framing of values—as something scientists, communicators, and publics all possess—avoids treating the subjectivity of publics as a problem to be solved. Values are not immutable or innate, but rather positions held by individuals who are informed by material conditions and social contexts. As such the values of scientists, science communicators, and publics may conflict. This recontextualises the reasons why publics may reject scientific evidence: not because they use values to compensate for a lack of understanding of scientific complexity and uncertainty, but because their values conflict with those implicit to the research, inherent to science, or expressed by the communicator. Consider, then, that the dominant cultural assumptions of science are those of its own authority and capacity for prediction and control, which can alienate publics who are concerned about the limitations and blind-spots of scientific knowledge. It follows that a more transparent approach to uncertainty that is honest about scientific ignorance and the complexities of doing research, might be an aid in finding common ground where uncompromising certainty might be confronting. If engaging the public with science effectively relies more on values than facts, then the empirical quality and reliability of facts will not be diminished by acknowledging the values and social factors inherent to their construction.

Earlier, I argued participants were converging around a constellation of concepts as the foundation for public engagement with science going forward. These include: the importance of values, a commitment to debiasing, a resistance to overly rationalistic scientific thinking, and the value of narrative as a tool for effective communication. Each of these concepts is well supported by the scientific evidence presented in Berentson-Shaw's book, which I think demonstrates the impact it has had on participants. As the example above demonstrates, however, scientists can interpret PES literature in materially different ways. The relevance of

personal ‘values’ to science communication can be constructed such that it draws a boundary between science and publics, suggesting the complexities and uncertainties of scientific practice should be restricted from view. It can also be constructed to favour transparency.

*A Matter of Fact* echoes many points from the PES literature I have drawn on in this thesis, but builds its argument with a heavy emphasis on research from psychology and health sciences—there is little in the way of interpretive or constructivist PES literature. There remains, I think, a lingering fundamental tension between such literature and the perspective expressed by participants that align with *A Matter of Fact*. The book exists within a scientific cultural frame that, tautologically, presumes the authority of ‘evidence-based’ knowledge, without acknowledging that things not considered ‘evidence-based’ by the dominant structures of science may nevertheless be true. Despite advocating for egalitarian ideals of transparency and democratic participation in science, much of the book is still focused on the conditions for more effective public assimilation of scientific narratives. How do we make *them* agree with *us*. Participants sometimes demonstrated a similar focus—as Roberts says, when you tell stories that humanise scientists it makes it “easier to accept what they tell you” (Roberts, personal interview, 26 July 2019). Berentson-Shaw encourages scientists to acknowledge their own values, they “have a right to take value-based positions”, but the values of scientists are constructed as “strong preferences for what should be done” (2018, p. 146) based on evidence. There is little analysis of the ways science and its structures are manifestations of specific values. Values are applied *to* science and, like public engagement, are constructed as a social project, undertaken after the fact(s).

### *6.2 A commercial imperative*

Throughout interviews participants often indicated they had concerns related to the distribution of funding for public engagement with science, science communication, and sometimes science

generally, in Aotearoa. Many participants communicated a sense of being overworked or undervalued; fighting to fund more robust public engagement within scientific institutions and funding structures that viewed engagement as an afterthought or as a means of promoting public acceptance of science. Wiles, in particular, expressed frustration at the systemic barriers protecting a homogenous cohort of senior scientists and decision-makers—a group Wiles connects with a tendency to fund reductionist approaches to scientific research (see sections. 3.4, 5.2). This tendency within the culture and institutions of science, in the context of the neoliberal turn in New Zealand science funding described in section 2.3, can not help but influence scientist-communicators and the character of their public engagement. A robust analysis of capitalism as a force on science and public engagement in this context would, I think, be revealing.

There is an affinity between the interests of capital, the neoliberal ethos embedded in science funding as described in section 2.3, and restrictive or reductionist approaches to science. Science—conceived of as an isolated exercise in generating novel, highly technical, reductionist knowledge—encourages the removal of complexities, risks, and uncertainties from public representations when they cannot be subjugated within cultural assumptions of predictability and control. Under such conditions, there is potential for commercial interests to encourage restrictive, reductive, and positivist conceptions of science because they lead to the production of commodifiable knowledge. Such knowledge is commercially preferable because it is novel, and describable in the precise, technical terms that lend themselves to privatisation through property mechanisms such as patents.

Recall that the minimal space dedicated to public engagement in New Zealand's *National Statement of Science Investment: 2015-2025* focuses on promoting public acceptance of science, and encouraging young people into STEM related careers so they can "compete

internationally" and secure "future economic development" (Ministry of Business Innovation & Employment, 2015, p. 62). This focus seems to configure publics as either consumers or potential producers of science. Such an impulse might encourage communication projects that serve to promote science unilaterally, rather than engage in genuine partnership with publics, and it might encourage restrictive public representations of scientific knowledge in service of maintaining epistemic authority—science's most marketable feature. While initiatives that focus on co-production of scientific knowledge or public participation in science do exist, they are far from the status-quo. The predominant modes of communication are inherently top-down, replicating linear, deficit models of science/society relations. These conditions create a division between public engagement and scientific knowledge production. A reductionist, technoscientific definition of science has no room for developing trusting and reciprocal relationships with publics. Instead, relationship building is a subjective process applied to scientific knowledge after the 'real' science has been done; after the fact(s). This process can be easily co-opted for the purposes of promoting science publicly and thereby increasing its commercial value. In this way a focus on reductionist, technoscientific approaches to science can order the relationship between science and publics such that authority over complexity, uncertainty, and risk remain in the scientific domain, rarely exposed to public scrutiny. This constructs defensive boundaries that protect scientific authority and financial interests, while undermining the legitimacy of other knowledges. By maintaining a façade of authority, objectivity, and certainty, science retains its commercial value.

Developing and evaluating public engagement strategies that move beyond linear, deficit model communication and towards more robust partnerships or co-production of knowledge takes time, resources, and effort not necessarily built into existing scientific research grants. This is important given that many of the participants interviewed here are *scientist-communicators*: they are primarily scientists; they do public engagement in addition to their

scientific research. Scientists who want to move beyond deficit-model engagement with their own research must rely on the small number of scientific organisations, like Te Pūnaha Matatini, who try to make robust public engagement a priority. Or, they must perform that labour themselves, often uncompensated and/or facing institutional resistance. Changing the way science relates to society will take money, time, and the labour of scientists—things not often provided for, nor enabled, by the current political orientation of science funding. If, as much of the PES literature suggests, science is responsible for 'disorienting' the public, then consider that those scientists doing the disorienting may be constrained by the material conditions within which they work, even if they see the need for change.

### *6.3 Comparison with PES literature*

Overall, this project set out to explore the extent to which the experiences of scientist, communicators engaged in communicating about complexity, risk, and uncertainty aligned with the literature on public engagement with science. In conclusion, the PES literature I reviewed only partially describes the experiences of scientist-communicators, at least in the context of this group of participants in Aotearoa. The claim that public engagement activities in Aotearoa have "generally developed based on 'what feels right' and personal or institutional motivations" made by Salmon et al. (2017, p. 62) holds true. Participants often became involved in public engagement work because of chance opportunities arising as part of their scientific career and, once involved, much of their learning on the subject has happened informally, via social media or peer groups. I think this manifests in the variety of ways participants construct complexity, risk, and uncertainty; and the different ways they each construct the publics they engage with.

Earlier in this thesis I drew on literature describing the social construction of scientific knowledge to argue that the assumptions scientists and science communicators make about

publics are packaged into the scientific knowledge they produce and present, and, in doing so, they may alienate said publics (Stilgoe, 2007; Wynne, 2001, 2005). Interviews with participants supported many of the critiques this body of literature presented about scientists and their relationship with publics. This literature provides useful, often accurate frameworks for analysing how scientist-communicators actively construct meaning through concepts such as complexity, risk, and uncertainty. Participants exhibited a tendency to think defensively about representing these concepts in public because they saw them as potentially undermining scientific authority—reflecting Wynne's assertion that scientists' framing of the public often "embodies deep and persistent concerns over public mistrust in science" (2005, p. 68). This cultural mistrust, manifested in an inclination towards conservative representations of complexity, risk, and uncertainty, where publics were judged to be unable to engage with them responsibly. This can potentially alienate publics by presenting scientific knowledge in a manner that could be interpreted as condescending or paternalistic. Participants exhibiting defensiveness towards publics, while prevalent, does not represent the totality of their experience.

Many participants expressed a desire to move towards more transparent, collaborative and democratic forms of public engagement—a desire in tension with defensive tendencies around complexity, risk, and uncertainty. This desire for change was often accompanied by participants identifying cultural and structural barriers within science that resisted change. The desire for change, and efforts to enact it among scientists (who also do public engagement) was not identified in the public engagement literature I reviewed. While most PES literature agreed that reflexivity was a way forward, scholars tended to characterise their calls for reflexivity as falling on deaf ears.

Salmon et al. (2017) claimed that scientist-communicators "are neither informed by theory nor informing research in this field" (p. 62). I expected this to be true given participants were not trained science communicators with history of study in public engagement, but I have found it to only be partially so. Participants were informed by theory in the field, partly due to some uptake of the ideas presented in "The Reflexive Scientist" (first published in 2015 with two of the three authors being Te Pūnaha Matitini investigators), but also because of the influence of *A Matter of Fact* on this cohort of scientist-communicators. I think it is telling that these locally situated, internationally informed works, written accessibly for public engagement practitioners, have had significantly more impact—at least according to the scientist-communicators themselves—than international social science scholarship, however insightful.

### *1.3.1 Limitations*

There remain limitations to this study. Primarily this is a small and distinct cohort of scientist-communicators that does not necessarily represent the general state of public engagement with science in Aotearoa. These participants were, to an extent, self-selecting: Te Pūnaha Matatini has a strong culture of highly engaged and motivated scientist-communicators, many of whom had expressed interest in research-informed science communication practice. In addition, this project has taken a broad view of complexity, risk, and uncertainty, and the impact and construction of complexity, or risk, or uncertainty within public engagement could sustain independent theses. This thesis sacrificed specific attention to the contours of each in an attempt to address them all.

## *6.4 Conclusion*

The literature reviewed for this thesis discussed the social construction of science. In this thesis, I extend that idea to consider the social construction of public engagement with science. In chapter three I demonstrated that participants did not have a standard or common conception

of complexity, risk, or uncertainty; instead adopting constructions that were informed by their scientific discipline or public engagement activities. Each made conscious decisions about how to construct scientific complexity, risk, and uncertainty in (and for) public(s). Some simplified representations with the aim of distilling essential information to ease communication, in doing so obscuring local contingencies and contexts from public view. Others consciously constructed complexity, uncertainty or risk in order to incentivise public action on climate change, or to combat narratives of scientific uncertainty that disincentivised action. Constructions that could influence publics to take (or not take) particular actions were presented as an 'ethical and moral decision' made by scientific experts—a personal choice informed but not dictated by scientific information. This drew boundaries that divorced the act of scientific knowledge production from the public representation of scientific knowledge, despite public representations being the way the majority of people interact with or experience science. Public engagement was conceived as something that occurred after the fact(s).

As shown in chapter four, all participants, to some extent, took a defensive orientation towards publics when constructing complexity, uncertainty and risk. Again, participants drew boundaries between science and publics, this time based on publics' perceived incapacity to reason about science. Participants each anticipated the ways in which their public representations might be misinterpreted, dismissed because of publics' inherent subjectivity, or misused by antagonistic audiences like climate change deniers. These considerations influenced participants' choices about how to represent scientific information. They were conscious of the ways in which the public might be deficient in their understanding of complexity, uncertainty, and risk in scientific contexts; and in their understanding of the scientific method more generally. The specific deficiency of understanding assumed by scientist communicators varies by audience, but the anxiety about misinterpretation persists regardless. This encouraged a conservative approach when deciding which research is exposed

to public scrutiny; restricting visibility of nuance and ambiguity to experts and erecting a public facing façade of certainty that does not accurately reflect scientific knowledge. These defensive concerns often revolved around a perception that complexity, risk and uncertainty, in the hands of non-experts, were tools for undermining the epistemic authority of science. A potential consequence of assuming certain publics do not, or cannot, understand scientific complexity, uncertainty, and risk appropriately is that scientific definitions of these concepts are privileged while a plurality of other definitions are marginalised—a justifiable reason for publics to then mistrust scientific institutions. This can encourage scientist-communicators to double down on technical explanations, reinforcing objectivity and certainty because they misinterpret the public's lack of trust as a lack of understanding and a demand for greater certainty. In doing so they reinforce the very cultural features that cause mistrust. By constructing scientific complexity, risk, and uncertainty in public, scientist-communicators also construct the publics they communicate to.

As shown in section 4.4, participants also exhibited a defensiveness towards their scientific colleagues. Some indicated that their drive to be more transparent about scientific complexity, risk, and uncertainty—or to convince scientific decision-makers of the utility of other systems of knowledge, such as mātauranga Māori—makes some scientists, particularly those of older generations, uncomfortable. By attempting to make these elements of scientific knowledge visible, by demonstrating that science does not have an exclusive claim to robust knowledge about the world, and by making their expertise freely available through informal channels such as social media, these scientist-communicators disrupt the structures of control and authority that traditionally mediated which scientific information—and which experts—were made available to the media, and thereby the wider public. This also suggests that one of the publics scientists-communicators construct when representing complexity, risk and uncertainty in public is other scientists.

As discussed in chapter five, participants actively identified and resisted systemic and cultural barriers acting to entrench science as an inaccessible, exclusive, and unilateral arbiter of knowledge about the world. Some participants pushed to make the scientific process more transparent by publicly acknowledging the presence of bias and values within science, resisting overly rationalistic scientific thinking, and embracing the value of narrative as a tool for effective communication. They have found that presenting a more accurate, complex picture of science—with all its uncertainties and failures—has not undermined public confidence in science. This suggests that a defensive orientation towards publics that is protective of complexity, risk and uncertainty may be counterproductive. Perhaps being transparent about those features of scientific knowledge will do more to foster a relationship of trust than it will to undermine scientific authority. The implication here, I think, is that reflexivity makes for more effective public engagement. A scientific culture that does not affect objectivity in order to privilege itself over others, and other systems of knowledge, has a better chance of forming meaningful partnerships with publics. Hikuroa demonstrated that pūrākau can present an alternative model for how complexity, uncertainty and risk, might be communicated—embracing values, metaphor, and trust, as opposed to prescribed, quantified scientific representations. If scientist-communicators want to overcome boundaries and transform the way science relates to society, in all its diversity, they can start by lifting up—and making space for—indigenous and traditionally under-represented systems of knowledge. In doing so they might also create space to imagine alternative relationships with society.

The critiques presented by constructivist PES literature often focused on the cultural attitudes and imaginations of science. What they fail to capture is that scientist-communicators—while embedded in, arising from, and to an extent reproducing the culture and politics of science—are not wholly creatures of science; they have one foot outside these systems. As scientist-communicators construct complexity, uncertainty, and risk for public consumption, they also

have an opportunity to construct science in public, reflecting a vision of science as they wish it to be back to scientists. Participants demonstrated a dissatisfaction with systemic and cultural elements of science that they felt prevented efforts to move towards public engagement built on genuine partnerships and relationships of reciprocity. They have acted to try and circumvent these barriers. There is a generative politics at work here—attempts to push beyond the criticisms of science and its relationship with society presented by the literature on public engagement with science.

Finally, it is no longer the case that this small sample of scientist-communicators "are neither informed by theory nor informing research in this field" (Salmon et al., p. 62). While the established public engagement with science literature—esoteric, challenging, and often focused elsewhere—has had little impact on these scientist-communicators, locally-authored and accessible texts that summarise findings from multiple disciplines, such as *A Matter of Fact* and "The Reflexive Scientist", have had significantly more impact. There is a will, at least among these participants, to transform the way science engages with society. Contemporary PES scholarship, however insightful, has not empowered them to do so. If scholars of public engagement with science want to materially impact the practice of those who engage the public with science, they would do well to meet practitioners where they are.

## Chapter #7 Epilogue

On 12 November 2019 I sat in the glass-walled fishbowl of a campus conference room. The webcam refused to turn on. Earlier in the day Izi had emailed in a rush to say they wouldn't make it—something about urgent issues with a contract. Dion had declined the invitation from the beginning; on Twitter I saw photos of them digging trenches and sieving wet clay in unnamed green fields. Ceridwyn joined me in the room, as did my supervisor Rebecca. After a brief visit from IT, Shaun and Siouxsie beamed in from Auckland to join us on the large wall-mounted screen. A short email arrived from Dan saying they were delayed but would be joining us in half an hour. Dan never arrived—they were supporting one of their master's students through a potential crisis: "Yay for saving files frequently on print-off day," they said by email. I would later hastily backup my own thesis to a USB stick.

"I think defensiveness is a big part of explaining what happens in science communication" said Shaun, after I presented my provisional findings. "It's just so much a part of science communication, I don't think it's the sort of thing we can just wish away." To ignore defensiveness, they said, would be to ignore the political realities of working in that space. As such, they argued a necessary response to defensiveness is consciously "identifying it, understanding when it's present, and how that shapes the discourse."

"I've been thinking about defensiveness and audiences" responded Siouxsie, "and sometimes the definition of audience is not necessarily the people you are talking to but the *other people* who are listening."

Shaun agreed, "the bystanders are important."

I asked everyone if they thought it was possible for scientists to engage with publics as both experts and as equals. Siouxsie responded: "I think [it is about] being yourself and making it

really clear what your values are. Being transparent about all that kind of stuff, while imparting your knowledge, or offering yourself up as someone who is available to have a dialogue—should people want it." Siouxsie went on to question how academic and research institutions treat their workers, and how that might shape people's behaviour. "This is also a lot about that support network you have. This idea that you are trying to take yourself off the pedestal—so are you mentally OK with being off the pedestal?" they asked, pointing out that someone in a precarious working situation might be forced into self-promotion to secure their next job.

Our conversation shifted to the transparency of research methodologies and processes. "For me transparency has [involved] an internal journey to say that I'm willing to open up everything we do to criticism," explained Siouxsie, "that's been a really hard thing, and we're not there yet, but we're working on it." They added that scientists usually don't share like that at all, "certainly not in the biological sciences."

Ceridwyn added that transparency can often conflict with the interests of funders. They paraphrased conversations from work, recounting the process of pitching research to funders and gathering data, only to realise the data wouldn't let them do the research in the way they expected: "shall we [shift] and try this piece of research instead?" Ceridwyn asked, "because that's what the statistics allow us to do." Siouxsie's chuckle of agreement crackled through the speakers. Ceridwyn continued: "…and then there's reselling [the new approach] to the funders who might not actually be interested in it at all. And not coming up with a result is… yeah," Ceridwyn paused, "'We can't do it [with the data available]' isn't a particularly great thing to say to someone who's promised you lots of money."

"[There is a] mismatch between expectations and what you can actually deliver," agreed Shaun, "And of course in order to get funding we have to talk up the expectations. Actually, the things that overdeliver are those accidental things that you promised to absolutely no-one." Shaun

went on to explain that they have worked in competitive scientific disciplines where transparency, even among fellow researchers, was impossible: "[transparency is] a very real issue, people deliberately leave things out of their methodology, it's unethical."

Shaun pointed out that working close to government—close to power—introduces its own set of concerns: "[transparency is] an issue in policy adjacent fields too, where you know what you are going to say is going to upset someone powerful. Within government there are lots of forces acting against transparency—to prevent the Minister being embarrassed." Shaun specifically cited the 'no surprises' clause of the Cabinet Manual, which requires government departments to promptly inform their Ministers of matters significant to their portfolio, particularly where such matters are controversial or might become subject to public debate.

"I was completely shocked at the last SCANZ conference," agreed Ceridwyn "[we were] a bunch of science communicators, and I was shocked at how many people had been stopped from talking about their research in the way they wanted to. It was most of the people there."

After the discussion had finished, Shaun and Siouxsie blinked out of existence. Ceridwyn, Rebecca and I shuffled out of the fishbowl, talking idly about how well the discussion had gone. I had a lot to think about. These experienced science communicators agreed that defensiveness was an issue—that it shaped scientific discourse—but identified so many different systems that entrench it, acting against transparency: scientific cultures, funding, bureaucratic precaution, academic institutions that value performance over wellbeing. I recalled an offhand comment from earlier. "I'm quite interested in where anxiety fits in with reflexivity" Ceridwyn had mused aloud. We had all shared a knowing laugh.

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# Appendix 1: Interview guide

## Content

- You're part of TPM, so clearly there's some element of complexity in the work you do, or the data you work with. Can you tell me about complexity in your research? What is complex about your research or the data you use?
- What about risk? Is there a risk element, or a perception of risk, in the work that you do, or the data that you're working with, or the topic you're working on?
- And what about uncertainty? All scientists deal with uncertainty – but how significant is this in your area of research?
- I asked you to provide an example of a communication project you've been involved with, why did you pick this one? Can you describe it for me?

## Communication

- All science gets communicated in some form. Sometimes it's just with peers, sometimes its published, and sometimes it goes wider. In what ways did you communicate about this work and what led you there?
    - {Think about institutional/peer influence}
- What did you want to achieve by using this particular form of communication? Did you choose the form? Why?
- Thinking about what you told me about {C/R/U} in your work above, how did you present that {C/R/U} in this piece of communication?
    - Does that differ from the way you would talk about it with a peer?
    - What did you think of the media's interpretation of {complexity/risk/uncertainty}? If it was misconstrued or presented, how?
- Is it important was it to talk about {C/R/U} in this situation?
    - Do you think it is important to talk about {C/R/U} in public generally?
- Did you discuss your methodology or just the results of your research?
    - What about the political and institutional elements of the research? Funding?
- Do you try to engage your audiences emotions?
    - Why? What did you want to achieve
    - How did you engage their emotions, what was the response?

- Do you use stories to communicate about your work?

**Constructing the Audience**

- Can you describe your audience for me? Who were they, what do they know about science?
    - Did you learn anything about your audience over the course of your interactions with them? Did your perception of them change?
    - How do you think they perceive science? How is that perspective formed?
- Why were you talking to this particular audience? Why did they need to hear what you had to say?
- How did you expect them to react to the elements of {C/R/U} in your work?
- How did that affect the way you presented {C/R/U} to that audience? Why that approach?
- What were the challenges you encountered communicating {c/r/u} to this audience?
- How do you think communicating about {C/R/U} in the way that you did affected your audience?
- Do you think the audience learned something about science more generally from your interaction?

**General**

- **Do you discuss the institutional and political context of your research?**
- **Do you read about complexity, risk, uncertainty and engagement. If so where?**
- **If you could read a research paper about science communication, what would you most want to know? I.e. What question do you want the literature to answer for you? (come up with tight wording for this)**

**Conclusory**

- So I've asked you about {C/R/U} in your work, in communication, and the audience you've communicated with. What would be a useful outcome of this research for you?
- Why do you think this project is necessary?
- Ask about a potential follow up roundtable