

Human Culture and Science Fiction: A Review of the Literature, 1980-2016

SAGE Open
July-September 2017: 1–15
© The Author(s) 2017
DOI: 10.1177/2158244017723690
journals.sagepub.com/home/sgo


Christopher Benjamin Menadue¹ and Karen Diane Cheer¹

Abstract

This article aimed to uncover the foci, themes, and findings of research literature that utilized science fiction content or concepts to describe and illustrate human culture. To capture a representative range of research, the PRISMA process was applied to database searches across a range of disciplines, not restricted to science fiction journals. Findings revealed that science fiction literature has been used in research across disciplines including theology, semantics, natural sciences, and education. Two characteristics of the use of science fiction in research became evident in the review: its role as a tool for advocacy and cultural insight and its effectiveness as an aid to learning and teaching. An unclear boundary between real science and science in the public imagination is problematic for research success, but the purposeful integration of fictional representations of science (both natural and social) into the research story has demonstrable benefits. To address the limited application of objective methodologies, adoption of increasingly robust quantitative analysis into research in the fields of literature and culture is recommended. This would assist in bridging the two cultures divide between the humanities and natural sciences.

Keywords

convergence, fiction, methodology, multidisciplinary, science communication, two cultures

Introduction

Culture has been defined as “the symbolic, ideational, and intangible aspects of human societies. The essence of a culture is not its artifacts, tools, or other tangible cultural elements but how the members of the group interpret, use, and perceive them” (Banks & Banks, 2004, p. 8), or, more simply, as knowledge and behaviors shared within groups of interacting individuals (Useem, Useem, & Donoghue, 1963). For the purposes of this review, we accepted that the search terms employed would capture the definitions of culture that were understood by the authors of the sources we discovered. These sources indicated that science fiction has become prominent in social and cultural research that is not purely focused on science fiction content, but which uses science fiction to complement research across a broad range of disciplines and research activities.

Science fiction is significant in studies of human culture as it is an ancient and enduring form of literature that has been part of what Brian Aldiss called our “cultural wallpaper” since the origins of recorded history (Aldiss & Wignmore, 1986, p. 14). Adam Roberts suggested that science fiction begins with the “voyages extraordinaires” of the Ancient Greeks (Roberts, 2005, p. vii), but we might go back a millennium further to the Sumerian creation story, with the supreme god Marduk “cloning” mankind from the blood and bone of the renegade god Kingu (Enûma Eliš, 5.26). Science

fiction became an increasingly significant genre for literary study after Darko Suvin’s (1979) epochal publication of *Metamorphoses of Science Fiction*, which raised the profile of science fiction as a legitimate field of academic enquiry (Hassler, 1999). Suvin’s work has become a core text around which the study of science fiction circulates, and it has been used accordingly as the limiting date for this review.

The complexities of the relationship between science fiction and human realities are manifest. From a literary-critical perspective, Carl Freedman described science fiction as the most legitimate genre for academic study, placing it above all other forms of literature for its analytical potential (Freedman, 2000). From the human perspective, science fiction has grown from a more or less plausible science focus in the early 20th century to adopt more sociological and cultural factors over time. By the 1960s and 1970s, science fiction generated by the “British New Wave” reflected dramatic changes in contemporary culture, especially political aspects of gender, conflict, and freedom of expression. Driven by the need to provide some sort of manageable interpretation of an

¹The Cairns Institute, James Cook University, Queensland, Australia

Corresponding Author:

Christopher Benjamin Menadue, The Cairns Institute, James Cook University, MacGregor Road, Cairns, QLD 4870, Australia.
Email: ben.menadue@jcu.edu.au



increasingly complex and unstable social and intellectual reality, it absorbed and softened the impact of that complexity by depicting possible futures as being similarly iconoclastic and haphazard (Greenland, 1983). It has even been argued that the intermingling of science fiction and fact regarding the creation of artificial intelligences and synthetic humans permeates our culture so deeply that it influences our existential relationship with God (Geraci, 2007).

Science fiction questions the role, relevance, costs, and benefits of current and future technologies, and presents ideas that can influence public opinion. Brian Stableford claimed that science fiction could determine the worldview of individuals, by the modification of attitudes to the significance of current and future science and technology (Stableford, 1979). Marshall Tymn agreed that as a literature, science fiction equips us to accept change as natural and inevitable (Tymn, 1985). As change is a natural outcome of applied scientific research, science fiction has been employed as a tool by researchers to provide metaphors, analogies, and models that describe the findings of their research (Bina, Mateus, Pereira, & Caffa, 2017; Hansen, 2004; Kotasek, 2015; McIntire, 1982; Toscano, 2011). Human acceptance of change is difficult and resists authoritative statements of fact, as has been identified in applied psychological and sociological studies (Nyhan, Reifler, Richey, & Freed, 2014; Prochaska, DiClemente, & Norcross, 1992). Science fiction is an effective agent for change, and, as Stableford (1979) has suggested, it also has a “directive effect” on people’s interpretations of science. Ann Rigney described how Kurt Vonnegut’s widely read 1969 science fiction novel *Slaughterhouse-Five* has educated readers about the scale and impact of the bombing of Dresden, despite the dubious accuracy of Vonnegut’s depiction compared with historical records (Rigney, 2009). This is an example of how science fiction can overwrite the cultural memory of historic events and has become “centrally relevant in many explorations of contemporary culture” (Hollinger, 1999, p. 1).

This “cultural wallpaper” exerts influence on society, which is persistent, and pervades the work of researchers in both the humanities and the natural sciences. Sheila Schwartz suggested that science fiction “is not *only* a bridge between the *two* cultures of science and the humanities; it is a bridge between all cultures as it summarizes and expresses the nightmare fears, myths, and inescapable concerns of all people today” (Schwartz, 1971, p. 1044). Science fiction narratives also provide a historical record of changes over time in social and cultural values that can be used to map these to their original contexts (Menadue, 2017). A deeper understanding of the relationship between research, culture, and science fiction is necessary, and the application of science fiction as a tool in the context of research should be encouraged. There is evidently a relationship between science, science fiction, and the cultural imagination, and the significance of this relationship should be assessed; however, reviews of academic literature on this subject were not located.

The purpose of this literature review was to provide an overview of the research relating science fiction to culture across a range of academic disciplines, and was not limited to science fiction studies. This review aimed to uncover the breadth and depth of the relationships between science fiction and human culture that have been expressed in peer-reviewed research that

1. investigated the uses of science fiction by researchers who described possible causal or correlational relationships between science fiction content, culture, and society; and/or
2. employed science fiction concepts as analogies to explain or illustrate cultural activity.

Selected journal articles and book chapters indexed in four online databases were analyzed. A limitation of the study was that nonindexed publications were excluded, and consequently, older and more specialized publications were underrepresented. The objectives of the review were to report the focus of research, theme of research, and summary findings. To add objective rigor to the study, the reviewing team included members from multidisciplinary backgrounds.

Method

A PRISMA¹ process was applied to identify papers and book chapters from JSTOR, PubMed, SCOPUS, and Web of Science databases. To ensure all relevant research literature was identified, an advanced search strategy was undertaken with librarian consultation, described in Figure. 1. We included articles and book chapters published in English. Reviews, editorials, and conference papers were excluded.

The scope of sources to investigate was based on publications between 1980 (following Suvin’s *Metamorphoses*) and 2016. Web of Science Social Sciences Citation Index (SSCI) and Arts & Humanities Citation Index (A&HCI), SCOPUS, and PubMed databases were searched using the following search terms:

- Web of Science SSCI and A&HCI: Title Search = litera* AND (science AND ficti* AND cultur*)
- SCOPUS: Title Search, Abstract, Key Words = science AND Key Words ficti* AND Key Words = litera* AND Title, Abstract, Key Words = cultur*
- PubMed: ((litera*) AND science) AND ficti*) AND cultur*
- JSTOR: (((abstract:(science) AND abstract:(cultur*)) AND abstract:(litera*)) AND abstract:(ficti*))

Abstracts of retrieved publications were scanned for content that included overt or strongly implied themes related to science fiction and culture. Abstracts with no clear links between science fiction and cultural topics or with only peripheral references to science fiction and culture were excluded.

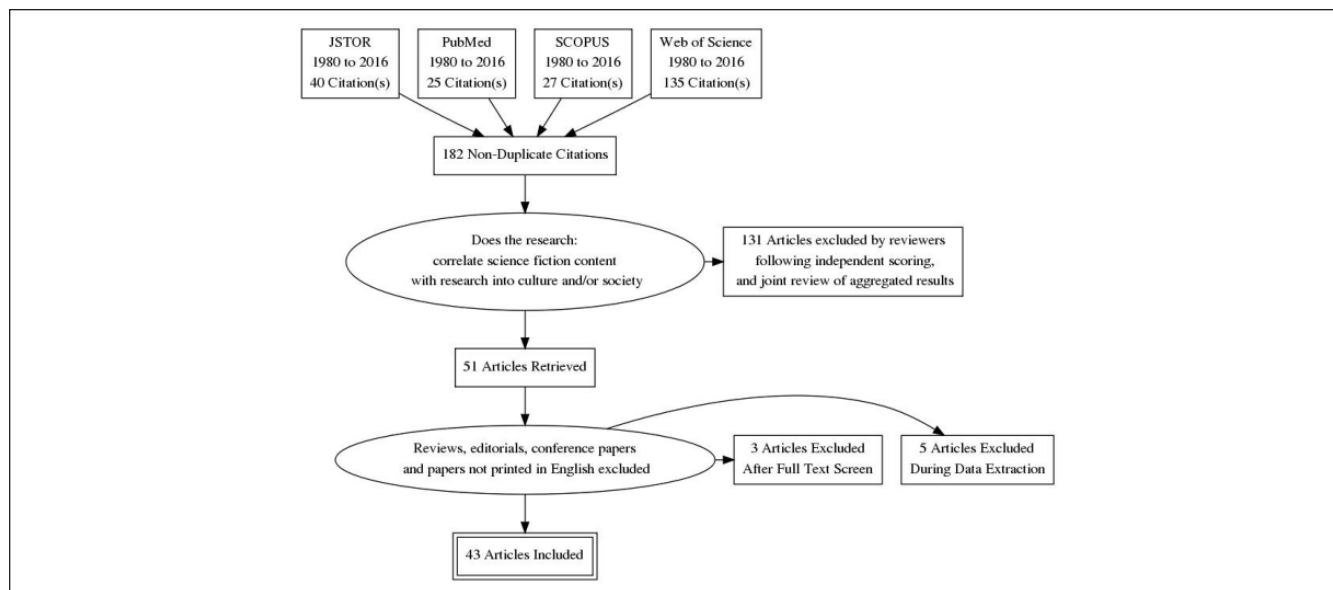


Figure 1. Flowchart of the selection of relevant articles using the PRISMA model.

Selected abstracts were distributed among the coauthors and an independent reviewer for validation according to three selection criteria:

Did the publication

- relate science fiction (SF) content or concepts to society or culture,
- employ science fiction to illustrate culture or society, or
- employ science fiction to illustrate, promote or otherwise advance science?

For each criterion, reviewers individually assigned a value from zero to three to each paper by examining the title and abstract content only. Total scores were aggregated. Papers receiving a score of six or more points out of the nine available across all categories, or three points in any one category were selected for full reading, which examined the research focus, research themes, data sources, methodology, and research findings.

Themes were classified into major headings using an iterative methodology of reduction from initially broad and descriptive themes to a list of summary themes.

Results and Discussion

The use of controlled vocabulary thesauri or subject headings varies across databases. For example, SCOPUS, as an indexing database, may include subject headings originating from a source database. Often however, documents from the humanities and social science fields in SCOPUS contain only author keywords. Authors choose keywords representing what they regard as the most significant descriptors of the content of

their work (Névél, Dogan, & Lu, 2010). This may result in duplication, as keywords are commonly terms appearing in the abstract (Mack, 2012; Strader, 2011). Furthermore, limitations on the number of keywords an author can nominate during the manuscript submission process, and whether these keywords/phrases are determined from a controlled vocabulary or using natural language influences keyword selection (Peh & Ng, 2008). Author selection of keywords affects retrieval patterns, indicating authors should carefully consider their target reading audience when self-selecting keywords.

Considering these factors, we searched across the selected databases using a combination of terms for title, abstract, and keywords. Our decision to restrict search parameters enabled more focused retrievals; however, a limitation of this method is that some papers published in journals with a science fiction focus may not have been retrieved. Performing full-text searching results in a greater number of retrieved documents but this can be at the expense of relevance (Beall, 2008). Researchers should, therefore, carefully consider search structure, working within individual database features to create an efficient search strategy that helps achieve their research objectives.

The study characteristics from each reviewed article are summarized in Table 1. The data from the selected articles come from 34 journals across 15 disciplines, and include results published in English of analysis of primary sources from eight countries, including material from Brazil, Russia, and Holland. Only four papers were published before 2000: two in the 1990s and two in the 1980s (Jameson, 1987; McIntire, 1982; Nerlich, Clarke, & Dingwall, 1999; Van Dijck, 1999). The prevalence of more recent works was due to the search methodology, which excluded hand searching, investigating works cited in the selected papers, or gray literature, rather than a reflection on the proportional volume of publications in this field over the period.

Table 1. Study Characteristics of Each Reviewed Article.

Author(s)	Date	Title			Publication
Bainbridge, W.S. Focus of research If scientific and cultural development can be assessed in terms of semantic and systematic systems, considering growing technological capabilities for computational analysis	2004	"The Evolution of Semantic Systems" Theme Science and technology studies	Data sources A range of critical-historical texts and quantitative analysis of online recommendation systems, surveys, and government statistics	Methods Quantitative	<i>Annals of the New York Academy of Sciences</i> Summary The convergence of social and natural sciences brought about through technological applications and concerns may enable the collecting together of disparate disciplines with different approaches into a more functional and effective way of approaching the world from a convergent scientific perspective
Author(s)	Date	Title			Publication
Banerjee, A. Focus of research The depiction of electricity in 20th-century Russia and how it reflects political and cultural values and change	2003	"Electricity: Science Fiction and Modernity in Early Twentieth-Century Russia" Theme Connections between science fiction and human culture	Data sources Science fiction and historical texts	Methods Qualitative	<i>Science Fiction Studies</i> Summary Seemingly radical elements of the Bolshevik vision, such as the construction of a technological utopia in a traditionally "backward" agrarian society, originated and developed in the era that it actively tried to negate"
Author(s)	Date	Title			Publication
Bina et al., Focus of research On the use of science fiction to identify trends in human interest and concern that can be used to inform the development of government policies on science innovation	2017	"The Future Imagined: Exploring Fiction as a Means of Reflecting on Today's Grand Societal Challenges and Tomorrow's Options" Theme Influence of human culture on science fiction content	Data sources Science fiction texts, government policy, and advisory papers	Methods Quantitative	<i>Futures</i> Summary Changes in public concerns and attitudes toward science and innovation should be monitored through examination of science fiction film and text, and governments and funding bodies should use this information to guide policy development
Author(s)	Date	Title			Publication
Brandau, D. Focus of research How the boundaries between fiction and popular science became blurred in the 1900s: how this can be illustrated by the emergence of spaceflight as a popular fictional theme	2012	"Cultivating the Cosmos: Spaceflight Thought in Imperial Germany" Theme Science and technology studies/two cultures	Data sources Primary texts and subsequent literary criticism	Methods Qualitative	<i>History and Technology</i> Summary The links between science and fiction were of variable value in Imperial Germany but the relationship did demonstrate more general interests in science
Author(s)	Date	Title			Publication
Carpenter, C. Focus of research The influence of science fiction on global international relations policy—carrying out objective observational research on this topic	2016	"Rethinking the Political/Science-/Fiction Nexus: Global Policy Making and the Campaign to Stop Killer Robots" Theme Science communication	Data sources Interviews, participant observation notes	Methods Mixed	<i>Perspectives on Politics</i> Summary More reliable information is gained by primary interview and participant observation than other interpretative or pedagogical approaches. Science fiction breeds familiarity but is not demonstrably causal of attitudes. This methodology exposes scope for further valuable work.
Author(s)	Date	Title			Publication
Coyer, M.J. Focus of research Studying the relationship between comparative representations of medical and fictional medical content in a single magazine and the resulting hermeneutic issues	2014	"Phrenological Controversy and the Medical Imagination: A Modern Pythagorean in Blackwood's Edinburgh Magazine" Theme Relationship between science fiction and science culture	Data sources Articles from Blackwood's Edinburgh Magazine	Methods Qualitative	<i>Scottish Medicine and Literary Culture, 1726-1832</i> Summary Popular science and real science reinforce and inform each other: Writers and public seemed quite sceptical of phrenology (among other medical approaches that were covered in the magazine).

(continued)

Table 1. (continued)

Author(s)	Date	Title	Publication
Dunnett, O.	2012	Patrick Moore, Arthur C. Clarke and "British Outer Space" in the Mid 20th Century"	<i>Cultural Geographies</i>
Focus of research How the notion of "space from Earth" is illustrated by the works of Patrick Moore and Arthur C. Clarke and is linked to the philosophy of the British Interplanetary Society (BIS)		Theme Relationship between science fiction and science culture	Summary This article seeks to rediscover trends such as the cosmographical connection to geography, working toward "a human geography of celestial space, a cosmography for the twenty-first century."
Author(s)	Date	Title	Publication
Erren, T.C.; Falaturi P.	2009	"Research Insights and Insides: "Science-in-Fiction" as a Contribution to the Third Culture Concepts"	<i>Medical Hypotheses</i>
Focus of research How science fiction may be an instructional/educational medium addressing Snow's two-culture issues (synthesis of humanities and science) of 1960 and extension into a "third culture" by Brockman in 1995		Theme Pedagogy/two cultures	Summary Science fiction can be used as an educational medium to promote science in two-culture and three-culture environments
Author(s)	Date	Title	Publication
Fendt, J.	2015	"The Chromosome as Concept and Metaphor in Anitav Ghosh's <i>The Calcutta Chromosome</i> "	Anglia-Zeitschrift Fur Englische Philologie
Focus of research To explore within the context of science studies how a subject of scientific research can be inscribed in a literary text and can offer insights beyond its "factual" or "hard" knowledge of the sciences		Theme Science and technology studies/two cultures	Summary That fiction may be a good way of linking the imagination and the concrete and that this is essential for the proper development of science, that it forms an essential part of the cultural ecology that enables science to progress and there is a strong interconnectedness between science and literature
Author(s)	Date	Title	Publication
Geraci, R.M.	2007	"Robots and the Sacred in Science and Science Fiction: Theological Implications of Artificial, Intelligence"	<i>Zygon</i>
Focus of research Whether human beings have elevated intelligent machines to divine status and if this is a threat to traditional Christian theologies		Theme Connections between science fiction and human culture	Summary The allure and dread of technology often parallels human metaphysical and theological concerns and concepts. That our relationship with machine intelligence is ambivalent seeing it as both a source of fear and one of inspiration.
Author(s)	Date	Title	Publication
Gunway, M.E.	2005	"A Working Model for Analyzing Third World Science Fiction: The Case of Brazil"	Science Fiction Studies
Focus of research Aims to create a critical model for analyzing third-world science fiction		Theme Literary criticism/influence of human culture on science fiction content	Summary Brazilian ideas of national and cultural identity are strongly demonstrated by the representation in science fiction of analogues for slaves and neoliberal colonists and the application of mythological Brazilian notions of their culture and values to overcome and surmount problems that appear in the narrative
Author(s)	Date	Title	Publication
Guerra, S.	2009	"Colonizing Bodies: Corporate Power and Biotechnology in Young Adult Science Fiction?"	Children's Literature in Education
Focus of research Cultural concerns about technology that are reflected in the content of science fiction		Theme Relationship between science fiction and science culture	Summary Juvenile fiction concerned with cultural developments and impacts of the applications of biotechnology warn that the future of humanity will be defined by corporate greed and loss of individual freedom, and that the prevalence of these themes in fiction should be of concern to current policy and decision makers

(continued)

Table 1. (continued)

Author(s)	Date	Title	Publication
Hansen, B. Focus of research How comic book "real story" literature with medical heroes affected the perception of medical science and the attractiveness of a medical career to young Americans in the mid-20th century	2004	"Medical History for the Masses: How American Comic Books Celebrated Heroes of Medicine in the 1940s" Theme Pedagogy/science communication	<i>Bulletin of the History of Medicine</i> Summary It is very likely that the "true story" medical comics had a significant positive impact on the cultural value and profile of medical advances and medical scientists. That they provided simple but realistic information in an immediately accessible form and reflected the common themes in mass culture of the time.
Author(s)	Date	Title	Publication
Hills, M. Focus of research The distinction between the style and purpose of counterfactual, counterfactual, and fictional literature	2003	"Counterfictions in the Work of Kim Newman: Rewriting Gothic SF as "Alternate-Story Stories" Theme Literary criticism	<i>Science Fiction Studies</i> Summary The cultural politics of existent fiction can be explicitly and directly questioned by counterfiction. When existent fictional worlds become the starting point for extrapolation, a wider, more intertextual, view of science fictional "alternate-story stories" is called for.
Author(s)	Date	Title	Publication
Hrotic, S. Focus of research Cognitive group membership of SF genres, possibility that genre SF no longer exists as a specific—Steampunk as evidence to support this hypothesis	2014	"The Evolution and Extinction of Science Fiction" Theme Connections between science fiction and human culture	Public Understanding of Science Summary Familiarity with the disappointing outcomes of technological progress has led to a decline in the attractiveness of genre science fiction and this is reflected in a switch to an imaginative genre (Steampunk). This is rooted in an alternate reality that is able to conceive of a positivistic vision of technology and the future, borrowing this view from characteristics of Victorian culture.
Author(s)	Date	Title	Publication
Hull, E.A. Focus of research The relationship between science fiction and broader American culture. The role of popular fiction as accessible cultural commentary	2005	"Science Fiction as a Manifestation of Culture in America" Theme Connections between science fiction and human culture/ two cultures	<i>Foreign Literature Studies</i> Summary Science fiction analysis is best carried out in a mixture of forms, that historical perspective is necessary for most interpretation, that science fiction contains rich examples and can be read from a number of different, mixed, perspectives.
Author(s)	Date	Title	Publication
Idema, T. Focus of research Applying science and technology studies approaches (primarily) to the study of science fiction as a "minor literature," which is embedded in scientific and sociocultural constructs	2015	"Toward a Minor Science Fiction: Literature, Science, and the Shock of the Biophysical" Theme Connections between science fiction and human culture/ science and technology studies	Configurations Summary Science fiction, as well as other literature, can be read as a mode of thinking with science about the future of human life
Author(s)	Date	Title	Publication
Jameson, F. Focus of research What science fiction offers which goes beyond the formulas of soap opera and distinguishes it from what might be considered equally banal forms	1987	"Science Fiction as a Spatial Genre: Generic Discontinuities and the Problem of Figuration in Vonda McIntyre's "The Exile Waiting" Theme Literary criticism/connections between science fiction and human culture	<i>Science Fiction Studies</i> Summary Science fiction adds richness primarily due to the imaginary of space, being less to do with time than with more openly structured and flexible environments

(continued)

Table 1. (continued)

Author(s)	Date	Title	Publication
Jonsson, E. Focus of research How early stories by Wells reflect upon evolutionary and cultural historical/biographical factors that give them their resonance and lasting success	2013	“The Human Species and the Good Gripping Dreams of H.G. Wells” Theme Relationship between science fiction and science culture/ connections between science fiction and human culture	Style Summary Wells explored the differences between natural and artificial culture that were new and confronting during his period, the theory of evolution only recently having been published. That adventurous “gripping yarns” on these topics have become Wells’ legacy due to their popularist content.
Author(s)	Date	Title	Publication
Kohlmann, B. Focus of research Ecology: Exploring the interaction and mutual reinforcement of cultural concerns in early cold-war literature and science	2014	“What Is It like To Be a Rat? Early Cold War Glimpses of the Post-Human” Theme Relationship between science fiction and science culture/ connections between science fiction and human culture	Textual Practice Summary Early cold-war fascination with the posthuman drove a preoccupation with nonhuman forms of human existence and consequently raised ecological concerns for the future
Author(s)	Date	Title	Publication
Kotasek, M. Focus of research The function of science fiction in shaping ideas about evolution, posthumanism, artificial intelligence, and the processes that define the human mind	2015	“Artificial Intelligence in Science Fiction as a Model of the Posthuman Situation of Mankind” Theme Connections between science fiction and human culture/ science and technology studies	World Literature Studies Summary Connections between humans and technology, and fiction written about technology, exist in a hermeneutic relationship
Author(s)	Date	Title	Publication
Larsen, K. Focus of research Use of fantasy literature to teach astronomy	2011	“Hobbits, Hogwarts, and the Heavens: The Use of Fantasy Literature and Film in Astronomy Outreach and Education” Theme Pedagogy	Role of Astronomy in Society and Culture Summary That fantasy literature is a very effective tool for teaching astronomical science
Author(s)	Date	Title	Publication
Lin, T.H. Focus of research Classification of a specific work of science fiction as a genre hybrid	2013	“Beyond Science Fiction: Vladimir Odoevskij’s The Year of 4338 as a Hybrid Text” Theme Literary criticism	Russian Literature Summary That the work in question is more effectively considered as a hybrid text than specific genre
Author(s)	Date	Title	Publication
Maguire, M. Focus of research Analysis of the relationship between science fiction featuring engineers and their status in contemporary society esp. Stalinism	2013	“Aleksii N. Tolstoi and the Enigmatic Engineer: A Case of Vicarious Revisionism” Theme Science and technology studies	Slavic Review Summary There is a strong correlation between the socio/cultural environment of Stalin’s Russia and how harshly or positively engineers were portrayed in fiction

(continued)

Table 1. (continued)

Author(s)	Date	Title	Publication
McIntire, E.G. Focus of research To examine how geographers might benefit from examining how science fiction treats notions of space and environment	1982	"Exploring Alternate Worlds" Theme Pedagogy/science communication	Yearbook—Association of Pacific Coast Geographers Summary Science fiction provides a way of creating environments and ecologies and modeling human interactions with them that enables us to see our own geographical and environmental issues in a fresh light
Author(s)	Date	Title	Publication
Miller, T.S. Focus of research Examination of the role of science fiction as a lens through which to focus the narrative of the novel <i>The Brief Wondrous Life of Oscar Wao</i>	2011	"Preternatural Narration and the Lens of Genre Fiction in Junot Diaz's <i>The Brief Wondrous Life of Oscar Wao</i> " Theme Literary criticism/two cultures	Science Fiction Studies Summary Science fiction serves as a very effective lens through which the narrative of the novel is focused, in part due to the expansive and imaginary qualities of the genre
Author(s)	Date	Title	Publication
Milner, A. Focus of research To test theoretical models of utopia/dystopia in science fiction studies and assess the value of science fiction as the source of thought experiments on climate change	2009	"Changing the Climate: The Politics of Dystopia" Theme Pedagogy	<i>Continuum Journal of Media & Cultural Studies</i> Summary There are undervalued yet apposite tales of resonance and wonder, intelligence, and warning to be found in Australian dystopian SF. That these stories have resonance with the environmental questions and issues raised in contemporary society
Author(s)	Date	Title	Publication
Nerlich, B.; Clarke, D. D.; Dingwall, R. Focus of research How existing human ideas about science, often expressed in metaphors and sourced from science fiction, influence public perception of and representations of science	1999	"The Influence of Popular Cultural Imagery on Public Attitudes Towards Cloning" Theme Science communication	<i>Sociological Research Online</i> Summary Discourse on cloning is based on a network of metaphors and commonplaces that are provided by vivid images linked to science fiction media. We use common knowledge to provide meaning and cannot ignore the impact of public images of technology that have been created in fiction.
Author(s)	Date	Title	Publication
Newell, D.; Lamont, V. Focus of research How women represented domesticity and frontier themes in SF written by women pre-1970	2005	"Rugged Domesticity: Frontier Mythology in Post-Armageddon Science Fiction by Women" Theme Literary criticism/influence of human culture on science fiction content	<i>Science Fiction Studies</i> Summary Female SF writers made strong contributions to feminist literary concepts before the 1970s, that they portrayed a characteristic "frontier" domestic style in the representation of women in the narrative
Author(s)	Date	Title	Publication
Parrinder, P. Focus of research The distinction between the human and posthuman as portrayed in science fiction and from a historical perspective on the nature of humanity	2009	"Robots, Clones and Clockwork Men: The Post-Human Perplex in Early Twentieth-Century Literature and Science" Theme Connections between science fiction and human culture	<i>Interdisciplinary Science Reviews</i> Summary Consideration of the gradually changing historical concepts of what it is to be human informs the current (and complex) posthumanism debate and contrasts the postmodern approach to earlier perspectives. A historical view is invaluable for rationally examining current debates.

(continued)

Table 1. (continued)

Author(s)	Date	Title	Methods	Publication
Piper, A. Focus of research Analyzing the validity of belief that a specific work of science fiction was prophetic	2013	"Leo Perutz and the Mystery of St Peter's Snow" Theme Literary criticism	Data sources Primary source and comparative historical literature	<i>Time & Mind—The Journal of Archaeology Consciousness and Culture</i> Summary That the author would have had ready access to preexisting information that would explain the narrative content without the need for prophecy
Author(s)	Date	Title	Methods	Publication
Rabkin, E.S. Focus of research The future of criticism lies in making qualitatively more informed, imaginative, judgments that draw on systemic analysis of a vast, technologically mediated set of collective knowledge and experience	2004	"Science Fiction and the Future of Criticism" Theme Literary criticism/connections between science fiction and human culture	Data sources Examples of cultural artifacts in science fictional culture. Analysis of 1,959 stories in American SF Magazines between 1926 and 2000	Publications of the Modern Language Association Summary Science fiction is a "system" that reflects modes of modern science, and is fundamentally networked and collaborative. It is the most influential cultural system now that technological change "constantly provokes hope, fear, guilt, and glory." Analysis of science fiction texts may provide insights into cultural attitudes and contemporary society.
Author(s)	Date	Title	Methods	Publication
Rutten, K; Soetaert, R; Vandermeersche, G. Focus of research What science fiction tells us about cultural literacy and literary culture, analyzed through work of rhetorician Kenneth Burke. Examining specifically science fiction as "equipment for living" (literature) as a genre of "satire by <i>entelechy</i> ."	2011	"Science Fiction and a Rhetorical Analysis of the 'Literature Myth'" Theme Literary criticism	Data sources Works of Kenneth Burke, selection of primary fiction texts—1984, <i>Brave New World</i> , <i>Fahrenheit 451</i> , TV and Film	CLCWeb: Comparative Literature and Culture Summary Rhetorical analysis of science fiction narratives "offers possibilities to reflect critically on our contemporary attitude towards literacy, literacy culture, and art in general . . . perspectives of the future dramatized in science fiction reveal much about the context in which these narratives are told and therefore can teach us something about cultural practices and social values."
Author(s)	Date	Title	Methods	Publication
Schwartz, M. Focus of research Genre definition and role of Soviet Science Fantasy. Relation between cultural demands and literary content and form—especially anxieties and stress	2013	"How Nauchnaia Fantastika Was Made: The Debates About the Genre of Science Fiction From NEP to High Stalinism" Theme Science and technology studies	Data sources Literature, contemporary accounts	<i>Slavic Review</i> Summary The efforts of the Soviet state to control science fantasy were inconsistent and had strong influences on direction at certain times, even subduing the genre almost entirely during the mid-1950s.
Author(s)	Date	Title	Methods	Publication
Shaddox, K. Focus of research How sentiment and the rights of the human are expressed in <i>Never Let Me Go</i> similarly to abolitionist literature, and other emotionally charged cultural critique	2013	"Generic Considerations in Ishiguro's 'Never Let Me Go'" Theme Literary criticism/connections between science fiction and human culture	Data sources Primary texts and subsequent literary criticism	<i>Human Rights Quarterly</i> Summary That <i>Never Let Me Go</i> has stronger links to sentimental literature than to science fiction and that the issue it discusses deserves broader treatment outside of fantastical fiction
Author(s)	Date	Title	Methods	Publication
Sielke, S. Focus of research The link between science studies and the cultural work of literary texts that probe the history of knowledge production	2015	"Science Studies and Literature" Theme Science and technology studies	Data sources Science studies research, historical two and more cultures debates and the work of Richard Powers	Anglia-Zeitschrift Fur Englische Philologie Summary Defines and positions science studies within the current discussions on science, culture, and literature

(continued)

Table 1. (continued)

Author(s)	Date	Title	Publication
Slaughter, A.	2014	"Ray Guns and Radium: Radiation in the Public Imagination as Reflected in Early American Science Fiction"	<i>Science & Education</i>
Focus of research		Theme	Summary
The representation of radiation in early American science fiction as a corollary to existing history and philosophy of science treatments of the subject		Science and technology studies	Early science fiction reflects the popular interest in science but does not contain proper or realistic scientific method.
Author(s)	Date	Title	Publication
Steinmuller, K.	2003	"The Uses and Abuses of Science Fiction"	<i>Interdisciplinary Science Reviews</i>
Focus of research		Theme	Summary
Influence of science fiction on science, pseudoscience, and the realism of science and scientists portrayed in literature		Relationship between science fiction and science culture	Science fiction is strongly linked to pseudoscience and has reflected social and cultural historical interests in science. The relationship and focus between science and science fiction reflects contemporary issues of the time.
Author(s)	Date	Title	Publication
Strauss, K.	2015	"These Overheating Worlds"	<i>Annals of the Association of American Geographers</i>
Focus of research		Theme	Summary
Ecological issues: Opportunities to explore climate change in human geography are opened up by utopian and dystopian representations in science fiction		Relationship between science fiction and science culture	Utopias and dystopias are fundamentally spatial, stories of a better present and archaeological of the present, enabling exploration of alternative political futures and other socioeconomic systems
Author(s)	Date	Title	Publication
Toscano, A. A.	2011	"Using I, Robot in the Technical Writing Classroom: Developing a Critical Technological Awareness"	<i>Computers and Composition</i>
Focus of research		Theme	Summary
How technical writing and comprehension can be enhanced beyond the practical elements by considering science fiction representations of technology in a broader cultural context		Pedagogy/science communication	Students must understand that technologies are not merely tools but products of culture and society before they can acquire critical technological literacy
Author(s)	Date	Title	Publication
Van Dijk, J.	1999	"Cloning Humans, Cloning Literature: Genetics and the Imagination Deficit"	<i>New Genetics and Society</i>
Focus of research		Theme	Summary
Science fiction as a tool for comprehending and evaluating the scientific "imagination deficit" and associated oversimplification of science		Pedagogy	Cloning is represented in a variety of positive, negative, and neutral ways in fiction, and literary narratives are important intermediaries (between nature and science, science and culture) and rhetorical tools in the construction of public meanings and the public understanding of science.
Author(s)	Date	Title	Publication
Van Gorp, B; Rommes, E; Emons, P.	2014	"From the Wizard to the Doubter: Prototypes of Scientists and Engineers in Fiction and Non-Fiction Media Aimed at Dutch Children and Teenagers"	<i>Public Understanding of Science</i>
Focus of research		Theme	Summary
Identifying prototypes of scientists in juvenile media and how that may affect the image of science in society		Pedagogy	Creates seven prototypes of fictional scientists and contrasts with prototypes of real scientists—the fictional prototypes provide misinformation that is unrepresentative and often negative
Author(s)	Date	Title	Publication
Wilsing, M; Akpinar-Wilsing, N.	2004	"Integrating 'Outer Space Design' Into Design Curriculum"	<i>International Journal of Art & Design Education</i>
Focus of research		Theme	Summary
Using science fiction concepts to stimulate the creative imagination of design students		Pedagogy	Science fiction is a very effective pedagogical tool for teaching design students and the use of it is to be encouraged as an aid to conventional curricular teaching.

Table 2. Thematic Classification of Publications, Number in Each Category.

Theme	Number
Connections between science fiction and human culture	12
Influence of human culture on science fiction content	3
Literary criticism	10
Pedagogy	9
Relationship between science fiction and science culture	7
Science and technology studies	7
Science communication	5
Two cultures	5
Total	58

The thematic classification of texts is shown in Table 2. The total is greater than the number of publications as 15 papers were classified as having two balanced themes.

Thematic Analysis

Cultural themes dominated the content of the publications (Table 2). The “two cultures” debate initiated by the British novelist and polymath C. P. Snow (1961), regarding the perceived cultural gap between the natural sciences and humanities, was explicitly addressed in five papers (Brandau, 2012; Erren & Falaturi, 2009; Fendt, 2015; Hull, 2005; Miller, 2011) but was implicit in a majority of the works examined. Among cultural themes, there were clear distinctions between research examining the relationship between science culture and science fiction, which examined the influence of human culture on science fiction content, and the research that focused on connections between science fiction and human culture. The first two of these themes are bidirectional—science fiction can influence science and scientists (Dunnett, 2012; Hansen, 2004; Steinmuller, 2003), science can influence science fiction (Guerra, 2009; Kohlmann, 2014), and this relationship can be reciprocal (Coyer, 2014; Jonsson, 2013; Strauss, 2015). The theme of “connections between science fiction and science culture” indicated a less directive association: Observations of congruence rather than influence were specifically noted in nine papers (Banerjee, 2003; Geraci, 2007; Hull, 2005; Jameson, 1987; Jonsson, 2013; Kohlmann, 2014; Kotasek, 2015; Parrinder, 2009; Shaddox, 2013).

The primary discipline-specific themes were literary criticism and pedagogy, appearing in 10 and nine publications, respectively (see Table 2.). Two of the literature papers were focused on traditional close reading of specific texts (Lin, 2013; Piper, 2013). Literary criticism is an expected theme in a review of publications on fiction; pedagogy, however, was not a search term and consequently the prevalence of the use of science fiction in education and for educational purposes was a significant finding. This varied from classroom

education employing science fiction texts and media as aids to learning (Larsen, 2011; Toscano, 2011; Wilsing & Akpinar-Wilsing, 2004), to observations on how science fiction has served as popular, informal, education on a range of topics; leading to both positive (Coyer, 2014; Hansen, 2004; Jonsson, 2013; Strauss, 2015) and negative outcomes (Banerjee, 2003; Geraci, 2007; Hull, 2005; Jameson, 1987; Jonsson, 2013; Kohlmann, 2014; Kotasek, 2015; Parrinder, 2009; Shaddox, 2013; Van Gorp, Rommes, & Emons, 2014), to recommendations on the use of science fiction as an effective educational medium or resource (Erren & Falaturi, 2009; McIntire, 1982; Milner, 2009; Van Dijk, 1999).

The majority of the remaining papers were classified under the closely related, but distinct, themes of science and technology studies (Bainbridge, 2004; Brandau, 2012; Fendt, 2015; Maguire, 2013; Schwartz, 2013; Sielke, 2015; Slaughter, 2014) and science communication (Carpenter, 2016; Nerlich et al., 1999), which were also connected to pedagogy in three papers (Hansen, 2004; McIntire, 1982; Toscano, 2011). The two explicitly communications-themed papers were concerned with the melodramatic and negative effect of use of science fiction tropes in media representations of science. The two papers approached this from different methodologies and came to differing conclusions. Carpenter concluded from participant observation within nongovernment organizations focused on campaigning against “Killer Robots” that tropes used from science fiction (e.g., *Terminator*, *RoboCop*) were effective as inducements to draw people into more fruitful debate about politically sensitive research policy, whereas Nerlich, Clarke and Dingwall found media associations of cloning with stories such as *Frankenstein* and *Brave New World* had a very negative and damaging effect on public perceptions of research. Their findings could be interpreted as illustrating that negative “diegetic prototypes” (Kirby, 2010) can be employed for sensationalist purposes. Carpenter’s participant observation confirmed positive outcomes arising from the appropriation of fearful film tropes for the purpose of attracting interest in open debate of their subject matter. Nerlich et al. examined literary and media examples, more than film, and these tended to be darker and more negative—promoting fears about emerging science. The “directedness” of the authorship of these narratives is manifest: positive from expert research advocates, negative from less well informed, and sensationally invested, news media. Carpenter’s paper illustrates what Jan Schwarz styles as “storylistening” (Schwarz, 2015, p. 512). The organization uses popular narratives to embody the fictional in the factual debate on robotic futures, and creates a compelling hybrid for the engagement of the public. This builds an “alternative mode of knowing” (p. 512), in which the public will discuss the factual science due to their interest in the fictional narrative, and the organization can learn more from the public. The alternative mode retains the human significance of the fictional versions, enabling future research design to include measures to address these

human concerns. Science and technology studies-themed papers tended to be more abstract; all the authors except Bainbridge examined specific aspects of science appearing in historic literature that can be related to theory. Bainbridge's paper, being a forward-looking description of the potential to employ advances in technology to aid the convergence of natural sciences and humanities, was focused on applied science. To achieve this, Bainbridge advocated using systematic semantic systems to integrate research cultures that are currently isolated. He demonstrated the practicality and effectiveness of this systems-based approach by applying it in this paper, employing quantitative analysis to support qualitative evaluation of the theory across multidisciplinary frameworks. Two other papers also utilized quantitative methodology, to apply science fiction to the interpretation of cultural change (Rabkin, 2004), and to drive innovation policy (Bina et al., 2017). The remaining papers employed qualitative or mixed methods.

The six publications that have not yet been mentioned (Ginway, 2005; Hills, 2003; Hrotic, 2014; Idema, 2015; Newell & Lamont, 2005; Rutten, Soetaert, & Vandermeersche, 2011) exhibited foci or approaches that were either very specific or not readily classifiable. Ginway discussed science fiction from the developing world, specifically Brazil, making observations on the specificity of science fiction themes and mythology to cultural values, which are valuable in demonstrating this entanglement from a perspective outside of the English-speaking tradition. Hills and Hrotic both examined modern developments in science fiction writing that reuse historic literary and cultural traditions: Hrotic suggested current disappointment in science explains the success of Steampunk literature, which harkens back to the scientific optimism of the Victorian era, and Hills discussed Kim Newman's reuse and exploration of classic science fiction and horror literature (*Dr. Jekyll and Mr. Hyde, Dracula*) as a means of exploring modern culture in historic literary environments already very familiar to readers. The only paper with gender as a critical subject was Newell and Lamont's discussion of pre-1970s science fiction by female writers from a feminist perspective, although Hills also discussed gender concepts as regard to Newman's "queering" of the Jekyll and Hyde story. Idema concluded that futuristic, "hard" science fiction could be read as a mode of thinking with science about the future of human life. Rutten, Soetaert, and Vandermeersche employed rhetorical models of analysis to describe science fiction as a "satire for living"—particularly with regard to fictional dystopias: Theirs is the only paper that applied this approach.

Discussion

There were two prominent applications of science fiction that became evident in the close examination of the publications reviewed. The first was the power of science fiction as

a tool for scientific and social advocacy and cultural insight: Erren and Falaturi said that science fiction might be used "to smuggle scientific facts into the consciousness of a scientifically illiterate public" and Kotasek concluded that as society depends upon the influence of our models of reality, so science fiction has a role in "constructing such cultural and social systems also to implicate the genre as a cultural, social, and political institution." (p. 76) Nerlich, Clarke, and Dingwall agreed, "the general public uses metaphors to talk about human dignity and autonomy, and they reach back not to philosophy books but to sci-fi novels and films to underpin their arguments." (p. 1.13) Bina used science fiction for "a form of forward-looking technique" that might have a significant role in influencing real-world policy. The clearest statement of this position was made by Van Dijck:

Science Fiction, throughout the centuries, has been a significant cultural tool for comprehending and evaluating the scientific, moral and social consequences of new technologies . . . besides projecting a possible future, science fiction often entails criticism of present technological or social arrangements. (p. 9)

The second major application was in the enhancement of learning and teaching. Research undertaken on this subject demonstrated a broad range of applications and was predominantly positive when the use of science fiction as a pedagogic tool was integrated purposefully into the curriculum. Toscano notably employed science fiction to educate students about good technical scientific writing: the most efficient combination of pedagogy and communication that was found in this review. The exception was Van Gorp's study, which was focused on passive, observational, learning absorbed by the subjects from the representations of science through fictional representations of science and scientists across a range of media. This was found to lead to negative or inaccurate views of science and scientists. In contrast, however, Hansen's analysis of comic book portrayals of science in the 1940s suggested that media representations could have positive impacts. In a formal, directional, context, the pedagogical applications are varied and have a measurable beneficial impact. Therefore, classroom use of science fiction provides valuable tools to both encourage interest in science and to inspire scientists, but passive absorption of science fiction concepts that cross over into real science is more problematic.

Considering the demonstrable impact of research applications of science fiction content and concepts, the small number of quantitative methodologies found in the review is significant, as is the variable quality of their implementation. Bainbridge provides a cogent and well-structured methodological example of the potential for science fiction to be an insightful and meaningful tool, and employs quantitative methodologies to analyze chaotic and granular data of the sort that is found in cultural studies. The strength of Bainbridge's multidisciplinary research in semantics is

evident in the consistent quality of his methodology. Rabkin's study included the intent to remove qualitative selection bias by engaging a pool of researchers from the field of literature to apply content categories to stories so that they could then be analyzed quantitatively. Yet, predefinition of coding categories appears to have constrained the freedom of analysis. For example, a strong correlation between the categories of genre form "alien contact" and genre content "alien" was one of the "provocative results" (p. 466) described in the findings, but such a correlation is naturally predicated at a one-to-one ratio in science fiction narratives. The study findings would arguably have been strengthened by identification of the statistical insignificance of this correlation by members of a multidisciplinary research team. Bina et al. applied iterations of subjective criteria to identify films and novels that were analyzed mathematically to create new suppositions, but the methodology is not described in replicable detail, and may have been subject to confirmation bias arising from the use of online databases to validate the selection. Using quantitative tools to analyze research findings in fields that have traditionally been dominated by qualitative methods is constrained by access to expertise. During the design and execution of the project, engaging experts from outside of the author's own specialism may improve the application of quantitative methodology to humanities research. The application of techniques such as data and text mining, robust statistical and structured methodological analysis, to studies that are traditionally located in the humanities would support the convergence between the arts and sciences, and the breaking down of the perceived gap between them that was highlighted by Snow in 1961. For analysis of literary content to become a credible tool in broader research contexts, a stronger focus on the use of quantitative, replicable, methodologies is to be recommended.

Conclusion

Science fiction has been used as a metaphor and as an illustration of human culture by researchers in fields that are not restricted to studies of science fiction literature. As such, there are indicators that science fiction is employed as a lens through which human culture may be viewed to discover new interpretations. These may be relevant to cultural, social, scientific, and literary studies, and support efforts at improving science communication, and especially science education. Researchers described the effectiveness of popular science fiction in capturing the imagination of the public, and creating unrealistic portrayals of science and scientists. This has both positive and negative impacts on science communication, and may even affect priorities in science funding. It seems that in the public imagination, science fiction is closely linked to real science, and this can be problematic for the dissemination of research. Rather than ignoring these links due to their fictional origins, it is necessary to engage with the public to learn about their hopes, fears, and

expectations of science, and to consider how science fiction may be employed for diegetic purposes. Raising awareness among scientists of the significance of these factors may build researcher capacity for successful science communication. Convergence of research between the humanities and natural sciences may be one route to supporting and encouraging more positive communication with the public, the credibility and efficacy of interdisciplinary science, and consequently more efficient and beneficial outcomes of research. This convergence should be driven by the increased application of structured and quantitative methodologies to the analysis of science fiction, and other traditionally humanistic forms, now that the technology exists to do this effectively and rapidly, to reduce the researcher bias in selection and interpretation of sources that is at the heart of the rejection of humanistic approaches by natural scientists. This breakdown of barriers is especially important when we consider the human, cultural perspective that can be added to hard sciences by this method, and how this may affect the effectiveness of science communication and the reputation of science in the minds of the public. The time is now for the integration of hard science methodology into the humanities.

Authors' Note

Christopher B. Menadue developed the initial concept and performed database searches. Menadue took the lead role in data analysis and drafted the article. Both authors edited and revised the draft article and approved the final article. Richard Lansdown, Komla Tsey, and Susan Jacups provided editorial input.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Menadue and Cheer are both recipients of Australian Postgraduate Awards for their PhD candidatures.

Note

1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Liberati et al., 2009; Stevens et al., 2014).

References

- Aldiss, B. W., & Wigmore, D. (1986). *Trillion year spree: The history of science fiction*. London, England: Gollancz.
- Bainbridge, W. S. (2004). The evolution of semantic systems. *Annals of the New York Academy of Sciences*, 1013, 150-177.
- Banerjee, A. (2003). Electricity: Science fiction and modernity in early twentieth-century Russia. *Science Fiction Studies*, 30, 49-71.
- Banks, J. A., & Banks, C. A. M. (2004). *Handbook of research on multicultural education* (2nd ed.). San Francisco, CA: Jossey-Bass.
- Beall, J. (2008). The weakness of full-text searching. *The Journal of Academic Librarianship*, 34, 438-444.

- Bina, O., Mateus, S., Pereira, L., & Caffa, A. (2017). The future imagined: Exploring fiction as a means of reflecting on today's Grand Societal Challenges and tomorrow's options. *Futures*, 86, 166-184. doi:10.1016/j.futures.2016.05.009
- Brandau, D. (2012). Cultivating the cosmos: Spaceflight thought in Imperial Germany. *History and Technology*, 28, 225-254. doi:10.1080/07341512.2012.722790
- Carpenter, C. (2016). Rethinking the political/-science/-fiction nexus: Global policy making and the campaign to stop killer robots. *Perspectives on Politics*, 14, 53-69. doi:10.1017/s1537592715003229
- Coyer, M. J. (2014). Phrenological controversy and the medical imagination: "A modern pythagorean" in Blackwood's Edinburgh Magazine. In M. J. Coyer & D. E. Shuttleton (Eds.), *Scottish medicine and literary culture, 1726-1832* (pp. 172-195). Amsterdam, The Netherlands: Rodopi.
- Dunnett, O. (2012). Patrick Moore, Arthur C. Clarke and "British outer space" in the mid 20th century. *Cultural Geographies*, 19, 505-522. doi:10.1177/1474474012452069
- Erren, T. C., & Falaturi, P. (2009). Research insights and insides: "Science-in-fiction" as a contribution to the third culture concepts. *Medical Hypotheses*, 72, 487-490. doi:10.1016/j.mehy.2008.12.017
- Fendt, J. (2015). The chromosome as concept and metaphor in Amitav Ghosh's "The Calcutta Chromosome." *Anglia-zeitschrift Fur Englische Philologie*, 133, 172-186. doi:10.1515/anglia-2015-0011
- Freedman, C. (2000). *Critical theory and science fiction*. Middletown, CT: Wesleyan University Press.
- Geraci, R. M. (2007). Robots and the sacred in science and science fiction: Theological implications of artificial intelligence. *Zygon*, 42, 961-980. doi:10.1111/j.1467-9744.2007.00883.x
- Ginway, M. E. (2005). A working model for analyzing third world science fiction: the case of Brazil. *Science Fiction Studies*, 32, 467-494.
- Greenland, C. (1983). *The entropy exhibition: Michael Moorcock and the British "New Wave" in Science Fiction*. London, England: Routledge & Kegan Paul.
- Guerra, S. (2009). Colonizing bodies: Corporate power and biotechnology in young adult science fiction. *Children's Literature in Education*, 40, 275. doi:10.1007/s10583-009-9086-z
- Hansen, B. (2004). Medical history for the masses: How American comic books celebrated heroes of medicine in the 1940s. *Bulletin of the History of Medicine*, 78, 148-191.
- Hassler, D. M. (1999). The academic pioneers of science fiction criticism, 1940-1980. *Science Fiction Studies*, 26, 1-22.
- Hills, M. (2003). Counterfictions in the work of Kim Newman: Rewriting Gothic science fiction as "Alternate-Story Stories." *Science Fiction Studies*, 30, 436-455.
- Hollinger, V. (1999). Contemporary trends in science fiction criticism, 1980-1999. *Science Fiction Studies*, 26, 232-262.
- Hrotic, S. (2014). The evolution and extinction of science fiction. *Public Understanding of Science*, 23, 996-1012. doi:10.1177/0963662513478898
- Hull, E. A. (2005). Science fiction as a manifestation of culture in America. *Foreign Literature Studies*, 6, 41-47.
- Idema, T. (2015). Toward a minor science fiction: Literature, science, and the shock of the biophysical. *Configurations*, 23, 35-59. doi:10.1353/con.2015.0003
- Jameson, F. (1987). Science fiction as a spatial genre: Generic discontinuities and the problem of figuration in Vonda McIntyre's "The Exile Waiting." *Science Fiction Studies*, 14, 44-59.
- Jonsson, E. (2013). The human species and the good gripping dreams of H.G. Wells. *Style*, 47, 296.
- Kirby, D. (2010). The future is now: Diegetic prototypes and the role of popular films in generating real-world technological development. *Social Studies of Science*, 40, 41-70.
- Kohlmann, B. (2014). What is it like to be a rat? Early cold war glimpses of the post-human. *Textual Practice*, 28, 655-675. doi:10.1080/0950236x.2013.858066
- Kotasek, M. (2015). Artificial intelligence in science fiction as a model of the posthuman situation of mankind. *World Literature Studies*, 7, 64-77.
- Larsen, K. (2011). Hobbits, Hogwarts, and the Heavens: The use of fantasy literature and film in astronomy outreach and education. In D. VallsGabaud & A. Boksenberg (Eds.), *Role of astronomy in society and culture* (pp. 306-310). Cambridge, UK: Cambridge University Press.
- Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P., . . . Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *British Medical Journal*, 339, b2700. doi:10.1371/journal.pmed.1000100
- Lin, T. H. (2013). Beyond science fiction: Vladimir Odoevskijs "The Year of 4338" as a hybrid text. *Russian Literature*, 74, 305. doi:10.1016/j.ruslit.2013.11.002
- Mack, C. (2012). How to write a good scientific paper: Title, abstract, and keywords. *Journal of Micro/Nanolithography, MEMS, and MOEMS*, 11, 020101.
- Maguire, M. (2013). Aleksei N. Tolstoi and the enigmatic engineer: A case of vicarious revisionism. *Slavic Review*, 72, 247.
- McIntire, E. G. (1982). Exploring alternate worlds. *Yearbook—Association of Pacific Coast Geographers*, 44, 93-108.
- Menadue, C. B. (2017). Trysts tropiques: The torrid jungles of science fiction. *Etropic*, 16, 125-140. doi:10.25120/etropic.16.1.2017.3570
- Miller, T. S. (2011). Preternatural narration and the lens of genre fiction in Junot Diaz's "The Brief Wondrous Life of Oscar Wao." *Science-Fiction Studies*, 38, 92-114.
- Milner, A. (2009). Changing the climate: The politics of dystopia. *Continuum: Journal of Media & Cultural Studies*, 23, 827-838. doi:10.1080/10304310903294754
- Nerlich, B., Clarke, D. D., & Dingwall, R. (1999). The influence of popular cultural imagery on public attitudes towards cloning. *Sociological Research Online*, 4, U237-U250.
- Névéol, A., Dogan, R. I., & Lu, Z. (2010). Author keywords in biomedical journal articles. In *AMIA Annual Symposium Proceedings, 2010*, 537-541.
- Newell, D., & Lamont, V. (2005). Rugged domesticity: Frontier mythology in post-Armageddon science fiction by women. *Science-Fiction Studies*, 32, 423-441.
- Nyhan, B., Reifler, J., Richey, S., & Freed, G. L. (2014). Effective messages in vaccine promotion: A randomized trial. *Pediatrics*, 133, e835-e842. doi:10.1542/peds.2013-2365
- Parrinder, P. (2009). Robots, clones and clockwork men: The post-human perplex in early twentieth-century literature and science. *Interdisciplinary Science Reviews*, 34, 56-67. doi:10.1179/174327909X421452

- Peh, W. C. G., & Ng, K. H. (2008). Abstract and keywords. *Singapore Medical Journal*, 49, 664-665.
- Piper, A. (2013). Leo Perutz and the mystery of "St Peter's Snow." *Time & Mind: The Journal of Archaeology, Consciousness and Culture*, 6, 175-198. doi:10.2752/175169713x13589680082172
- Prochaska, J. O., DiClemente, C. C., & Norcross, J. C. (1992). In search of how people change: Applications to the addictive behaviors. *American Psychologist*, 47, 1102-1114.
- Rabkin, E. S. (2004). Science fiction and the future of criticism. *Publications of the Modern Language Association of America*, 119(3), 457-473. doi:10.1632/003081204X20488
- Rigney, A. (2009). All this happened, more or less: What a novelist made of the bombing of Dresden. *History & Theory*, 48, 5-24.
- Roberts, A. (2005). *The history of science fiction*. London, England: Palgrave Macmillan.
- Rutten, K., Soetaert, R., & Vandermeersche, G. (2011). Science fiction and a rhetorical analysis of the "Literature Myth." *CLCWeb: Comparative Literature and Culture*, 13, 5.
- Schwartz, M. (2013). How nauchnaia fantastika was made: The debates about the genre of science fiction from NEP to High Stalinism. *Slavic Review*, 72, 224-246.
- Schwartz, S. (1971). Science fiction: Bridge between the two cultures. *The English Journal*, 60, 1043-1051. doi:10.2307/814025
- Schwarz, J. O. (2015). The "Narrative Turn" in developing foresight: Assessing how cultural products can assist organisations in detecting trends. *Technological Forecasting and Social Change*, 90, Part B, 510-513. doi:10.1016/j.techfore.2014.02.024
- Shaddox, K. (2013). Generic considerations in Ishiguro's "Never Let Me Go." *Human Rights Quarterly*, 35, 448-469.
- Sielke, S. (2015). Science studies and literature. *Anglia-zeitschrift Fur Englische Philologie*, 133, 9-21. doi:10.1515/anglia-2015-0002
- Slaughter, A. (2014). Ray guns and Radium: Radiation in the public imagination as reflected in early American science fiction. *Science & Education*, 23, 527-539. doi:10.1007/s11191-012-9559-0
- Snow, C. P. (1961). *The two cultures and the scientific revolution: The Rede lecture 1959* (1st ed.). New York, NY: The Cambridge University Press.
- Stableford, B. (1979). Notes toward a sociology of science fiction. *Foundation: The Review of Science Fiction*, 15, 28-40.
- Steinmuller, K. (2003). The uses and abuses of science fiction. *Interdisciplinary Science Reviews*, 28, 175-178.
- Stevens, A., Shamseer, L., Weinstein, E., Yazdi, F., Turner, L., Thielman, J., . . . Moher, D. (2014). Relation of completeness of reporting of health research to journals' endorsement of reporting guidelines: Systematic review. *British Medical Journal*, 348, g3804.
- Strader, C. R. (2011). Author-assigned keywords versus Library of Congress subject headings. *Library Resources & Technical Services*, 53, 243-250.
- Strauss, K. (2015). These overheating worlds. *Annals of the Association of American Geographers*, 105, 342-350. doi:10.1080/00045608.2014.973805
- Suvin, D. (1979). *Metamorphoses of science fiction: On the poetics and history of a literary genre*. New Haven, CT: Yale University Press.
- Toscano, A. A. (2011). Using "I, Robot" in the technical writing classroom: Developing a critical technological awareness. *Computers and Composition*, 28, 14-27. doi:10.1016/j.compcom.2010.12.001
- Tymn, M. B. (1985). Science fiction: A brief history and review of criticism. *American Studies International*, 23, 41-66.
- Useem, J., Useem, R., & Donoghue, J. (1963). Men in the middle of the Third Culture: The roles of American and non-Western people in cross-cultural administration. *Human Organization*, 22, 169-179. doi:10.17730/humo.22.3.5470n44338kk6733
- Van Dijck, J. (1999). Cloning humans, cloning literature: Genetics and the imagination deficit. *New Genetics and Society*, 18, 9-22. doi:10.1080/14636779908656887
- Van Gorp, B., Rommes, E., & Emons, P. (2014). From the wizard to the doubter: Prototypes of scientists and engineers in fiction and non-fiction media aimed at Dutch children and teenagers. *Public Understanding of Science*, 23, 646-659. doi:10.1177/0963662512468566
- Wilsing, M., & Akpinar-Wilsing, N. (2004). Integrating "outer space design" into design curriculum. *International Journal of Art & Design Education*, 23, 73-80. doi:10.1111/j.1476-8070.2004.00383.x

Author Biographies

Christopher Benjamin Menadue MA(Cantab.), MBA is a PhD candidate at James Cook University, Australia, applying digital tools to analyse ephemeral literature, specifically science fiction. He is an advocate of inter-disciplinary and multi-disciplinary research. He is also an educator in the field of digital literacy.

Karen Diane Cheer is a PhD candidate at James Cook University, Australia. She has a multi-disciplinary background in library and information science, social and cultural research.