

THE CHANGING USES OF ACCURACY IN SCIENCE COMMUNICATION

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Abstract

Tracing its historical trajectories, this article explores the preoccupation with accuracy in science communication research and explores the resurgence in the present century of concerns about accuracy, balance and impartiality in public communication of science. It is argued that many of the original insights from news and journalism research are still relevant and important if re-formulated in constructionist terms about voice, access and claims-making, and asking: in whose interest? Key to this is also the recognition of a radically changing - technologically, economically and professionally - media and communications environment, with implications for science journalism and a very different dynamic regarding the range and type of actors involved in discursively constructing opinions and information about controversial science and expertise. The article concludes with proposals for future emphases and directions in research broadly concerned with accuracy in science communication.

Keywords

Science communication, science journalism, public understanding of science, media and science, accuracy, balance, impartiality, media representations

Concerns about ‘accuracy’ have long been central to both research and public debate about public communication/understanding of science, but such concerns have also waxed and waned over time and indeed have been expressed through a variety of closely related terms, including certainty/uncertainty, bias/balance, objectivity and impartiality. The aim of this article is to explore the historically changing preoccupation with accuracy in science communication research, including its resurgence in the present century.

A key argument is that many of the original insights from journalism research focusing on journalistic values of accuracy, objectivity and balance in reporting are still relevant and important if re-formulated in constructionist terms about voice, access, claims-making and a changing media environment with implications for changing dynamics between information providers and consumers. Traditional explanations surrounding science journalism are changing, particularly in terms of a different dynamic regarding the range and type of actors involved in discursively constructing opinions and information about controversial science.

Concern, and associated scholarly research, regarding accuracy, balance and objectivity in public communication of science has focused broadly on, on the one hand, news journalism and factual media representation, and on the other, fictional representation. I will argue that the key driver in research on both factual and fictional media representations of science, medicine and related areas is a concern about how such representations may influence public and political behaviour and decision-making. Concern is thus, not surprisingly, particularly strongly expressed in relation to representations perceived to result in public resistance to developments otherwise deemed to be scientifically, politically or economically advantageous or in relation to representations perceived to adversely affect public health.

Historical contours of concern.

Concern and research about accuracy in science reporting have a long pedigree. Studies of accuracy in journalism have, as Maier (2005) argues citing a study by Charnley (1936), been around at least since the 1930s. The 1970s and 1980s saw a proliferation of studies of accuracy in science journalism with studies by Tichenor et al. (1970) and by Tankard and Ryan (1974) signalling the model of research followed by many subsequent studies (e.g. Borman, 1978; Moore & Singletary, 1985; Singer, 1990; Salomone et al., 1990).

Accuracy has also been a recurring theme in numerous reviews of science communication and science journalism (Singletary, 1980; Cronholm and Sandell 1981; Nelkin, 1987; Dornan, 1990; Dunwoody and Peters, 1992; Dunwoody, 2008 and 2014; Stocking 1999; Weigold, 2001; Hansen, 2009; Mellor, 2009) and health communication (Seale, 2002 and 2010; Hallin and Briggs, 2015). Reviewing the literature on accuracy, however, also indicates that after the initial prominence in studies of the 1970s and 1980s, the term accuracy faded into the background in the 1990s and early 2000s, but then seems to have enjoyed a renaissance in the first decade and a half of the present century. These trends also appear to be confirmed by a simple Ngram as shown in Figure 1.

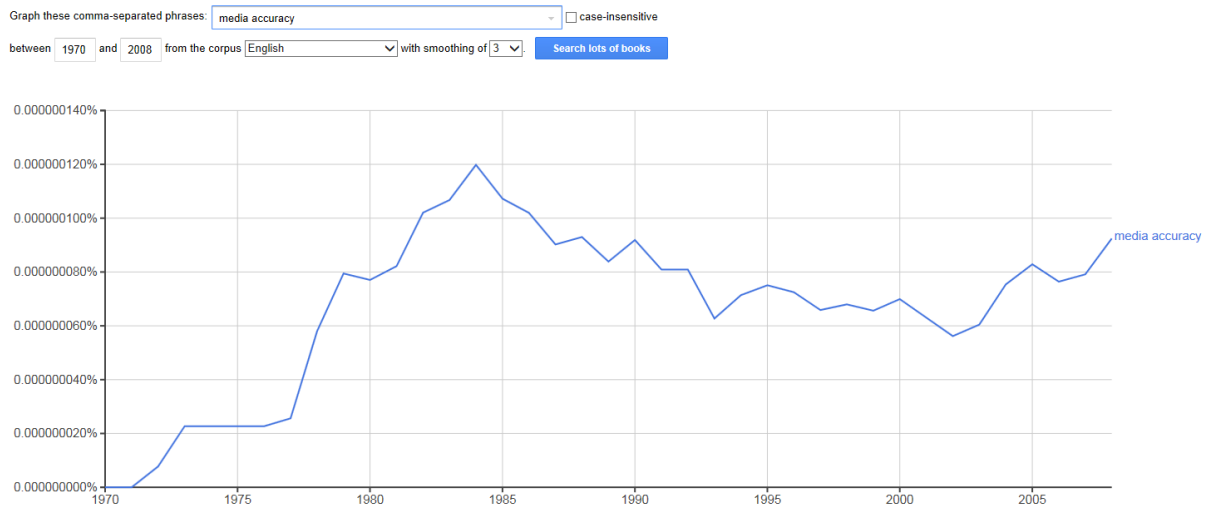


Fig.1 Google Books Ngram of ‘media accuracy’, 1970-2008

While research on accuracy has seemingly fluctuated significantly over the last half century, such fluctuations are to some extent more indicative of a changing terminology than of underlying concerns. In very general terms ‘accuracy’ was the dominant term in the 1970s and 1980s; ‘uncertainty’ dominated in the 1990s as indicated by the title of the key collection edited by Friedman, Dunwoody and Rogers at the end of this decade: *Communicating Uncertainty: Media Coverage of New and Controversial Science* (1999); and ‘balance/bias’ and ‘impartiality’ are the key terms featuring prominently in debates in the present century.

The changing terminology is of course not merely a matter of changing lexis, but is itself indicative of changing research paradigms, underlying understandings of how and why scientific knowledge is produced, about how research is communicated, and ultimately – and this is the core argument of the article – about control and boundary-policing in public communication of science.

Hilgartner and Bosk (1988: 71), while not mentioning ‘accuracy’, articulated this perspective very well with reference to ‘political biases’: “All public arenas have political biases that set the acceptable range of discourse in that arena” and “most of the public arenas (especially powerful ones) are heavily influenced by dominant political and economic groups. Thus, social problem definitions that reflect these biases have a higher probability of success”.

The renewed interest seen in this century in questions about impartiality, accuracy and objectivity in science communication can be understood then in large part as a consequence of the increasing challenges to boundary-setting around public debate caused by the proliferation and widening accessibility of public arenas. Traditional trusted sources/media of information and traditional science journalism (adhering to traditional professional journalistic values re accuracy, source-checking, objectivity, impartiality, etc.) have increasingly been complemented with, and in some cases superseded by, a diverse multitude of providers of information.

Communication has been seen as central to public understanding of science throughout, but while early concerns focused on blaming the media and communication professionals for inadequate transmission of scientific information, later perspectives have recognised that public opposition is not solely driven by ‘lack of understanding’, caused by errors/inaccuracies/inadequacies of communication. The original Public Understanding of Science ‘deficit model’ (see e.g. Gregory and Miller, 1998) made the assumption that resistance to new technology was primarily driven by lack of understanding – and therefore the key task, as articulated by the Royal Society Report (1985), was to make the public more scientifically literate. However, as many including Priest (2015) have pointed out since the late 1980s, opposition to new science or technology is often not about ‘lack of understanding’ but rather about difference of values or perspective. I would argue that the concern with accuracy and public understanding was always primarily – even if rarely articulated as such – with control and influence over public debate, particularly where the ‘wrong’ kind of information/interpretation was seen (whether by government, business, industry, health officials, the scientific community, etc.) as threatening to political, economic and of course ‘public’ interest.

While studies of accuracy in journalism have, as Maier (2005) argues, been around at least since the 1930s, it has not been possible for researchers to enlighten us much on how the degree of accuracy in news reporting might have improved, deteriorated or perhaps fluctuated. Maier (2005) ascribes these challenges to lack of comparability in terms of media focused on, methodological inconsistencies and attendant problems of validity and reliability in accuracy research.

While differences in terms of media, content types, and analytical approaches of course make comparisons and generalisations difficult (as in all comparative communication research, see Esser and Hanitzsch, 2012), it is not these differences but perhaps rather the

concept of accuracy itself that is problematic. The concept implies a simple measurable entity involving a simple comparison between a correct/true account (often assumed to be the scientist's/expert's account, or the scientific paper published in a reputable journal) and a mediated version (e.g. the news item aimed at a large audience).

The key problem with the traditional concepts of accuracy and the many closely associated terms, objectivity, balance, impartiality (and sometimes 'quality' – e.g. Salomone et al. 1990) etc., is their deceptive simplicity and seeming common-sense quality, but most emphatically their implied binary 'yes/no' quality and their obscuring of human agency and interest, context and standard of measurement. 'Accuracy' is not an inherent or easily measured quality of text/communication, but rather can only be understood with reference to the communicative context and, as Mellor (2009: 135) rightly argues, as "a product of the rhetorical apparatus of the text."

The semantic flexibility of 'accuracy' was amply clear already in early accuracy studies of the 1970s/1980s which demonstrated that judgements about accuracy in science reporting depended very much on who one asked and on such factors as whether scientists were asked about accuracy in news reports in which they themselves were mentioned or about science reporting in general (e.g. Tichenor et al, 1970; Hansen and Dickinson, 1992). The meaning of accuracy is also highly context-dependent, varying according to whether measured at the level of the individual text/news report or at the aggregate level of a larger body of media representation over an extended period of time.

Accuracy: the regulatory context

In the UK and many other countries, there is a regulatory context with mechanisms for monitoring and complaining about the nature of public communications media, including regarding questions concerning accuracy, fairness, balance and impartiality. Interestingly, as the media and communications environment has become increasingly diverse and competitive, pressures have also increased on traditional public service media institutions, like the BBC, to adhere to strict regulatory norms and to publicly demonstrate – through regular auditing – accuracy and impartiality in its reporting.

A series of studies and reports in the last decade or so relating to the BBC (see http://www.bbc.co.uk/bbctrust/our_work/editorial_standards/impartiality.html) demonstrate the resurgence and continued importance of questions regarding accuracy and closely related concepts in relation to public communication about science, medicine, the environment and other topics. These reports are highly instructive because they testify to the problems of applying – in a regulatory monitoring context – common-sensical but conceptually poorly defined journalistic concepts such as accuracy, balance, objectivity, impartiality etc.

In a comprehensive ‘Review of impartiality and accuracy of the BBC’s coverage of science’ (BBC Trust, 2011), there is clear recognition that not only are there many different ways and levels at which accuracy, balance and impartiality can be measured (e.g. balance of argument, balance of sources quoted, gender-balance of presenters, geographical balance, etc.) but also, that for regulatory requirements to be implemented sensibly, the wider social, cultural, political and ideological contexts need to be taken into account. The report recognises the futility of defining or applying concepts like accuracy and impartiality out of context, that by themselves these concepts lack meaning, and have little utility as policy instruments or in regulatory prescription: “there should be no attempt to give equal weight to opinion and to evidence” and “ ‘due impartiality’ should be applied in different ways depending upon the nature and context of a story.” (BBC Trust, 2011: 6).

By the end of the 1980s and early 1990s, communication researchers and sociologists of science communication had largely dismissed accuracy research as symptomatic of many of the critical problems with the study of ‘science and the media’ (Dornan, 1990; Hilgartner 1990) and the underlying linear transmission model.

The original decline in interest in accuracy-research resulted from changing paradigms in the way news was studied, as the study of news moved out of the narrow focus on journalism and journalistic professional values and into a much broader sociological analysis of the media as commercial organisations in the public sphere. Pivotal, the increased (sociological) interest in the role of news media brought with it a move away from circular arguments about bias, balance, objectivity and accuracy toward a (constructionist) view of the news process as a process of public arena claims-making by multiple claims-makers competing for space, attention and successful framing of public issues.

The recognition that multiple actors compete to promote their particular version of fact or evidence also re-directs the traditional accuracy concerns of the hierarchical (scientists at the top; the public towards the bottom) linear transmission model towards a view of communication as the exercise of power, that is the power to define and frame issues in terms of what they are, who is responsible and how to move them forward. From this perspective, questions about accuracy become much less interesting, because the key concern shifts to understanding whose definitions are most successful in the public sphere, and to understanding the processes which give some actors and their definitions more visibility and success than others in public debate.

Hilgartner (1990) and Stocking (1999) thus years ago argued strongly the case that much of the focus on accuracy and associated ‘problems’ in the communication of science was a proxy for concerns about maintaining particular ‘social hierarchies of expertise’ (Hilgartner, 1990). Variability in how scientists adjusted for example the way that they communicated certainty thus pointed to the fact that scientific evidence and information are communicated with a view to achieving particular outcomes and serving particular interests in the public sphere. Research therefore needs to be directed beyond perceived problems of accuracy to asking, “whose interests are served when particular patterns of media coverage of ignorance or uncertainty are defined as *problematic* in the first place.” (Stocking, 1999: 38).

Accuracy in news journalism studies

As indicated previously, much of the research on accuracy has focused on news reporting of science in the mass media, very predominantly the press and to a lesser extent television news (but very little on radio news). As I have argued elsewhere (Hansen, 2009), such research has drawn predominantly on a linear model of communication and examined the

flow of information from science-sources to communication professionals/media to wider publics. Studies of science journalism have identified a range of media related factors impacting on the communication of science, including: the size of media organisation (Friedman, 1986); ownership and political-economic interests of media organisations; the professional beliefs, general/specialist designation and qualifications of journalists covering science (Dunwoody 1979); the professional beliefs, policies and practices of editors (Endreny, 1985); scientists' stereotypes of journalists and vice versa (Dunwoody & Stocking, 1985); and the images which media professionals have of their audiences (Tannenbaum, 1963; Hansen, 1994). As shown in the previous section, the media regulatory context is a further factor circumscribing the communication of science, including how requirements of accuracy and impartiality are defined, adhered to and monitored.

Signaling an early development of the relatively simplistic linear transmission view of science communication, researchers in the 1980s started focusing on the growth of information officers or media liaison officers acting as middlemen between scientists/science institutions and journalists/media institutions (Rogers, 1986; Dunwoody & Ryan, 1983) and in turn on these as potential influences on accuracy. While signaling recognition that the process of science communication was significantly more complex than the direct interaction between scientists and journalists implied, the linear transmission model and associated notions of science communication as 'flow' and 'translation' continue to feature strongly (de Semir et al, 1998; Saguy and Almeling, 2008; Brechman et al. 2009 and 2011), particularly in health communication research (Hallin and Briggs, 2015).

Perhaps the most prominent articulation of accuracy concerns in the present century has so far been what has become widely known and recognised as the 'balance as bias' argument (Boykoff and Boykoff, 2004), most prominently articulated in relation to research on the public mediation of research on climate change, but also prominent in health communication (Dixon and Clarke, 2013; Jensen et al., 2013). Much cited research in this vein in the context of climate change are Boykoff and Boykoff (2004), Corbett and Durfee (2004) and Oreskes and Conway (2010), but the argument itself has been part of the accuracy debate rather longer, as indicated for example by Dunwoody and Peters (1992), Dearing (1995), Stocking (1999), Wilson (2000) and Weigold (2001).

The argument itself is admirably simple and elegant in its demonstration that media representations at odds with scientific consensus on an issue are a largely inadvertent result of the journalistic values of balance and objectivity.

Dixon and Clarke (2013) note how journalistic balance in science reporting may take both a simple point/counter-point form of two opposing scientific views within a single news story, or may take the form of journalists citing as many different views – regardless of the weight of evidence – as they can find in an attempt at covering themselves against accusations of biased or subjective reporting. Similarly, Dunwoody (2014: 33) reiterates her long-standing observation that the journalistic norms of objectivity and balance arose as “surrogates for validity, that is, as ways of compensating for journalists’ inability to determine whether their sources’ assertions are true or not.”

Research on journalism, journalistic values and news values thus provides a strong explanatory framework for understanding the connection between balance, objectivity and accuracy in science reporting. What has been less widely recognised in the balance as bias debate and research of the last decade or so is the considerable variability across national/cultural contexts, across different media, and across types of news reporting (e.g. routine day-to-day coverage versus news reporting of focus events such as major international summits).

Shehata and Hopmann (2012) and Philo and Happer (2013), in their reviews of research on climate change communication, capture these dimensions particularly well. They show the ‘balance as bias’ patterns identified in research of the early part of the present century changing later to a more accurate reflection of the scientific consensus on climate change, only for the consensus view to be questioned again with renewed vigour around the so-called Climategate scandal and the Copenhagen climate summit in 2009.

Shehata and Hopmann (2012) also indicate the importance of not equating a balance of voices with a balance of views/perspectives in relation to climate change. They thus argue that the balance as bias evidence of Boykoff and Boykoff (2004) was at odds with other evidence showing that while voices on both sides of the argument were prominent in media coverage, the overall media message/frame was one which tended relatively early on to resonate well with the emerging consensus view. Crucially, they demonstrate how dimensions such as balance are highly dependent on historical and event-context, including key focusing events such as the Copenhagen Climate Summit of 2009.

The dynamic, fluid and evolving nature of public communication about controversial science is best captured and understood, not from short term cross-sectional research, but in comparative and longitudinal research (Hansen, 2015). One of the key lessons from such

research is the finding that the ‘science discourse’ on a controversial (science) topic rarely if ever remains the dominant discourse for very long, but is soon competing with a wide array of different discourses: economic, legal, political, moral, etc.

This process was demonstrated early on in research on public communication about genetics (Plein, 1991). More recently, Philo and Happer (2013) have demonstrated similar proliferation-of-voices trends in climate change reporting, while also noting growing evidence (Painter, 2011 and 2013; Painter and Ashe, 2012) of the association between a news organisation’s/news-outlet’s political/ideological stance and the range and type of voices that predominate in coverage of climate change. While these are important findings, contributing to an understanding of the context of accuracy and balance, less is known about the potentially much more elucidating question of how the surface manifestations of balance/bias and accuracy in news reporting (as uncovered through for example systematic content analyses of news output) are influenced by the strategic approaches and communicative resources of key actors seeking to influence what views/perspectives come to dominate in the public sphere.

What is argued here, is that research needs to go significantly further to un-cover and to understand how balances/biases in media coverage of science result not only from journalistic practices and values, but that these practices/values are also skilfully manipulated/exploited by sources keen to promote their particular views. What is needed then is perhaps not so much further research on the values and practices of science journalism, about which a great deal – firmly anchored in a long and well developed tradition of journalism research generally – is now known, but an enhanced focus on the increasing professionalization and strategic organisation of science communication in the public sphere. While these trends have been well researched in relation to press officers, science communication officers and public relations offices charged with promoting scientific research on behalf of universities and other science institutions (e.g. Rogers, 1986; Stocking, 1999), it is only more recently that researchers have started to throw light on how the public media and communications environment is being actively influenced and manipulated through the careful campaigning strategies not just of traditional pressure groups, but by industry and big business through ‘front groups’ (Beder, 2002 and 2004), think tanks (Miller and Dinan, 2015) and coalitions of various sorts (Williams, 2015) keen to promote particular ‘evidence’ consonant with their vested interests. Or, as the evidence suggests in relation to tobacco/smoking and more recently in relation to climate change, to

counter the emerging or prevailing scientific consensus by ‘sowing doubt’ and amplifying scientific uncertainties. Increasing awareness of how the communication of science is a multifaceted process with many more actors than the traditional focus on scientists and (science) journalists suggests, undoubtedly helps explain the resurgence of interest/concern regarding accuracy, balance, objectivity and impartiality. At the same time, it is clear that much more needs to be done to understand how successful resource-rich sources are in influencing and manipulating such journalistic values as balance and objectivity in order to promote particular interests/views.

Accuracy in entertainment and film representations of science

There is a long tradition of concern about media representation of health and illness. In a comprehensive review in 2002, Seale reviews studies which demonstrate the media’s tendency to give disproportionate prominence to diseases, causes of death and risks which are statistically relatively rare, while giving little emphasis to those that pose the major health problems and threats. The concern articulated in such studies is the notion that an ‘inaccurate’ portrayal (in the sense of a discrepancy between ‘media reality’ and ‘real life’) leads to unrealistic public expectations (e.g. of the curative powers of medicine), confusion (Dixon and Clarke, 2013; Jensen et al., 2013) and erroneous public perceptions, which then in turn impact on people’s health and risk-related behaviour and potentially influence political decisions. This version of concern has been prominent for at least the past 40-50 years, and continues to inform – albeit not always explicitly – much of research on both factual and fictional media portrayal of health, medicine, science, the environment, etc. The basic premise of such concerns is the notion, most clearly articulated in the tradition of communication research known as cultivation analysis and initiated by George Gerbner and his colleagues in the 1960s (Morgan and Shanahan, 2010), that public beliefs and attitudes are influenced by those images, values and behaviours which most consistently tend to dominate our symbolic environment (most notably the mass media). Criticisms of inaccuracy and distortion, in this context, then revolve around ‘mismatches’ between e.g. the types of risks or diseases which receive most attention in media representations and those that are statistically most prominent in society. But as Gerbner and many others have long pointed out, such notions of inaccuracy miss the point that the media are not a simple ‘window on the world’ or ‘mirror of reality’ but are highly selective in what they represent

and how they frame what is represented – they are and should be interpreted as ‘symbolic representations’.

Film studies have been particularly helpful in highlighting the relevance of this to arguments about the ‘accuracy’ of media representation. Thus, Ingram (2000), in his analysis of public reactions to the Hollywood film *The China Syndrome*, noted how nuclear scientists, when asked about the film’s portrayal of risk and safety in the nuclear power industry interpreted the film in a realist context, and criticised it for presenting a view that was “inaccurate and incredible” leading “to an irresponsible misrepresentation of the nuclear industry as they knew it.” (Ingram, 2000: 172).

In a recent insightful and comprehensive overview of science and technology representations in film, Kirby (2014) similarly discusses the seemingly increasing attention to, yet persistent problems and difficulties associated with ‘accuracy’ in film/fictional representations of science. While Kirby succeeds excellently in demonstrating the analytical futility of ‘accuracy’, reiterating how context-dependent (e.g. whose perspective, the narrative and other constraints of the mode of communication – in this case, film – etc.) it is, and persuasively argues for ‘authenticity’ as a better concept for reconciling the divergence of objectives between science/scientists and film/film-makers, his analysis could usefully have gone significantly further in highlighting the vested economic and political interests that drive the surface concern with ‘accuracy’ in film portrayal. Kirby hints at this when charting the rise of science-organisation led consultancies/mediations and interventions aimed at influencing representations of science and concluding that “scientists and scientific organisations benefit from this arrangement [scientists advising film-makers] as popular films can promote research agendas, stimulate technological development, contribute to scientific controversies and even stir citizens into political action.” (Kirby, 2014: 99).

Kirby (2014) indicates that the rise in scholarship about ‘science and film’ as well as in science advisory and consulting services available to film-makers is partly driven by the change away from concern with (lack of) scientific literacy towards the more nuanced recognition that it is not scientific knowledge per se, but the social/cultural meanings of science that influence public attitudes to science. However, what could usefully have been pushed significantly further in this argument, is the point that concern about ‘accuracy’ in film and other fictional portrayal reflect significant underlying concerns about how public perceptions and attitudes are influenced.

This then, as in news studies, means asking – as Hilgartner (1990), Stocking (1999) and many others have done so well before – whose interests are served by particular portrayals of science, and how is the concern with ‘accuracy’ being used as a proxy (or euphemism, perhaps) for disagreement about the values and ideological messages being conveyed by particular ‘uses’/representations of science in popular film and entertainment media?

Accuracy in the changing media and communications environment

A key justification for research on science and health communication has long been the argument that the mass media serve as main sources of public information and education (Wade and Schramm, 1969; Brechman et al., 2011; Hallin and Briggs, 2015). Brechman et al. (2011: 496) thus argue that increasingly “in the absence of alternative sources, individuals turn to news sources for developments and/or commentary relating to matters of health”, and they go on to point to the key role of public information officers and news media journalists as intermediaries between scientists/medical researchers and the lay public, “selectively presenting certain pieces of information over others”. While there can be little doubt about the (traditional) importance of journalists and the increasing role of information officers, the premise “in the absence of alternative sources” would appear to be at odds with the rapid proliferation of sources which is a key characteristic of the new digital media environment. Contrary to Brechman et al.’s argument, I would argue, that it is the massive proliferation of sources and associated views and opinions, which is the key challenge, as sources/views/opinions are beyond the conventional processes for establishing accuracy, credibility and authenticity (including those exercised by traditional science/medical journalism). In a similar vein of criticism, while Hallin and Briggs (2015) provide a strong argument for bringing the changing paradigms of journalism research to bear on health communication, they say little or nothing about how the changing media environment is impacting on the roles of journalists and traditional media in health communication.

The resurgence in the present century of debates about accuracy and the closely related concepts of uncertainty, balance, objectivity and impartiality in science communication is perhaps unsurprising in light of the very significant developments over the last 20-30 years in communications technology and the concomitant changes to the media and communications environment, and indeed to journalistic work. Friedman (2015: 147) notes

how economic pressures, media-downsizing, new media platforms changing how audiences consume/interact with news have undermined traditional news reporting practices, leading “news people to question whether the core values of accuracy and verification could be maintained when fewer people were being asked to do more (Pew Research Center’s Project on Excellence in Journalism, 2008)”.

Williams (2015: 198) likewise summarises evidence showing how “Journalism’s contraction in the past two decades has been more than matched by an expansion in the field of PR” and he goes on to note that “Not only have those in the energy, chemicals, agriculture, pesticide and biotechnology industries expanded their public relations efforts, but so have public and civil society players such as universities, research councils, specialist science publications, charities, NGOs and other activists [...]”

Williams reviews some of the important evidence beginning to emerge from research on the rise in public relations strategies (whether deployed by scientists/science institutions, activist groups or corporations/big business) and notes how the increasing pressures on journalism in general, and on science and environmental journalism very particularly, lead “to a newsroom environment where the same number, or fewer, journalists are asked to do far more with no extra resources.” (2015: 202). And this, he continues, has significant negative implications for the ability to execute traditional journalistic tasks, such as fact-checking stories for accuracy, exacerbating “an already extant shift in the balance of power between reporters and their sources.”

The massively increased public access (both as consumers and producers of information) to means of communication in the new digital media environment offers new opportunities for engagement in science communication (including, according to Jensen et al (2013), for dealing with uncertainty in health communication), but also has significant implications for questions about accuracy. Allan and Ewart (2015: 193), in their review of the rise of citizen journalism in science/environment/risk communication, note for example with reference to communication in the aftermath of the 2011 earthquake and tsunami in Japan how ‘social networking sites such as Twitter became highly useful sources of real-time information for citizens in the aftermath of the earthquake’. But crucially they go on to note, with reference to research by Friedman (2011), that “[D]espite the best intentions of many – albeit not all – of the citizens involved to be accurate, much of this reportage proved to be scientifically incorrect [...]”

The new media and communications environment then has already significantly altered the working practices and roles of science journalists and other media professionals, with implications for accuracy, fact-checking, etc. and in a much wider sense, with implications for control over and vetting of information. As Boykoff et al. (2015: 227) eloquently point out:

[...] these new media developments prompt us to reassess boundaries between who constitute “authorized” speakers (and who do not) in mass media as well as who are legitimate “claims-makers.” These are consistently being interrogated, and challenged (Gieryn 1999; Loosen and Schmidt 2012). Anthony Leiserowitz has written that these arenas of claims-making and framing are “exercises in power ... Those with the power to define the terms of the debate strongly determine the outcomes” (2005: 149).

In light of the rapid developments in the media and communications environment sketched above, it is unsurprising – and indeed appropriate – that traditional narrow concerns about the ‘accuracy’ of science communication have tended, in the present century, to be reformulated in the language of the closely associated journalistic values of balance, objectivity and impartiality. While still tainted by their origins in a linear transmission model, they direct attention to the range of voices and to questions about how and whose evidence/views/opinions regarding science come to dominate and influence public communication about science, risk, health, the environment, etc.

Conclusions and looking ahead

Hallin and Briggs (2015) succeed excellently in reiterating the argument that much is to be gained from combining the extensive literatures on science/health journalism with the likewise extensive literature on health communication. But this is not, as we have seen in this article, a particularly new argument. Indeed we now – thanks to the wealth of research on science/environment and health journalism over the last 3-4 decades – know a great deal about the multiple factors that impinge on, and the multidirectional – rather than linear – communication processes that characterise the mediation, communication and construction of science in society. Just as the questioning of the concepts of bias, objectivity and accuracy became well-rehearsed in journalism research in the 1970s and 1980s, so too did sociologists of science and researchers of science communication start to question their underlying assumptions and usefulness in models of public understanding of science.

I have argued in this article that this is borne out by a decline in studies of ‘accuracy’ in science journalism from the mid-1980s onwards, and a diversification of terms (and associated research foci) used in addressing concerns about the public understanding of science. Broadly speaking – and running the risk of oversimplifying – a relatively narrow focus on what was seen as a problem of inadequate or flawed ‘translation’ through the mainstream news media of science communicated to a wider lay public, and a matter of identifying the type of errors, inaccuracies and omissions that arose in this process, grew into a much more complex appreciation of the multiple influences on science communication. Importantly, the traditionally narrow focus on media science content also grew into a much wider range of research foci, including the study of sources and their deliberate framing of information for mediated dissemination and including the study of varieties of audiences/publics and their (active) role in interpreting and making sense of mediated scientific information.

While the constructionist view that science communication is a multifaceted process with many influences at work has been readily and widely accepted, the associated part that science communication and the concerns with accuracy, balance and impartiality are best understood as competition over the power to control and police what knowledge/information/evidence passes as correct and right in society has received less attention. Answering research questions about the nature and dynamics of how particular constructions/views/perspective come to dominate the public sphere, but also about whose interests are served by focusing on accuracy, balance and impartiality, remain as important now as when they were first articulated.

On the basis of the trends, lacunae of research and changes identified in the foregoing survey and discussion, I finish with the following suggestions for research questions for the future:

- 1) The implications of the rapidly changing communications environment (digital media, social media, user-generated content, civic science journalism, etc.) where a combination of rapid technological development and increasing economic pressures on media institutions result in a much changed type of mediation. Much of the authority and trustworthiness of traditional media organisations and modes of communication are replaced by a multitude of communications/sources/channels whose motives and science become increasingly difficult to assess. How do these changes impact on trustworthiness, credibility and indeed science’s very ability to act as the only recognised valid generator of evidence?

- 2) The manipulation of the mediated environment is becoming increasingly complex and diverse. Research has only just been catching up in the last decade or two with some of the fascinatingly skilful ways in which public communication and debate on climate change has been influenced by ‘front groups’ questioning the emerging scientific consensus by sowing doubt (famously articulated as ‘doubt is our product’) or siding with an assortment of so called climate sceptics, including the exploitation of the journalistic values such as ‘balance’ (leading to the ‘balance as bias’ argument). Some of the key challenges for future research on science communication (as indeed for health communication) concern the changing nature of how we interact with, assess and consume information. This involves moving from the focus on traditional media and genres, to examining how commercial companies and perhaps universities and related scientific institutions are increasingly making use of a wide variety of digital/online media and media forms (including gaming) for promoting products or ideas or indeed science/health information.
- 3) As the media and communications environment changes and becomes increasingly diverse and differentiated, there is an urgent need for a much greater use of comparative research. The predominant mode of research on public communication of science – and on associated concerns with accuracy, balance, impartiality etc. – has for a long time, and indeed continues to comprise of studies focusing on a single traditional mass medium (most often newspapers, less frequently television and rarely radio) and on science news journalism over relatively narrowly defined periods of time. Only by conducting comparative research in the full meaning of this term – i.e. comparative across media, across genres, across cultural/political environments, and most crucially across time - can we begin to understand the complexity of factors influencing the production, mediation and public engagement with scientific/medical evidence and expert knowledge. As we have seen in this review, while there has long been awareness of the need to differentiate between media and genres in science communication generally and in relation to research on accuracy and related dimensions particularly, few have drawn attention (Philo and Happer, 2013, being a significant exception to this pattern) to how levels of accuracy change significantly over time, vary by medium or are influenced by changing political rhetoric.
- 4) Just as research is needed on the increasingly active production/promotion and strategic use of science communication in the public sphere by multiple

‘sources’/communicators (Government, NGOs, business, corporations, universities, science institutions, pressure groups, etc.), so too is research needed on how different publics interact with and act upon public information, debate and controversy about science. Much more research is needed on how diverse publics interpret and ‘deal with’ accuracy, balance, uncertainty, hedging, etc. in public communication of science, and perhaps more significantly into how different publics choose their information sources and discern credibility and validity of information in an increasingly diverse media environment, where traditionally ‘trusted’ sources are just one amongst many providers of scientific or medical ‘evidence’.

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