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The Ecological Significance of the Overview Effect: Environmental Attitudes and Behaviours in Astronauts

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ABSTRACT OF THESIS submitted by:
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In the context of the 21st century's intensifying ecological crisis and the New Space Age, this year's 50th anniversary of the Apollo 11 Moon landing provides a functional framework for investigating potentially unknown connections between environmentalism and human space exploration. Limited evidence in the existing literature suggests that the Overview Effect – the cognitive shift in awareness experienced by astronauts as a result of seeing Earth from outer space – may contain much greater ecological dimensions than has been previously implied. Based on 14 first-hand interviews with astronauts, this study utilizes interpretive phenomenological analysis to qualitatively demonstrate that the Overview Effect has a distinct ecological significance that results in positive changes to astronauts' environmental attitudes and behaviours. Besides this change, the results qualitatively map the breadth and depth of astronauts' present environmental attitudes and behaviours, which has also not been done prior to this study. The outer space perspective of Earth, which includes negative perceptual views of anthropogenic ecological destruction on the surface of the planet, is shown to add a new and additional element to environmentalism, and as such discourse analysis is used to demonstrate how the ecological impulse concept is useful for advancing theoretical formulations of how spaceflight affects environmental attitudes. Furthermore, an expanded definition of the astroenvironmentalism concept is proposed to encapsulate this distinct form of environmentalism, to facilitate more straightforward discussions on the topic, and to make this phenomenon and form of environmentalism more relevant and accessible to a wider audience.

Keywords: overview effect, environmentalism, space exploration, astronauts, environmental attitudes, environmental behaviours, ecological impulse, astroenvironmentalism

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List of Abbreviations

CSA	Canadian Space Agency
EA	Environmental Attitudes
EAI	Environmental Attitudes Inventory
EPA	Environmental Protection Agency
ESA	European Space Agency
EVA	Extravehicular Activity
ISS	International Space Station
LEO	Low Earth Orbit
NASA	National Aeronautics and Space Administration
STE	Self-Transcendent Experience
SDG	Sustainable Development Goal
VR	Virtual Reality

CHAPTER 1
Introduction

1.1 Background

Environmentalism and human space exploration share complex psychological and philosophical linkages that warrant a re-examination in the context of the 21st century's intensifying ecological crisis and New Space Age – especially as the year 2019 marks the 50th anniversary of the first Moon landing by the Apollo 11 crew in 1969. Images from the Apollo missions such as *Earthrise* and *Whole Earth* appeared everywhere in the 1960s and 1970s and "provoked a sense of humanity's inherent responsibility to one another […] it galvanized the ecology movement in the U.S. and sparked a radical rethinking of our dependence on, and responsibility to, sustaining Earth's ecosystems and the diversity of life on our fragile biosphere" (Henry and Taylor 2009, 190). In fact, *Earthrise* has been coined "the most influential environmental photograph ever taken" (Zimmermann 1998, 242).

Despite historical and ongoing tensions between the space and environmental communities (Cockell et al. 2002, 301; White 2014, 25), both pursue scientific exploration in a way that influences our conceptualizations of the human-nature relationship, as "Earth and space exploration both stem from the same human drive to understand our environment and our place within it" (Cockell et al. 2002, 302). The relationship between space exploration and the modern environmental movement in the West, and specifically in the U.S., began in the early 1960s when then-president John F. Kennedy announced plans for manned missions to the Moon and subsequently the Ecological Society of America established a closer working relationship between ecologists, space researchers, and military engineers through a series of conferences on 'Human Ecology and Space Flight' (Anker 2005, 242). Additionally, 1962 marked the publication of Rachel Carson's *Silent Spring*, a book widely credited with helping to spark the modern environmental movement in the U.S. By the 1970s, leading ecologists such as James Lovelock and Edward O. Wilson were researching how the construction of human colonies on Mars could help understand Earth's ecosystems (Anker 2005, 239). In fact, Lovelock's Gaia Hypothesis—an ecological hypothesis, somewhat controversial in scientific circles, that describes the nature of life on Earth as a closely integrated, complex interacting and living system—was formulated in the early 1970s when NASA tasked Lovelock with consulting on

the search-for-life experiments on the 1975 Viking mission to Mars (Lovelock 1979, 1-2). In this sense, our current attitudes towards, and our relationship with, the environment have been historically at least partially shaped by images and activities of outer space exploration.

The 50th Apollo anniversary thus provides a functional framework for examining the known and for investigating the potentially unknown ecological dimensions of our current and planned activities in outer space. This is especially vital in the context of the New Space Age, due to which human space exploration is becoming increasingly commercialized and thus more accessible to non-career astronauts, and due to which numerous countries have already announced their intent to send manned missions back to the Moon in the next decade or two, and even further in the future, to Mars. The temporal context for these developments is human space exploration runs parallel to recent technological developments, such as Virtual Reality (VR) simulations that have the ability to provide unprecedentedly immersive experiences of space travel, and also runs parallel to the urgent need to limit anthropogenic temperature warming to a maximum of 1.5 degrees Celsius in the next decade, as assessed by the landmark Intergovernmental Panel on Climate Change (IPCC) special report (IPCC 2018).

One phenomenon in particular, produced as a result of human spaceflight, shows significant potential for containing an underexplored ecological dimension. As part of our activities in human space exploration, astronauts and cosmonauts have reported experiencing the Overview Effect—a term coined by Frank White in 1987— that is a "cognitive shift in awareness" triggered when the brain gets a realistic view of Earth from outer space (White 2014, 2). Psychologists believe this effect can best be explained through a heightened feeling of awe and wonder (Shaw 2017); however, despite its promising potential to lead people to transformative and enduring change (Gaggioli 2016), awe has only recently began receiving rigorous empirical attention (Chirico et al. 2016, 1). While White's definition of the Overview Effect indicates that the effect leads astronauts to "a renewed sense of responsibility for taking care of the environment" (White 2014, 2), there is some limited and fragmented evidence in the existing literature that hints at the possibility of the Overview Effect containing much greater ecological significance than what has been previously implied and investigated by White and others. Additionally, any 'transformative and enduring change' potentially resulting in astronauts from this potential ecological dimension, which could best be understood through changes in environmental attitudes and behaviours, is also important to investigate as the ability

to demonstrate long-term changes could carry lessons for enhancing current environmental communication and outreach strategies.

The potential ecological significance of the Overview Effect is thus worth investigating both empirically and conceptually, given that "it will not be possible to overcome the ecological crisis unless changes are made in the dominating anthropogenic consciousness that serves as the psychological basis of the crisis", and as such "it is necessary to make concerted efforts to shape a system of ecological values that represent a part of universal human values" (Biriukova 2005, 34) – a system of ecological values that could perhaps at least be partially developed and enhanced by the outer space perspective of Earth. With the growing commercialization of space travel and emerging immersive technologies such as VR, the argument that "stimulating the Overview Effect is humankind's runway to the actual experience enabling all of us—as collective stewards of the planet Earth—to understand more holistically not only our place in the created universe, but our role as well" (Bimm 2014) raises the question of whether the effect could be scaled and used to create a new source – and inspire a new form – of green commitment among future astronauts and space tourists, and perhaps also the wider public.

1.2 Aims and objectives

The overarching aim of this thesis is to investigate the potential ecological significance of the Overview Effect and to identify and explore its defining features.

The objectives, empirically, are to investigate how this ecological significance may result in changes to astronauts' environmental attitudes and behaviours and to map the qualitative breadth and depth of such attitudes and behaviours in the present. Conceptually, the objective is to suggest and advance philosophical formulations of this significance by utilizing existing but thus far unconnected concepts such as the ecological impulse and astroenvironmentalism as the main theoretical framework.

The main research question of this thesis is: (1) To what extent and in what ways does the Overview Effect contain a distinct and significant ecological dimension? Subsets of this main overarching research question include the following: (2a) Does the Overview Effect's ecologically significant dimension lead to detectable and durable change in astronauts' environmental attitudes and behaviours, and if it does, (2b) what are the qualitative features and

attributes in terms of breadth and depth of these in the present? (3) What kind of existing philosophical concepts can be utilized to build a theoretical interpretation and formulation of findings to the previous questions (1, 2a, 2b)?

1.3 Approach

To investigate these research questions, first-hand interviews were conducted with 14 astronauts; of these, 13 participants are career astronauts and one participant is a spaceflight participant, meaning, a space tourist. The qualitative and semi-structured interviews were analysed using interpretive phenomenological and content analysis to extract the richest possible data from the sample (Chapter 4). Additionally, for the conceptual analysis, discourse analysis of the existing literature was also utilized (Chapter 5). The Environmental Attitudes Inventory (EAI), developed by Milfont and Duckitt (2010), was also utilized in a qualitative manner, in which the EAI's 12 scale measures were used to help categorize the themes and patterns that emerged during the data analysis and to anchor the interpretations and discussion.

1.4 Structure

This thesis has been divided into the following six chapters:

- Chapter 1: Introduction
- Chapter 2: Literature Review
- Chapter 3: Methods
- Chapter 4: Results & Discussion: Empirical Data Analysis
- Chapter 5: Conceptual Discussion
- Chapter 6: Conclusions & Recommendations

Chapter 2: Drawing primarily from the disciplines of environmental psychology and environmental philosophy, the Literature Review was divided into three sections to help structure analysis of the interdisciplinary academic literature:

- Historical and Philosophical Dimensions (Section 1.1)
- Cognitive Dimensions (Section 1.2)
- Psychological Dimensions (Section 1.3)

Multiple research problems and gaps are raised in the literature review that are later addressed in Chapter 4 and Chapter 5 – these are cross-referenced with section numbers to ease the reader's comprehension.

Chapter 3: The Methods chapter describes the Overall Research Design (Section 3.1); Methods of Data Collection (Section 3.2); Methods of Data Analysis (Section 3.3), including detailed description of the EAI scale measures utilized for categorization; and issues of Validity, Reliability, Representativeness and Limitations (Section 4.4).

Chapter 4: The Empirical Data Analysis chapter was divided into three smaller Results and Discussion sections because three significant themes emerged from the astronaut interviews and all three themes make a distinct contribution to the existing academic literature, but to varying extents. The categories are as follows, plus a discussion summary:

- Category 1: Ecological Dimensions of the Overview Effect (Section 4.1)
  - Results (Section 4.1.1)
    - Outer space perspective of Earth (Section 4.1.1.1)
    - Distinct environmental dimensions (Section 4.1.1.2)
  - Discussion (Section 4.1.2)
- Category 2: Environmental Attitudes (Section 4.2)
  - Results (Section 4.2.1)
    - Attitude change (Section 4.2.1.1)
    - Attitudes towards ecological issues (Section 4.2.1.2)
  - Discussion (Section 4.2.2)
- Category 3: Environmental Behaviours (Section 4.3)
  - Results (Section 4.3.1)
    - Behaviour change (Section 4.3.1.1)
    - Environmental movement activism (Section 4.3.1.2)
    - Personal conservation behaviour (Section 4.3.1.3)
  - Discussion (Section 4.3.2)
- Discussion: Summary (Section 4.4)

Chapter 5: The Conceptual Discussion makes two distinct contributions to the existing academic literature through conceptual analysis of the Overview Effect and the Ecological Impulse (Section 5.1) and through Redefining Astroenvironmentalism (Section 5.2).

Chapter 6: The final chapter on Conclusions & Recommendations summarizes the main findings of this study (Section 6.1), summarizes the importance and implications of the new findings of this research (Section 6.2), and suggests future areas for research (Section 6.3).

CHAPTER 2
Literature Review

Given that the topic of this research is deeply interdisciplinary in nature, drawing primarily from the disciplines of environmental psychology and environmental philosophy, the following three categories have been employed to structure the interconnected concepts and phenomena of the existing literature that characterize the relationship between human spaceflight and environmentalism on Earth: (1) historical and philosophical dimensions; (2) cognitive dimensions; and (3) psychological dimensions.

Section 2.1 will discuss the Apollo images' impact on the modern Western environmental movement and examine the existing philosophical discussions and concepts that stem from this historical background, such as Spaceship Earth and astroenvironmentalism. Section 2.2 will examine key cognitive processes such as the Overview Effect, while Section 2.3 will discuss the psychological dimensions of awe and wonder experiences and how they pertain to environmental attitudes and behaviours in the context of human space exploration.

2.1. Historical and Philosophical Dimensions

In 1948, astronomer Fred Hoyle predicted that "once a photograph of the Earth, taken from outside, is available, […] a new idea as powerful as any in history will be let loose" (Kelley 1988, 43). A few decades later, two defining images of the Earth emerged, due to unprecedented scientific and technological advancements, that are important to briefly examine here because they continue to shape debates and attitudes about the environment to this day, both in astronauts and the wider public: Spaceship Earth and the Apollo images. First, the conceptual image of Spaceship Earth sailing through space as a giant space cabin filled with human astronauts came to dominate the ecological debates of the 1960s and 1970s (Anker 2005, 244). Second, the physical images of Earth, taken during the Apollo missions to the Moon – especially *Earthrise* (Figure 1.1) and *Blue Marble* (Figure 1.2) – galvanized the ecology movement in the U.S. (Henry and Taylor 2009).

Military research in the 1950s and 1960s into underground shelters and submarines, and then research by ecologists in the 1970s into the ecological colonization of space, centred on enclosed cabin ecological systems—designed to maintain human life in small and hermetically sealed cabins—that changed mainstream Western thinking about Earth and became a tool for

solving environmental problems (Anker 2005; Bimm 2014). In 1968, R. Buckminster Fuller published his *Operating Manual for Spaceship Earth*, widely popularizing the idea that all inhabitants of the planet are astronauts on Spaceship Earth, and that just like enclosed cabins, the Earth also had a 'carrying capacity' (Fuller 2008, 10). Fuller argued that the approaches developed for the sealed space cabins could be applied globally to environmental problems on Earth (Bimm 2014, 14), while environmentalist Stewart Brand was convinced that "eco-awareness would become widespread once people perceived the Earth as a delicate bio-sphere" (Tierney 2007: F1, quoted in Henry and Taylor 2009, 193). However, numerous prominent environmentalists, such as Paul Shepard and Edward Abbey, and environmental schools of thought, such as Deep Ecology, ecofeminism, and Earth First!, heavily criticized the metaphor for its technocratic thinking (Deese 2009, 74), and the image remains disputed to this day. Nonetheless, Spaceship Earth soon became a key term in U.S. mainstream vocabulary and it has been claimed that in the 1970s "environmental ethics became an issue of trying to live like astronauts by adapting space technologies such as bio-toilets, solar cells, recycling, and energy-saving devices to general use" (Anker 2005, 239).

Parallel to the launch of the Spaceship Earth metaphor, the physical image of the Earth was captured and published in December 1968. Taken by Apollo 8 crewmember William Anders, the photo *Earthrise* (Figure 1.1) was "the subject of immediate commentary and speculation about a reformed view of the world" (Cosgrove 1994, 273). The image became "the most influential environmental photograph ever taken" (Zimmerman 1998, 242), significantly changing the way humanity saw itself in relation to its home planet. Following closely in 1972, the *Blue Marble* image (Figure 1.2)—also often called *Whole Earth*—by the Apollo 17 crew became "the most commonly published photograph in all of history" (Gore 2003, 15). The two images appeared everywhere in public life and "powerfully provoked a sense of humanity's inherent responsibility to one another" (Henry and Taylor 2009, 190), as for the first time in human history, it allowed the wider public to collectively conceptualize and visually place its existence in a cosmic context. The images captured the interdependence of life on Earth and the finiteness of resources – both key messages of the then-budding modern environmental movement (Deese 2009, 70). The whole Earth perspective became the symbol of Earth Day, first held in the U.S. in April 1970 with 20 million participants, and gave rise to the Environmental Protection Agency (EPA) in December 1970.

Figure 1.1: *Earthrise* (Original orientation. Source: NASA 1968, NASA on the Commons, Image # : 68-HC-870; Date: December 24, 1968; https://www.flickr.com/photos/nasacommons/9460163430/in/album-72157634973839148/)

Figure 1.2: *Blue Marble* (Source: NASA 1972, NASA on the Commons, Image#: AS17-148-22727; Date: December 7, 1972, Link: https://www.flickr.com/photos/nasacommons/5052124705/in/album-72157634974000238/)

Although the effect that *Earthrise* and *Blue Marble* had on the modern environmental movement is impossible to fully quantify (Henry and Taylor 2009, 194), it is well documented and recognized in the academic literature that an "emergent ecological consciousness took root and bloomed into a significant cultural presence" (Byrant 1995, 46), which ecological consciousness continues to influence environmental attitudes and the modern environmental movement to this day. If Spaceship Earth led to a "broad conceptual shift" (Deese 2009, 72), then the Apollo images can be said to have led to a "change of perspective" (Grevsmühl 2016, 1) and "changed relationship" (Bryant 1995, 49) in broader conceptualizations of the human-nature relationship. This is important to emphasize, because as Grevsmühl notes:

> All global environmental images […] participate actively in the construction of the specific global objects and ideas they intend to visualise. And by making new objects, structures and connections visible, these images become in turn driving forces of new knowledge and ideas. […] In science, therefore, the visual fulfils mainly two functions and images are hence always both: objects and instruments of knowledge and imagination. (2016, 3).

To loosely interpret this in the context of this research, the quotation implies that environmental images and perspectives, such as the Apollo images or more broadly the outer space perspective of Earth, carry both objective (scientific) and subjective (imaginative or emotional) connotations that can be useful for generating, conveying and popularizing new ideas and new ways of thinking. As such, astronauts – who most directly experience the 'global environmental image' of Earth from outer space – would be expected to articulate a more profound and transformative version of this 'new way of thinking' as a result of the perspective 'making new connections visible'. For one, the phenomenon known as the Overview Effect covered later in Section 2.2 largely discusses exactly this more profound and transformative version of a 'new way of thinking' about the Earth. However, a small gap exists due to the Overview Effect not discussing the outer space perspective in terms of this objectivity and subjectivity as directly experienced by astronauts, and hence the data analysis in Section 4.1.1.1 and Section 4.1.2 of Chapter 4 will expand on this topic.

As a result of their impact on the modern environmental movement, the Apollo images can indeed be understood as 'global environmental images' given the broader effect they had on the wider American public's environmental awareness. According to former U.S. Vice President and environmentalist Al Gore, the ecological interpretation of the outer space perspective of Earth begins with a view of both the physical and philosophical whole Earth of which humans are a part too, meaning that "looking at it ultimately means looking at ourselves" (1992, 9). Perhaps for this exact reason, the extensive academic analysis of the past decades has shown that the images "do not provide simple readings, that they carry multiple, often contradicting messages, and that they can be vectors of highly ambiguous and even conflicting political beliefs" (Grevsmühl 2016, 1), and as such, have also proven somewhat controversial. For example, besides conveying strong conceptual and perceptual messages of unity, oneness, fragility, and beauty, the Apollo images – often termed as 'Whole Earth thinking' – have been accused of masking the ecological destruction humans are causing on the planet (Boes 2014; Garb 1985). Besides the criticism of the Spaceship Earth metaphor discussed earlier, in more recent times, there has also been some pushback in the environmental community against 'planetary' language, similarly arguing that the perspective masks local issues and complex realities on the ground (Collins 2016; Strong 2013). This topic will be investigated in greater detail in the data analysis section (Chapter 4), as astronaut interviews indicate disagreement with the critical literature here (Section 4.1.2).

Given both the positive and negative readings of the Apollo images discussed above, it can be said that "the Apollo era's impact on the ecological movement in the U.S. provides a powerful analogue for understanding current astroenvironmental initiatives" (Henry and Taylor 2009, 190). These current 'astroenvironmental initiatives' hold relevance to present-day iterations of the modern environmental movement and as such will be briefly discussed below.

2.1.1 Astroenvironmentalism

The academic literature is limited on astroenvironmentalism; however, the phrase has gained increasing, albeit still limited, traction in the past two decades. The term was coined in 2001 by R. W. Miller, but the idea has also been defined as 'cosmo-centric environmentalism' (Bohlmann 2003), and 'extraterrestrial environmentalism' (Montet and Loomis 2016). According to Miller, astroenvironmentalism can be defined as:

> A concept that applies the values of environmentalism and preservationism to developments in space exploration, commercialization, and militarization. It can be both an umbrella term to describe a variety of issues about space exploration as well as a component of the ongoing public debate about the environment. (2008, 245).

Miller argues the perspective is not widely discussed and acknowledged by space advocates despite the increasingly pressing need to protect other planetary objects and 'untouched' space wildernesses from human colonization and exploitation (2008, 246). Miller defines the main concerns of astroenvironmentalism as, among others: space pollution, including space debris and damage from rocket fuels; applying conservation efforts to space; treating other planetary bodies as wildernesses in need of protection; counteracting efforts to terraform other planets; and "the use of space technology to answer questions about the environment and environmental problems" (2008, 249).

As such, what Henry and Taylor imply by current 'astroenvironmental initiatives' is that, while the Apollo images triggered a "global ecocritical awareness", space exploration and realistic space art in recent decades has contributed to an emerging "astroenvironmental consciousness that envisions space as a natural extension of Earth's environment" (2009, 201), which is why the term has arguably gained some, albeit still very limited, relevance to present-day environmental discourses. The current conceptualization of astroenvironmentalism clearly implies an *outward* application of environmentalism towards outer space and other planetary bodies; however, if it is limited to this perspective, then the concept fails to add significant value to mainstream environmental discourses. As Block and Huebert (2008) argue, space is already

currently considered a 100% de facto wilderness preserve. Additionally, research from recent years has shown that terraforming Mars anytime in the foreseeable future is not possible (Jakosky and Edwards 2018). While the great wilderness struggle for the Hetch Hetchy created organizations such as the Sierra Club in the U.S. (Hay 2002, 14), there is a good reason why there is no "Mars First or Venus First" organizations, as conceptualized by Miller (2008, 247).

Therefore, in its current iteration, the concept remains narrow and limited in scope, which also helps explain why the term has failed to catch on in meaningful environmental discourses. A clear theoretical gap exists here to investigate whether the current definition of astroenvironmentalism can be changed to increase its utility and applicability to mainstream environmental discourses. This issue will be specifically covered as part of Chapter 5's conceptual discussion in Section 5.2.

2.1.2 Summary

To summarize, the academic literature overall indicates that the Apollo images have become both positive and negative images of the relationship between environmentalism and human space exploration. While the lasting impact of the Apollo images on environmental awareness and on the modern-day environmental movement is important for contextual understanding of this research area, the Apollo images must be separated from the direct experience of astronauts in space, who are able to look at Earth first-hand from the perspective of outer space. Indeed, "if a single photograph could influence a society's cultural awareness, how much more tremendous must be the effect of an in-person experience" (Yaden et al. 2016, 2). To reformulate this proposition: If a single photograph could influence a society's *ecological* awareness and concern to this extent, how much more tremendous would the effect of the in-person experience be?

To answer this question, "transcendental hopes"– meaning astronomer Fred Hoyle's comments from 1948 about a photo of Earth triggering a powerful new idea – "of ecological transformation due to a cognitive 'overview effect'" (Crook 2018, 7, referencing Lazier 2011) remain heavily under-researched in the academic literature and need to be investigated in astronauts, who would be the first people any significant 'ecological transformation' would occur in as a result of spaceflight and the subsequently triggered Overview Effect experience.

While these cognitive and psychological dimensions will be explored in greater detail in Sections 2.2 and 2.3, it is important to conclude here with a key text of the environmental

philosophy literature that perhaps can be best utilized to explain, conceptually, this 'cognitive ecological transformation'. In 2002, Hay wrote *The Ecological Impulse* (2002), which aims to make sense of the historical roots of our environmental attitudes, arguing that the 18th and 19th century Romanticism movement was to a certain extent the first expression of an 'ecological impulse' that today's modern environmental movement is a second expression of. The author defines this current ecological impulse as a "deep-felt consternation at the scale of the destruction wrought, in the second half of the twentieth century, and in the name of a transcendent human progression, upon the increasingly embattled lifeforms with which we share the planet." (Hay 2002, 3). Hay argues that discerning the historical evolution of this 'ecological impulse' is important for understanding our current attitudes and actions towards nature in the modern context, as it will remain the strongest source of recruitment for 'the green cause' in the present and future (Hay 2002, 18).

As such, it would be worth exploring conceptually whether this ecological impulse can be connected to the aforementioned 'cognitive ecological transformation' resulting from the outer space perspective of Earth and more specifically, whether the Overview Effect can be considered a significant type, or modern version of, the ecological impulse, or whether it can contribute to generating such an impulse? Besides astroenvironmentalism, this question will also be explored in greater detail in Chapter 5's conceptual analysis, in Section 5.1.

2.2 Cognitive Dimensions

The aforementioned Overview Effect is not a household concept, although it is relatively well-known to those in the professional and hobby space communities and it has also been frequently used by environmental and peace movements to justify 'whole Earth' and 'borderless' perspectives of the planet (Bimm 2014, 43). More rarely, it has been utilized outside of the space and activist communities, when for example former U.S. president Bill Clinton challenged every person in the room at the 1997 White House Conference on Climate Change to "rise to a vantage point high enough" to approach the issue from the 'whole Earth' and 'borderless' perspective that the Overview Effect provides (1997, 1295).

The Overview Effect has been termed many things: a perspective shift; a cognitive shift; a reliably produced mental effect; a physical experience; an emotional experience; a cognitive shift in awareness; an experiential understanding of the Earth (as opposed to an intellectual understanding of it); even a religious or spiritual experience. According to Frank White, who

coined the term in the 1987 first edition of *The Overview Effect: Space Exploration and Human Evolution*, the effect can be described as:

> A cognitive shift in awareness reported by some astronauts and cosmonauts during spaceflight, often while viewing the Earth from orbit, in transit between Earth and the moon, or from the lunar surface. It refers to the experience of seeing first-hand the reality that the Earth is in space, a tiny, fragile ball of life, 'hanging in the void', shielded and nourished by a paper-thin atmosphere. The experience often transforms astronauts' perspective on the planet and humanity's place in the universe. Some common aspects of it are a feeling of awe for the planet, a profound understanding of the interconnection of all life, and a renewed sense of responsibility for taking care of the environment. (White 2014, 2).

Based on dozens of first-hand interviews with astronauts, White makes a compelling case that such a psychological and philosophical effect indeed exists and attempts to lay out the effect's parameters in detail. For example, he argues the extent of the effect often depends on the distance and duration of the mission, since that also influences the specific perspective one can see of the Earth and the time available for Earth gazing and reflection. This necessity for differentiation is reinforced by multiple accounts from astronauts: Gemini and Apollo astronaut Eugene A. Cernan has said "being in Earth orbit versus going out beyond must be separated. Philosophically, we have really had two different space programs", while Apollo astronaut Edgar Mitchell has stated "[Going to the moon] gets you closer to a more universal experience because of the distance and the wider view" (Ibid., 33).

Besides the distance and duration factors, extravehicular activity (EVA)—known more commonly as spacewalking—has been reported to be a completely different experience from viewing the Earth from within a spaceship or station, where there is still at least a window of separation (Figure 1.3). Indeed, as White writes, "most astronauts who made EVAs confirmed that it is a completely different experience" (2014, 34). A lunar EVA, meaning walking on the surface of the Moon, is also a somewhat different experience from conducting an EVA in orbit: Apollo astronauts who landed on the Moon have reported some of the most profound experiences in space, as "the astronaut in orbit has a new and different relationship with the Earth, but the planet is still the primary point of reference […] by contrast, the lunar astronaut sees the Earth grow smaller each day of the voyage and enters the gravitational field of another planetary body" (White 2014, 36). The unique nature of the lunar missions is worth greater attention in light of NASA's upcoming Artemis Moon Program, which is aiming to send astronauts back to the Moon by 2024 (NASA 2019), as well as announced intentions by Russia, China and Japan to send crewed missions to the Moon in the 2030s.

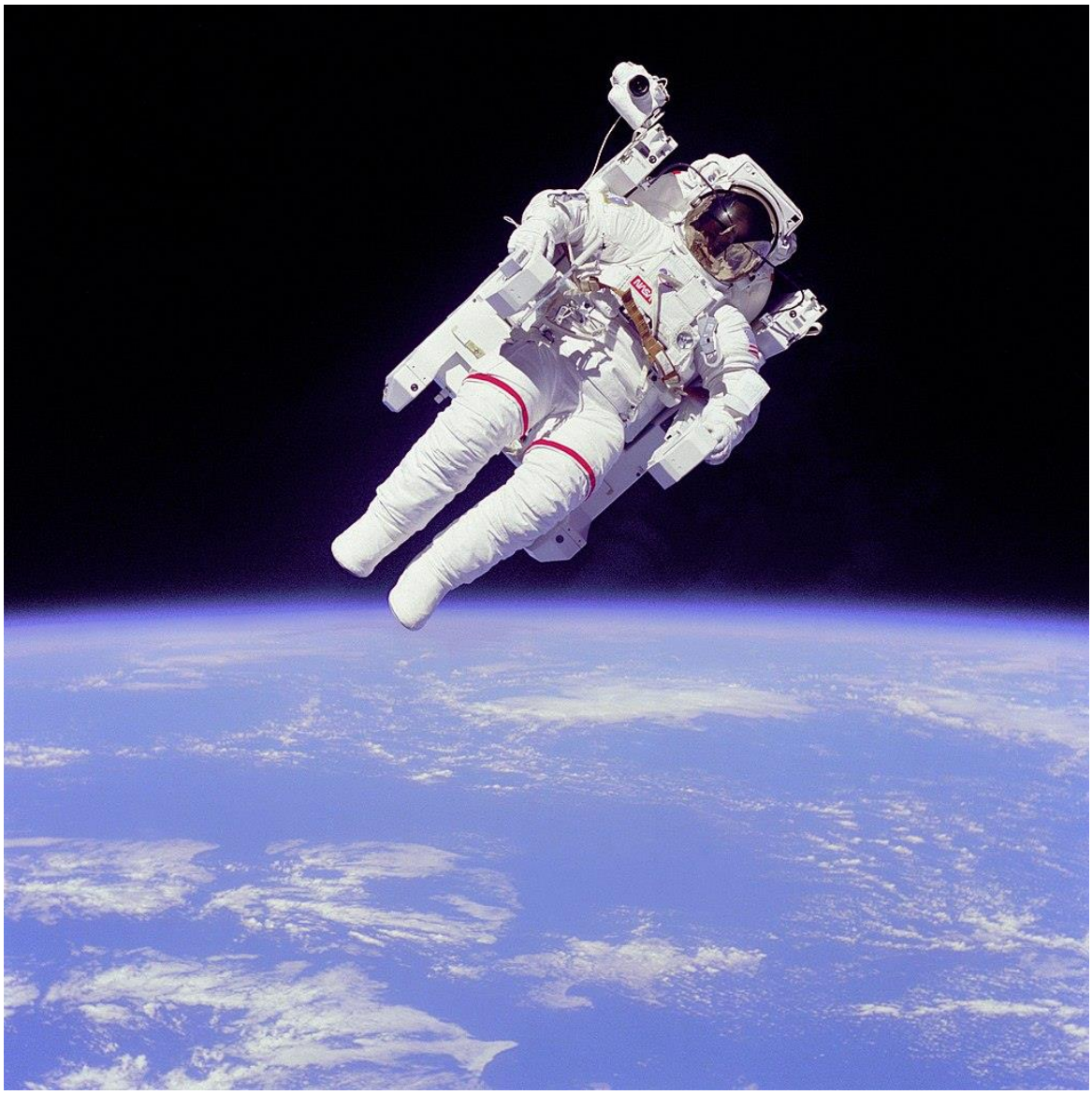

Figure 1.3: Extravehicular activity in Low Earth Orbit – Astronaut Bruce McCandless II performing an EVA a few meters away from the Space Shuttle Challenger's cabin (Source: NASA 1984, NASA on the Commons, UID: SPD-GRIN-GPN-2000-00 1156; Date: February 14, 1984, Link: https://www.flickr.com/photos/nasacommons/5134455469/in/album-72157650682898116/)

Astronauts and cosmonauts have utilized the following and similar terminology to describe their reaction to seeing Earth from outer space, all quoted in White (2014) unless otherwise noted: "The feeling is absolutely euphoric" (Edwin Garn, 233); "Beautiful […] calm, majestic" (Valentin Lebedec, 204); "Indescribable […] It is a dynamic, crystal-clear view that just glows, and that doesn't come across in the pictures or videos" (Nicole Stott, 18); "The sight was overwhelming […] and awe-inspiring" (Scott Carpenter, in Carpenter et al. 2010, 450). Astronauts Don Lind and Alan Shephard have expressed similar sentiments about being caught off guard despite their intellectual preparation for the view: Lind says "I have probably looked

at as many pictures from space as anybody […] so I knew exactly what [I] was going to see. There was no intellectual preparation I haven't made. But there is no way you can be prepared for the emotional impact… It was a moving enough experience that it brought tears to my eyes" (White 2014, 18). Similarly, Shephard says "I had been well briefed on what to expect […] but no one could be briefed well enough to be completely prepared for the astonishing view that I got. My exclamation […] about the 'beautiful sight' was completely spontaneous. It was breath-taking" (Carpenter et al. 2010, 254). These comments raise the question of whether the Overview Effect be recreated on Earth, and if it can, whether the Overview Effect – as experienced in and from space – is qualitatively still somewhat different from awe-inducing experiences on the surface, whether a beautiful natural sight or a virtual reality recreation of spaceflight? These questions will be answered based on the astronaut interviews in Chapter 4's data analysis, and specifically in Sections 4.1.1.2 and 4.1.2.

White identifies four underlying characteristics, relevant to the effect's interpretation and dissemination, that influence the transmission of the experience: (1) the experience itself and the communication of it may be different; (2) the experience begins long before and ends long after space flight; (3) the experience is private but becomes highly public upon the astronaut's return; and (4) the experience is often given meaning that serves societal needs that may have little to do with the astronaut's personal reality (2014, 12). These possible biases and limitations should be kept in mind when reading and analysing first-hand accounts from astronauts throughout Chapter 4 in this thesis as well as in the wider academic literature.

The Overview Effect is only one possible change in consciousness resulting from space flight that varies by the individual and the nature of their experience (White 2014, 12). This is important to emphasize, because some experiences – especially awe and wonder – have been proven to be commonly experienced by astronauts and cosmonauts, while in other experiences there has been more significant variation in the phenomena reported (Reinerman-Jones et al. 2013, 296). Astronauts come from widely varied cultural and occupational backgrounds—such as science, military, engineering, or medicine—yet almost without exception experience awe and wonder despite these personal variations. A landmark study by Yaden et al. posits that the profound reaction to viewing Earth from outside its atmosphere can indeed be termed the Overview Effect and can best be explained through a heightened feeling of awe and wonder (2016, 2), and as such, this thesis will primarily utilize this psychological interpretation of the effect going forward. This is important to state, because any experiences *beyond* awe and

wonder—either triggered by the personal interpretation of the awe and wonder experience or completely separate from it—are much more varied. It is here that the phenomena reported shows greater variation and a research gap exists in trying to interpret these variations, especially in relation to any potential ecological significance of the Overview Effect.

Finally, the effect can be understood as both an abstraction and phenomenon; the former because it is the description of what only a few hundred people have experienced, and the latter because there is enough evidence to support the existence of such an effect, however difficult the precise details and nuance of the phenomenon are to communicate to those who have not experienced it first-hand (White and Smith 2013). This reinforces that investigating any potential ecological significance of this phenomenon must also be done through the first-hand account of astronauts, who are the only people who experience the overall phenomenon directly. While White himself states that the effect leads to "a renewed sense of responsibility for taking care of the environment" (White 2014, 2), the academic literature shows that this potential ecological significance is perhaps the most underexplored aspect of the Overview Effect. Therefore, the extent to which the existing academic literature has explored the possible ecological significance of the effect will be mapped out in the section below, demonstrating the extremely limited extent to which this has been done up to date.

2.2.1 Greening the Overview Effect

Besides this singular line –"a renewed sense of responsibility for taking care of the environment" (White 2014, 1) – in the effect's definition, White does not expand on nor separately investigate what this "renewed sense" translates into either qualitatively or quantitatively, and perhaps even more importantly, whether it could lead to any detectable and long-term changes in the environmental attitudes and behaviours of astronauts.

The limited extent to which White's research does imply that the Overview Effect carries some level of ecological significance has been summarized by Cox as the following patterns that emerged from White's interviews with astronauts: "An abiding concern and passion for the well-being of the Earth […] a higher level viewpoint, involved new awareness and consciousness […] and the recognized need for a stewardship perspective and a global participatory management of the planet" (Cox 2014, xvi). White argues that the ecological perspective of Earth entails seeing the interdependence of the planet's systems, environments and habitants from the outer perspective (White 2014, 73) and seeing how species fit into

patterns, fill a niche, and play a vital role in the entire system (White 2014, 88). Numerous astronauts expressed concern about what their own species is doing to the planet, however, when specifically mentioning this element, White only uses the example of astronaut Jeff Hoffman calling the world's pollution situation "appalling" (White 2014, 88). In another example of the currently limited nature of this research topic, White tells an astronaut during their interview that he thinks the number of people who have flown in space has strengthened the environmental movement (2014, 281), but never expands on how exactly he thinks this has been done.

White's book can be divided into two sections, and this is important to explain for this analysis: The first section of his book (Part I and II) contains his own analysis and interpretation of the Overview Effect phenomenon, while the second section (Part III) contains first-hand interviews he has conducted with around three-dozen astronauts, in which he interviews them about the effect and includes the interview excerpts in nearly their full form. Most of what White *himself* says about any potential ecological significance of the Overview Effect can be found in the first section of the book; however, even here he only discusses the subject in vague terms:

> If the overview hypothesis is correct, the process of sending people into space should not only affect the astronauts, but as their insights are transmitted throughout society it should bring positive changes and a more responsible species. We would hope to see more people become interested in preserving the environment […] The evidence already presented suggests that this has happened in the environmental area and that it is linked to changes in awareness associated with space exploration. (White 2014, 93).

Based on my interpretation of this ambiguous reference to "this has already happened in the environmental area", White is likely referencing the Apollo images and the modern environmental movement that started in the 1960s and 1970s in the above paragraph as "evidence", as he has made reference to these events throughout the first section of the book.

Utilizing the second section of his book, which contains the first-hand interviews, references by the astronauts *themselves* can be found to this "renewed sense of responsibility for taking care of the environment" (White 2014, 1), but once again, White does not systematically collect nor analyse references to this potential ecological significance, nor does he ask astronauts to expand on their environmentally intriguing comments any further. This is precisely why it was crucial to conduct my own astronaut interviews for this thesis, as the existing literature – and interviews by White – indicate there is potentially an unexplored ecological dimension to the Overview Effect, but the existing source material is limited. To provide examples of this, the following comments by astronauts have been selected as

representative of the extent to which this subject emerges from the astronaut interviews in the second section of White's book:

Following her spaceflight, astronaut Sandra Magnus said "you want to go out and crusade for the planet on some level" (White 2014, 282), while astronaut Tamara Jernigan said "you get a sense that we do need to be good stewards of the planet" (White 2014, 260). Some astronauts expressed more profound environmental responses: "[Spaceflight] has changed my insight into life. I've got more appreciation for the world we live in. […] I think God has given us so much to be thankful for, and we are wasting so much time trying to destroy it" (Sultan Bin Salman Al-Saud, quoted in White 2014, 242); while some astronauts expressed more muted, but still apparent, environmental responses: For example, "I came from a family stressing issues like the environment, so seeing Earth from orbit didn't change that […] Seeing Earth from that perspective did reinforce my concept of a small fragile planet and a species needing to come to terms with itself" (Bonnie Dunbar, quotes in White 2014, 248), or "You do appreciate the Earth much more when you have had that vantage point of looking down on the Earth" (Akihiko Hoshide, quoted in White 2014, 298).

These comments from astronauts certainly indicate there is a distinct ecological dimension to their spaceflight and Overview Effect experiences but the extent to, and ways in which, this dimension is potentially significant have never been *qualitatively* explored before in the academic literature, and as such a significant research gap exists here that this thesis aims to fill. While a singular quantitative baseline study does exist on this topic (Ihle et al. 2006), it is also limited and will be analysed more appropriately in Section 2.3 of this literature review, as that section deals with the existing psychological literature on the subject.

2.2.2 Orbital Perspective

It is important to briefly discuss astronaut Ron Garan's even lesser known Orbital Perspective here, which can be understood as a subsection of White's Overview Effect. The Orbital Perspective, according to Garan, is the "call to action" resulting from the Overview Effect: "Seeing Earth from the vantage point of space not only provides a unique perspective but also can trigger a response that leads to a desire to make the world a better place for all its inhabitants" (2015, 49). Even further, Garan argues that "if the overview effect is a change in perception that one gets from physically seeing Earth from space and in space, then the orbital perspective derives from that experience and drives what we do with it" (Ibid., 59). In this

sense, if the Overview Effect is primarily interpreted as an awe and wonder psychological experience, as has been established in previous discussions, then the Orbital Perspective would constitute one of many possible personal interpretations of the awe and wonder experiences that result from the spaceflight experience. In short, the Orbital Perspective could be interpreted as the personal attitude or value the astronaut interprets from the experience.

Garan makes some references to a possible ecological dimension within his Orbital Perspective, arguing for example that from that perspective, the NIMBY ("not in my backyard" term from the 1980s environmental movement becomes irrelevant, as the Orbital Perspective shows that environmental radius of one's backyard is global (Garan 2015, 55-56). Another interesting example Garan cites in his book relates to the conservationist Dan Irwin. In the 1980s, Irwin had already spent an entire year mapping the Maya Biosphere Reserve in northern Guatemala on foot when he bumped into NASA's remote sensing expert Thomas Sever, who showed him satellite imagery of the exact same area Irwin was so painstakingly mapping. "Suddenly, Irwin's worm's eye view from the ground shifted to the orbital perspective from space" and he realized the value "in its ability to communicate the story to those most directly affected by the environmental issues he was studying" (Garan 2015, 101). As such, Irwin went village to village showing the satellite imagery of the reserve's agricultural and deforestation issues, which catalysed locals' "opinion and their spirit of purpose of this reserve and the importance of the rainforest" (Garan 2015, 101). While these examples show the utility of the Orbital Perspective in conceptualizing environmental issues from the grander scale that is unique to space, Garan also does not explore any potential long-term changes in environmental attitudes and behaviours that could result from this interpretation of the spaceflight experience.

2.3 Psychological Dimensions

While White's work has received some criticism (Bimm 2014), especially from scholars from the humanities – for example, historian Stephen J. Pyne said "unless you already accept its premises, the book is gibberish" (Pyne 1989) – the psychological validity of White's claims are less disputed, and as acknowledged by scholars from the field, it is due to White's work that the space community now recognizes the phenomenon of the Overview Effect (Yaden et al. 2016, 3). It is now generally accepted that astronauts experience "truly transformative experiences including senses of wonder and awe, unity with nature, transcendence and universal brotherhood" in space (Harrison and Fiedler 2011, 29), and this recognition lays an important scientific foundation for further investigating the effect's potential dimensions.

Psychologists believe the significant emotional reactions that are triggered as part of the Overview Effect can best be explained by a heightened feeling of awe, also known by the Japanese word 'yugen', which is related to a sense of vastness and aesthetic beauty (Silvia et al. 2015; Shaw 2017). The outer space perspective of Earth is said to be different from any other awe experience induced by vastness on Earth, as "it has tremendous, perhaps absolute, conceptual vastness" (Yaden et al. 2016, 4). In ecological terms, images from outer space show Earth in all its "sensual reality" as beautiful and fragile (Byrant 1995, 49). Numerous empirical studies confirm that the Overview Effect results in altered perceptions of the Earth's beauty and existential value (Ihle et al. 2006; Stuster 2010; Yaden et al. 2016). According to Corbin (2001), the intense blue colours of the Earth's atmosphere and waters closely follow aesthetic rules of the sublime. Scholar Emily Brady and numerous others, based on Immanuel Kant's aesthetic theory, have concluded that the experience of the sublime provides a strong aesthetic basis for an environmental ethic (Brady 2006; Mahoney 2016). This is important, as utilizing and further developing our knowledge about such aesthetics might "be a key catalyst to achieve a heightened feeling of awe from the overview effect" (Shaw 2017). As such, this potential of the aesthetic beauty of the Earth in triggering environmental responses will be further investigated in Section 4.1.1.2 and Section 4.1.2.

Besides aesthetics, feelings of awe triggered by the Overview Effect appear to have two major components. First, the aesthetics of the juxtaposition of Earth against the blackness of space emphasize (1) perceptual themes (i.e. physical beauty of nature or Earth from space) and (2) conceptual themes ('grand theories' such as the theory of relativity, feelings of interconnectedness, or the fragility of life from space, etc.) (Yaden et al. 2016, 4). Second, the perspective shift that results from seeing familiar landmarks from the completely different visual orientation of space elicits conceptual awe (Yaden et al. 2016, 4). The term 'worldview' was coined by Kant in the late 18th century to describe the literal 'view' of the world that is produced by human sensory perceptions, and also divides human experiences into (1) perceptual and (2) conceptual domains (McConville 2009, 10). White himself states in *The Overview Effect* that our 'worldview', as a conceptual framework, "depends quite literally on our view of the world from a physical place in the universe" because "mental processes and views of life cannot be separated from physical location" (2014, 1).

Despite its promising potential to lead people to transformative and enduring change (Gaggioli 2016), awe has only recently begun receiving rigorous empirical attention (Chirico

et al. 2016, 1). Awe is both an emotion that is powerful and complex and a response to a perception of vastness that challenges our mental schemas to accommodate that vastness (Keltner and Haidt 2003). Perhaps most relevantly for investigating the potential ecological significance of the Overview Effect, research has found that awe has numerous psychological benefits (Yaden et al. 2016), such as influencing beliefs and changing one's general perspectives toward the world and themselves (Schneider 2009). While some have argued that awe and aesthetic beauty alone might not be sufficient to explain some longer-term changes in astronauts as connected to the Overview Effect (Cohen et al. 2010), self-transcendent experiences (STEs) can be used to explain the more transformative versions of the experience (Yaden et al. 2016, 5). STEs are temporary, positive feelings of unity and connection to other individuals or humankind that can even be transformative – subjects have reported such experiences to be among the most important in their lives (Yaden et al. 2017; Hood et al. 2009; Griffiths et al. 2008). As such, Yaden et al. argue that the Overview Effect can best be understood "as a state of awe with self-transcendent qualities, precipitated by a particularly striking visual stimulus" (Yaden et al. 2016, 5). Overall, awe has great potential to lead to transformative changes at the psychological level, and "can change our perspective toward even unknown others thus increasing our generous attitude toward them" (Chirico 2018, 1).

Empirical research indicates that the outer space view of the Earth specifically, and not merely an outer space view of any other celestial body, is what is key to inducing enhanced awe and wonder experiences in people. A landmark neurophenomenological study utilized a mixed-reality simulation to show groups of participants simulations of Earth, and separately, of Deep Space (Reinerman-Jones et al. 2013, 295). This study was the first attempt in utilizing virtual simulation to induce awe and qualitatively analyse participants' responses to the Overview Effect (Yaden et al. 2016), and as such, the empirical research on this subject is relatively recent and still emerging. In the Earth view, participants slowly travelled away from the Earth until it looked like a blue marble, while in the Deep Space view, participants observed distant stars while travelling through space (Reinerman-Jones et al. 2013, 299). Perhaps most significantly, the study found that participants most likely experienced awe and wonder from the Earth perspective, and not the Deep Space perspective (Reinerman-Jones et al. 301). During the Earth perspective, elevated beta from baseline indicated participants' greater difficulty in accommodating the Earth perspective into their current mental structure, which is consistent with Keltner and Haidt's prediction for mental schemas being challenged (2003) and having to adjust to a new and truly unique perspective of the planet.

Even further, a singular baseline study (Ihle et al. 2006) – as mentioned on page 19 – has quantitatively measured that astronauts do experience a change specifically in their environmental behaviours: involving 39 NASA astronauts, it showed that the greatest change experienced by astronauts was an enhanced appreciation of the Earth's beauty (97.4% of respondents), its fragility (84.6%), valuing the Earth more (89.7%), and most relevantly for this thesis, an increase in their involvement with environmental causes (64.1%). Overall, the study confirmed that spaceflight "is a meaningful experience that makes an enduring positive impression on astronauts", with participants also reporting changes in both attitudes and behaviours (Ihle et al. 2006, 93). However, the only *environmental* behaviour the study explicitly measured was an increase in astronauts' 'involvement with environmental causes', of which almost two-thirds of participants reported a change, but the qualitative properties of this environmental behavioural change – for example, to what extent participants increased their involvement and in what ways – were not explored in the study whatsoever. Furthermore, while the study did not explicitly measure any *environmental* attitude change, participants' responses pertaining to an enhanced appreciation of the Earth's fragility could potentially be interpreted as a quantitative measure of such a change, as the Milfont and Duckitt (2010) environmental attitudes scale measures utilized in the methods section (Chapter 3) and data analysis section (Chapter 4) does contain an environmental fragility measure (scale #6). While long-term changes in astronauts' personal outlook and general attitudes towards their relationship to the Earth have already been documented (Yaden et al. 2016, 5-6), these changes have not been explored from an ecological perspective that could reliably demonstrate these changes constitute *environmental* attitude change.

The Ihle et al. study (2006) reinforces earlier remarks that there exists a significant research gap in the existing academic literature pertaining to the possible extent to which spaceflight and the Overview Effect could lead to long-term changes in environmental attitudes and behaviours in astronauts and spaceflight participants. Besides White's collection of astronaut interviews (2014), the study by Ihle et al. (2006) provides another implicit clue that the phenomenon may indeed have a greater ecological significance than what has been previously investigated. As such, the next section will briefly review and provide contextual insight on the environmental psychological literature pertaining to attitudes and behaviours.

2.3.1 Environmental Attitudes and Behaviours

Environmental attitudes and behaviours comprise a part of environmental psychology, which originated from the U.S. in the 1960s and which subfield examines the complex interactions between humans and the environment (Kollmuss and Agyeman 2002, 239).

Environmental Attitudes – sometimes abbreviated as EAs – are a psychological tendency expressed by evaluative responses to the natural environment with some degree of favour or disfavour (Milfont and Duckitt 2010, 80). Most often they are understood as pro-environmental attitudes, meaning concern for the environment and environmental issues (Gifford and Sussman 2012, 65). Environmental attitudes can be inferred from overt responses, self-report methods or implicit measurements, as they are a latent construct (Himmelfarb 1993). They have preservation and utilization dimensions, fluctuate over time, and vary according to socioeconomic status, age, nationality, gender, politics, urban-rural residence, religion, education, experience, and environmental knowledge (Gifford and Sussman 2012, 65).

Hundreds of measures of environmental attitudes are available, however, no "gold standard" measure has emerged from the literature (McIntyre and Milfont 2016, 96). Most prominent of these environmental attitudes measures are the Ecology Scale, the Environmental Concern Scale, the New Environmental Paradigm (Gifford and Sussman 2012), and the EAI scale developed by Milfont and Duckitt (2010) which has been adapted and used as part of this study's methodology (Chapter 3). The EAI assesses a broad range of beliefs about the natural environment and integrates past measures in a way that accounts for the hierarchical and multidimensional nature of environmental attitudes (McIntyre and Milfont 2016, 101).

Environmental attitudes are important because they often determine behaviour that increases or decreases environmental quality (Gifford and Sussman 2012, 65). The relationship between environmental attitudes and ecological behaviour is well-explored and has been subject to extensive academic debate (Hines et al. 1986, 87; Kaiser et al. 1999; 1). However, the majority of studies have established a strong link between pro-environmental attitudes and pro-environmental behaviour (Gifford and Sussman 2012, 66), with the added need to also address social norms, the cost and benefits of behaviour, individuals' emotions, values, and morals, and contextual factors for lasting behavioural change (Steg and Vlek 2009). The discrepancy between measured environmental attitudes and behaviour can be further explained by Rajecki's (1982) four causes, quoted in Kollmuss and Agyeman (2002, 242): (1) normative

influences, such as the aforementioned social norms; (2) direct experiences having a stronger influence on one's behaviour than indirect experiences; (3) temporal discrepancy of one's attitudes changing over time; and (4) attitude measurement being much broader in scope ("Do you care about the environment?") than measured actions ("Do you recycle?"), leading to discrepancies in the results. As such, these causes for potential discrepancies between environmental attitudes and behaviours are important to keep in mind for Chapter 4's analysis. Another important aspect to keep in mind pertains to the difference between environmental attitudes and environmental concern. The academic literature often uses the two terms interchangeably, and while distinct definitions exist in some articles, environmental concern is now largely considered to be an aspect of environmental attitudes (Bamberg 2003), and as such especially the latter is usually used (McIntyre and Milfont 2016, 94).

To summarize, the parameters of environmental attitudes and behaviours above are crucial for interpreting the interviews with astronauts conducted for this thesis research (Chapter 4). The ability to demonstrate long-term change in participants' environmental attitudes and behaviours can carry greater implications for enhancing environmental communication and messaging: As Gifford and Sussman (2012) state, "understanding how to effectively communicate a persuasive environmental message can lead to substantially increased environmental concern" (71) among the public, while well-designed pro-environmental messages can strengthen environmental attitudes and make pro-environmental behaviour more likely (74). As such, *qualitatively* exploring the potential ecological significance of the Overview Effect and the potential changes in environmental attitudes and behaviours, could provide "rich contextual subjective information" about astronauts' feelings, emotions and perceptions, and be used to unpack complexity and to identify processes of the phenomenon (Carrasco and Lucas 2015, 168), as well as to potentially use findings to improve environmental communication and messaging towards the wider public.

2.4 Concluding remarks

As this literature review has demonstrated, there are profound historical, philosophical, cognitive and psychological dimensions in the relationship between environmentalism and human space exploration, and more specifically, in the potential ecological significance of the Overview Effect. Other than a 2007 NASA study titled *The Societal Impact of Space Flight* (Dick and Launius 2007), the exploration of the potential wider societal impacts and uses of spaceflight experiences have gone largely underexplored, and as such, "the need for a broader

look remains urgent" (Cox 2013). This urgency, especially for the identification and wider environmental utilization of the phenomenon that could be scaled for enhanced public outreach, is exacerbated by numerous ongoing ecological crises (Ceballos et al. 2017; IPCC 2018), as well as the increasing commercialization of space travel, which is seeing private companies such as SpaceX, Virgin Galactic, Boeing, and Blue Origin planning to expand space tourism to commercially viable and active operations in the next decade.

This research is also necessary and timely due to the continued high societal standing of astronauts, which is contrasted by the polarization of public confidence in scientific issues, including environmental issues. While the American public confidence in the overall scientific community has remained mostly stable for decades, there are wide public divides over science-related issues such as climate change (Gifford and Sussman 2012, 68; Funk and Kennedy 2019). Astronaut Marc Garneau has talked about the special status of astronauts in society as people to whom special qualities are often attributed, which is significant because "by giving a kind of demigod status to the astronauts, society invests their words with a transcendent authority that can play a significant role in the movement of society beyond the obstacles it now faces" (White 2014, 75). Therefore, if astronauts *do* experience long-term changes in their environmental attitudes and behaviours as a result of spaceflight and the Overview Effect, astronauts' experiences and messages on this subject could be more systematically utilized to increase environmental awareness and concern among a divided public.

CHAPTER 3
Methods

3.1 Overall research design

The original conception of this research was to investigate, empirically, (1a) the extent and attributes of the potential ecological significance of the Overview Effect (1b) and the role it has in shaping astronauts' environmental attitudes and behaviours. Based on questions arising from the literature review (Chapter 2), conceptually, this research seeks to investigate (2a) whether the Overview Effect, and more broadly the outer space perspective, can be considered a significant type or modern version of Hay's ecological impulse, or whether it can contribute to generating such an impulse, and (2b) whether the conceptual framing of astroenvironmentalism can be redefined in a way to increase its applicability to current environmental issues on Earth and its utility to mainstream environmental discourses.

Empirical questions (1a and 1b) will be analysed in Chapter 4, while the conceptual questions (2a and 2b) will be answered in Chapter 5. To investigate these questions, qualitative research methods – and more specifically, semi-structured interviews with astronauts analysed through interpretive phenomenological and content analysis methods (Chapters 4 & 5) and discourse analysis (Chapter 5) – were chosen for numerous reasons.

For one, the baseline study by Ihle et al. (2006) already demonstrated one singular quantitatively measured change in the environmental behaviours of astronauts, in which 64.1% of their respondents said they increased their involvement with environmental causes following spaceflight. However, the greater breadth (environmental behavioural change in other categories, such as diet or voting) and qualitative depth (such as the extent to which those behaviours are practiced) of changes have not been categorically studied nor measured. Therefore, the literature review demonstrated a significant need to qualitatively assess and expand on these potential environmental behavioural changes and to explore any potential attitude changes.

Second, the nature of the phenomenon that is the Overview Effect and the psychological and philosophical effects of seeing Earth from the outer space perspective justify the use of qualitative methods due to the following distinctive features of this method that allow for

greater meaning-extraction: open and exploratory research questions; unlimited and emergent description options; emphasis on understanding a phenomenon in its own right; and the definition of success conditions in terms of discovering something new (Elliott 1999). Since qualitative data collection and analysis are usually exploratory and open-ended in nature (Elliott and Timulak 2005, 149), the approach is warranted for this study as it satisfies all of the following criteria set by Barker et al. (2002): there is very little known so far about this particular research area and thus theory construction is needed; existing research is limited, fragmented, at times confusing, and not moving forward; and the topic is highly complex. Indeed, qualitative methods are best suited for providing rich, subjective and contextual information about people's feelings, perceptions and emotions, and can be used for understanding their behavioural responses to different stimuli (Carrasco and Lucas 2015; 168), including the spaceflight experience. Additionally, "evidence from such studies can be used to provide narratives and messages that can be easily communicated to politicians and other decision makers" (Carrasco and Lucas 2015; 168), as well as the wider public, thus further increasing the potential utility and applicability of this study's findings.

Third, astronauts and spaceflight participants were targeted for interviews as the existing academic literature has already established they experience the phenomenon of the Overview Effect as well as the outer space perspective of Earth first-hand, meaning that any significant ecological aspects of this phenomenon would first be detectable in them and as such, astronauts and spaceflight participants are best qualified to offer insights.

Qualitative research in psychology, especially investigating aspects of awe experiences, have been successful in generating meaningful evidence in the past (Yaden et al. 2016, 1). Therefore, qualitative methods for this exploratory study on the empirical questions of the ecological significance of the Overview Effect were chosen due to their reliance on linguistic data and employment of meaning-based forms of data analysis (Polkinghorne 1983, quoted in Elliott and Timulak 2005, 147). Phenomenology was chosen as the research design because it provides a "systematic reflection and analysis of phenomena associated with conscious experiences, such as human judgement, perceptions, and actions, with the goal of (1) appreciating and describing social reality from the diverse subjective perspectives of the participants involved, and (2) understanding the symbolic meanings ("deep structure") underlying these subjective experiences" (Bhattacherjee 2012, 109). Three types of

phenomenological analysis were used, based on the categorization presented in Elliott and Timulak (2005), with an emphasized focus on the last category:

1. Definitional: What is the nature of the ecological significance of the Overview Effect and what are its defining features?
2. Descriptive: What kinds of varieties does the ecological significance of the Overview Effect appear in and what aspects does it have?
3. Interpretive: Why does an ecological significance of the Overview Effect come about and how does it unfold over time? For example, what changes led to what other changes? What is the sequence or story of changes in astronauts' environmental attitudes and behaviours?

Aspects of the existential phenomenological research method developed by Giorgi and Giorgi (2003) were used to refine the research procedures. The data collection and analysis phases were separated (Figure 3.1) according to the approach developed by Giorgi and Giorgi, as shown in the figure below:

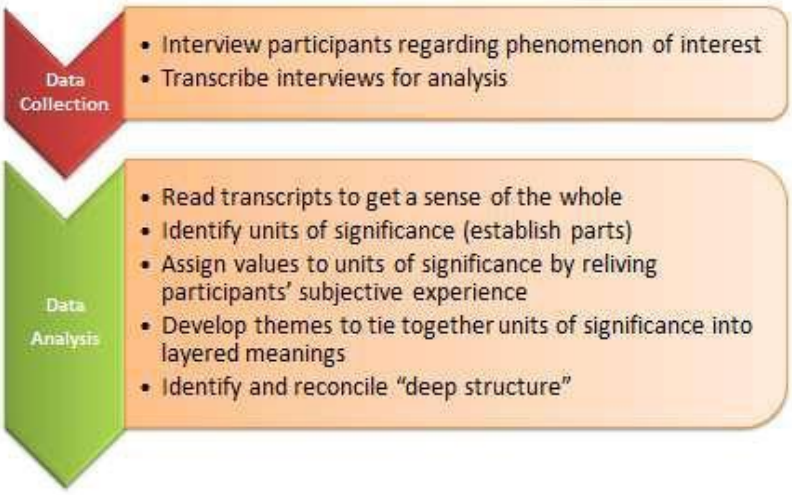

Figure 3.1: Phenomenological research method developed by Giorgi and Giorgi (2003) – Quoted in Bhattacherjee (2012, 109).

Based on the above phenomenological approach, the following sections will detail the data collection and data analysis methods and problems of research.

3.2 Methods of data collection

As a first step in the data collection phase, approximately 150 astronauts and four organizations were contacted in order to arrange interviews with potential participants. The Association of Space Explorers was contacted, as all those who fly in space gain automatic

membership to this association regardless of nationality. The National Aeronautics and Space Administration (NASA), European Space Agency (ESA), and the Canadian Space Agency (CSA) were also contacted with requests for interview participants.

The most important condition was that the participant must have flown in space at least once, and therefore astronaut-candidates and those still undergoing training were not eligible for the study, disqualifying many currently active astronauts still undergoing training. However, this condition enabled the participation of one of only seven existing 'spaceflight participants' in this study – the official term used by NASA and the Russian Federal Space Agency to describe space tourists, also called private space travellers or private astronauts.

Overall, 14 astronauts were interviewed for this study – 13 career astronauts and one spaceflight participant. Interviews were conducted over Skype and telephone over a three-month period, starting with an interview with American astronaut Story Musgrave on May 15, 2019 and concluding with an interview with Canadian astronaut Robert Thirsk on July 8, 2019. The semi-structured interviews with each participant consisted of a questionnaire of approximately 9-10 open-ended and exploratory questions (Appendix I) that were slightly adjusted and refined as the number of interviews progressed and themes both expected and unexpected emerged, as well as adjusted based on the individual background on the astronaut.

The approximately 150 astronauts who were contacted were selected for ease of sampling due to the limited timeframe available for the research: those astronauts who had publicly available contact information, whether a personal website, a social media account, or worked at an organization or academic institution that provided their email addresses online, were contacted directly by email or by social media platforms. Once I started receiving a number of responses, no further attempt was made to contact more astronauts. There were numerous limitations to the methods employed: for one, the self-selection bias of interview subjects meant that only those astronauts responded to my request who had some level of desire to speak about the subject matter. However, a conscious effort was made to discourage a bias in the sample as much as possible: the outgoing request for an interview only stated that my study was "researching the intersection of environmental attitudes and space travel", with no further details provided on the specifics of the topic or the nature of the study. A few participants asked for further details before consenting to be interviewed or asked to see the interview questions before the interview. In both cases, while limited additional information was provided

on the topic of the research, participants were straightforwardly told this was done in order to bias them as little as possible before the interview.

As the data analysis will demonstrate, not only astronauts with mainstream pro-environmental attitudes and behaviours responded to the request; in fact, quite the opposite. The at times extreme diversity of opinions and perspectives that emerged from the interviews demonstrates that a broad range of insights were captured and thus this lends more credibility to the validity and representativeness of the results. With a couple of exceptions, overwhelmingly American, Canadian and European astronauts were contacted primarily due to the availability of their contact information online and secondarily due their ability to conduct the interview in English, Hungarian or French, which are the only languages I would have been able to conduct the interviews in.

Furthermore, there were significant financial and temporal constraints on conducting the interviews. Ideally, both qualitative interviews and quantitative surveys regarding environmental attitudes and behaviours would be conducted with an astronaut before *and* after their first space flight, as well as a third time once a certain amount of time has elapsed since their spaceflight to search for any enduring changes in attitudes and behaviours. However, given that this thesis had to be written in a couple of months, this extensive approach was not possible. Qualitative semi-structured interviews in which participants were asked to recall from memory their pre-first spaceflight attitudes and behaviours was used as an imperfect but practicable approach to extracting information and meaning from their experiences. Since traveling from Hungary to various states and provinces in the United States, Canada and Austria was not possible given the temporal and budgetary constraints of this study, interviews were conducted on Skype (video or audio only) and over the phone, which means that in cases of audio-only conversations some non-verbal cues and reactions might have been missed.

As the interview participant summary (Table 3.1) demonstrates, all participants interviewed were retired astronauts, which is not surprising given that their schedules tend to make them more accessible to the public than active astronauts. This also meant that the average age of participants was 67 years of age (66.923), excluding the one anonymous participant, meaning that while the interviews may be representative of the overall group of all astronauts who on average do tend to be older, it is most likely not fully representative of astronauts from younger generations, many of whom are still active astronauts or undergoing training as

astronaut-candidates. Thus, possible limitations due to the generational, cultural, and gender-based representativeness of the sample are hereby important to acknowledge.

As the final step of the Data Collection phase based on Giorgi and Giorgi's (2003) approach, interviews were transcribed for analysis utilizing the Otter Voice Notes transcription software, available at the website www.otter.ai. Once the transcription was complete by the artificial intelligence-based software, each individual interview was listened to and compared against the voice recording to ensure the material was transcribed verbatim by the software, as well as to gain an important 'first impression' of the overall transcribed material as advised by the methodology literature (Elliott and Timulak 2005, 152).

In terms of research ethics, participants were offered confidentiality and anonymity in the initial request for an interview, and then again at the beginning of their interview, when they were asked if they would like to be named or anonymous. Some participants decided at the beginning that they would like to be named while some decided at the end of the interview, with only one participant requesting anonymous status at the end. Participants were made aware that their interview was conducted for a graduate thesis research, however, were also told that the study may be submitted for consideration to peer-reviewed journals later on.

	Participant	Age	Gender	Nationality	Astronaut status	Number of spaceflights	Year of first & last spaceflight	Total completed days in space	Number of EVAs
1	Story Musgrave	83	Male	American	Retired	6	1983 - 1993	53	4
2	James “Jim” Wetherbee	66	Male	American	Retired	6	1990 - 2002	66	–
3	Richard Garriott	57	Male	American, British	Spaceflight participant	1	2008	11	–
4	Loren Acton	83	Male	American	Retired	1	1985	7	–
5	Jerome “Jay” Apt	70	Male	American	Retired	4	1991 - 1996	35	2
6	Jeffrey “Jeff” Hoffman	74	Male	American	Retired	5	1985 - 1996	50	–
7	Anonymous	–	Male	American	Retired	–	–	–	–
8	Walter Cunningham	87	Male	American	Retired	1	1968	10	–
9	Dorothy Metcalf-Lindenburger	44	Female	American	Retired	1	2010	15	–
10	Ron Garan	57	Male	American	Retired	2	2008 - 2011	177	4
11	Nicole Stott	56	Female	American	Retired	2	2009 - 2011	103	1
12	Franz Viehbock	58	Male	Austrian	Retired	1	1991	7	–
13	Albert “Al” Sacco, Jr.	70	Male	American	Retired	1	1995	15	–
14	Robert Thirsk	65	Male	Canadian	Retired	2	1996 - 2009	204	–

Table 3.1: List of interview participants – in the order of interview date, and including name, age, gender, nationality, astronaut status, number of spaceflights, year of first (and if applicable, last) spaceflight, total days completed in space, and the number of EVAs.

3.3 Methods of data analysis

As described in Figure 3.1, the data analysis phase was conducted by reviewing and coding the transcripts of the 14 astronaut interviews in order to gain an understanding of the whole and to establish units and categories of significance that faithfully represent participants' subjective experiences, attitudes and insights. Themes were then developed to tie together these units and categories to create layered meanings of experiences and attitudes.

Open coding of the interview texts, meaning the analytical process through which concepts are identified and their properties and dimensions discovered in data (Strauss et al. 1998), was employed. This means that the data was closely examined and analysed either by sentence, broken down into discrete parts, compared for differences and similarities, and then categorized and subcategorized together if conceptually similar in nature or related in meaning.

Notably, the 12 scale categories identified in the EAI by Milfont and Duckitt (2010) intrinsically emerged as distinct categories during the data analysis. The EAI utilizes the following 12 scale categories: (1) enjoyment of nature; (2) support for interventionist conservation policies; (3) environmental movement activism; (4) conservation motivated by anthropogenic concern; (5) confidence in science and technology; (6) environmental fragility; (7) altering nature; (8) personal conservation behaviour; (9) human dominance over nature; (10) human utilization of nature; (11) ecocentric concern; and (12) support for population growth policies. All 12 of these categories were identified and labelled under differently worded but similar labels in the data analysis *before* the EAI scale measures was used to rename and group the categories and their respective subcategories together, which reinforces the usefulness and correct categorization of Milfont and Duckitt's (2010) 12 scale categories. Participants were only asked explicitly about two scale measures: their environmental movement activism (#3) and their personal conservation behaviour (#8), both later categorized in the third theme of environmental behaviour (Chapter 4, Category 3). Indeed, three distinctive themes emerged from the data analysis, into which the 12 categories intrinsically fit and were subsequently grouped into: The ecological dimensions of the Overview Effect (Category 1); Environmental attitudes (Category 2); and Environmental behaviours (Category 3).

The approach of open coding emphasizes the second level of interpretive analysis, with the first being the viewing of the phenomenon from the subjective perspectives of the astronauts. The second level aims to understand the meaning of astronauts' experiences and attitudes in order to provide a rich narrative story of the phenomenon that is able to communicate why participants acted the way they did (Bhattacherjee 2012, 106). As such, the specific experiences, attitudes and insights of astronauts, when used as examples to justify specific categorization and interconnections, constitutes the first level of analysis, while the broader categorizations and theory-building constitute the second level of interpretive analysis in this study. Additionally, a hermeneutic circle of interpretation was applied, which allows movement between the micro and the macro, namely the observations (text) and the phenomenon (context), in order to construct theory that is representative of the diverse subjective experiences of participants and is theoretically saturated, meaning additional iterations and interpretations of the text do not yield any more insight into the phenomenon (Bhattacherjee 2012, 106).

3.4 Validity, reliability, representativeness and limitations

Following the principles set forth by qualitative research, this study aimed to sample broadly and interview deeply enough to capture all the important variations and aspects of the ecological significance of the Overview Effect (Elliott and Timulak 2005, 151). Rigor was applied through the systematic and transparent approach to data collection resulting from the semi-structured interview approach. The sample size provided a manageable amount of data, and by the time it reached 14, it had also reached the point of saturation (Strauss and Corbin 1998), which meant that no significantly new information was emerging from the interviews. Given that only approximately 560 humans have been to space so far (Berger 2019), the sample size of 14 quantitatively represents approximately 2.5% of all people who have been to space.

Validity of this qualitative research was challenging because it had to be balanced between the necessity of incorporating rigor, creativity and subjectivity into the scientific process (Johnson 1999). Validity of the data analysis was ensured through triangulation, in which the qualitative interview data collected was assessed against the quantitative environmental behaviour finding of the Ihle et al. study (2006); and through resonation with the reader, meaning that findings were grounded in numerous illustrative examples and quotes to allow the readers to make their own judgements (Elliot and Timulak 2005, 156).

Additionally, through the open coding and categorization process, claims to knowledge were made explicit, and techniques such as the hermeneutic circle of interpretation was used to address threats to validity such as not accurately representing the wide diversity of opinions (Whittemore et al. 2001, 527).

Besides some of the limitations to data collection mentioned in Section 3.2, other limitations exist that are important to mention here. Perhaps most significantly, despite all participants having flown in space and being qualified to do so, they might not be equally knowledgeable, credible or unbiased about the specific dimension of the phenomenon investigated and may even have undisclosed political agendas (Bhattacherjee 2012, 105). While political orientation was not addressed in the interviews, opinions that directly contradicted mainstream scientific evidence revealed at least some level of bias and lack of credibility among some participants. However, as the researcher, I aimed to maintain complete neutrality by never interrupting or arguing with participants and asking non-leading questions that were open to interpretation by the participant – for example, the term 'environmental issues' being interpreted exclusively as pollution by those astronauts who rejected other anthropogenic ecological issues such as climate change or biodiversity loss.

Another limitation is participants' occupation: test pilots and military personnel are known to not display excitement during flight, which is "reinforced by the tradition that radio time is precious commodity, not to be wasted in idle chatter" (White 2014, 28). This is further reinforced by the continuous criticism that astronauts, often coming from military, scientific, engineering and medical backgrounds, are too laconic in describing their experience in outer space (White 2014, 7). The study aimed to counteract this with the semi-structured approach to interviews, by asking participants open ended questions and prompting and re-prompting questions in different ways when needed. This limitation is also counterbalanced by the experiences of astronauts being more contextually rich due to their scientific understanding of earth and atmospheric sciences (Shaw 2017), which factor also emerged during interviews.

Finally, there exists a systemic incentive for astronauts to only report positive experiences of spaceflight, as often their next flight assignments and careers depend on their psychological and psychiatric performance (Harrison and Fiedler 2011, 45; Bimm 2014, 44). While this has been an enduring obstacle in psychological research on astronauts (Harrison and Fiedler 2011, 45), the interdisciplinary nature of this study that specifically focuses on

environmental aspects of the phenomenon, as well as the conscious decision to not explicitly mention the term 'Overview Effect' during interviews, aimed to prevent self-reinforcing narratives sometimes found in White's research. The retired status of participants also meant they did not have to be concerned about future flight assignments by their respective agencies.

To conclude, as American-Spanish astronaut Michael Lopez-Alegria said, "it is extremely hard to describe quantitatively the change in people before and after spaceflight" (White 2014, 269). As such, analysis of the qualitative interviews conducted with astronauts follows to investigate the potential ecological significance of the Overview Effect, changes to participants' environmental attitudes and behaviours resulting from the significance, and the current breadth and depth of those attitudes and behaviours.

CHAPTER 4
Results & Discussion: Empirical Data Analysis

Based on qualitative interviews with 14 participants, the data analysis has been grouped into three separate results and discussion sections contained within this chapter – with a discussion summary at the end – as all three categories represent a distinct addition to the existing academic literature. The 12 scale measures identified in the EAI in Milfont and Duckitt (2010) were used to anchor the analysis, as these themes independently emerged from the interviews and fit intuitively into the three broader categories as seen below:

- Category 1: The ecological dimensions of the Overview Effect (Section 4.1)
  - Environmental fragility (#6)
  - Ecocentric concern (#11)
- Category 2: Environmental attitudes (Section 4.2)
  - Enjoyment of nature (#1)
  - Support for interventionist conservation policies (#2)
  - Conservation motivated by anthropogenic concern (#4)
  - Confidence in science and technology (#5)
  - Altering nature (#7)
  - Human dominance over nature (#9)
  - Human utilization of nature (#10)
  - Support for population policies (#12)
- Category 3: Environmental behaviours (Section 4.3)
  - Environmental movement activism (#3)
  - Personal conservation behaviour (#8)

This section seeks to answer research questions that arose from the academic literature pertaining to (1) the potential ecological significance of the Overview Effect, (2) the qualitative breadth and depth of participants' present environmental attitudes and behaviours, and (3) the potential relationship between the first two factors. The first category analysed below investigates the ecological dimensions of the Overview Effect, including the outer space perspective of Earth and its more distinct environmental dimensions.

4.1 Category 1: Ecological Dimensions of the Overview Effect

Two subcategories emerged within this category, namely the outer space perspective of Earth (4.1.1.1) and distinctive environmental dimensions (4.1.1.2). The experiences described in these two sections often proved to be the precursor to any subsequent positive

effect on participants' environmental attitudes and behaviours. As such, it was important to examine participants' extent and intensity experience of the Overview Effect, as well as more personal insights, sentiments and conceptualizations of the outer space perspective's relation to environmental issues back on Earth.

4.1.1 Results

4.1.1.1 Outer space perspective of Earth

Overview Effect

The table below (Table 4.1) was made based on the author's interpretation of participants' statements and added in order to ease the reader's understanding of the results.

	Participant name	Intensity of the Overview Effect
1	Richard Garriott	Strong
2	Jeff Hoffman	Strong
3	Dorothy Metcalf-Lindenburger	Strong
4	Ron Garan	Strong
5	Nicole Stott	Strong
6	Franz Viehbock	Strong
7	Al Sacco	Strong
8	Robert Thirsk	Strong
9	Loren Acton	Moderate
10	Jay Apt	Moderate
11	Anonymous	Moderate
12	Story Musgrave	Minimal
13	Jim Wetherbee	Minimal
14	Walter Cunningham	None

Table 4.1: Intensity of the Overview Effect experience in participants

Participants were asked to describe their reaction to seeing the Earth from the outer space perspective as a way to indirectly measure the extent and intensity of their experience of the Overview Effect – although astronauts Nicole Stott and Robert Thirsk and spaceflight participant Richard Garriott did mention the words "Overview Effect" without being prompted. Eleven of the 14 participants had moderate to intense Overview Effect experiences, while three participants had relatively weak or non-existent experiences. Three participants described having an intense physical reaction to seeing Earth from the outer space perspective: Richard Garriott said "I had this physical epiphany where you suddenly think to yourself I now know the true scale of the Earth by direct observation […] it literally made me physically shudder

and gave me goosebumps" while Dorothy Metcalf-Lindenburger said "sometimes I got chills and goosebumps, it's just so beautiful" and Robert Thirsk said looking out the window "sent a chill up my spine". Other intense accounts described it as follows: "a very mind-altering kind of experience" (Al Sacco), "the most beautiful thing I've ever seen" (Ron Garan), "an enormous, gorgeous view down to our home planet" (Franz Viehbock), "an outrageously gorgeous experience of nature" (Story Musgrave), "a stunning view" (Anonymous participant) and "unbelievably impressive" (Jim Wetherbee). One astronaut, Walter Cunningham, who seemingly had the weakest effect, said: "It was what we expected to see. […] We saw some nice things on the planet […] but I don't think we were very surprised at what it was. Some people might have been". Cunningham also mentioned problems with visibility due to the windows of the spacecraft deteriorating during the mission. Additionally, as predicted by the Overview Effect, themes of unity, interconnectedness and insignificance emerged, with participants mentioning reactions such as "you feel like you're one with everything living" (Al Sacco), a "sense of interconnectivity […] we all are in space together already" (Nicole Stott), and "it really drives home the undeniable unity that the planet represents" (Ron Garan).

EVA

Two participants were asked to describe how their EVA experience might have differed from viewing the Earth from inside their respective spacecrafts. Both astronauts described at least a minimal level of qualitative difference, with Nicole Stott saying "there's more of an appreciation of the vulnerability" that comes with the spacesuit becoming an astronaut's "own little personal spaceship" that allows them to conduct the EVA. Ron Garan described his EVA experience more intensely: "Part of the experience, whether conscious or unconscious, is the realization that we've stepped into this great void, this realm of nothingness, and just like removing ourselves from the planet – from a visual point of view, like stepping outside a painting and looking back – this takes us one dimension further".

Distance

The physical variations in the distance from the surface of the Earth was brought up by five participants. Walter Cunningham said "we were all military fighter pilots, so we had been living a career up until that time where we were above the surface […] the only difference was that we were 100 miles plus high [in the spacecraft] as opposed to being just 10 or 11 miles high, so the visibility was different. The view was impressive, very impressive. But it was what we expected", while Richard Garriott said "my first thought was wow, we're not nearly as high

up as I thought we would be", citing photos captured with wide angle lens from the International Space Station (ISS) as "exacerbating the feeling" of distance. Dorothy Metcalf-Lindenburger compared the Great Salt Lake in Utah, U.S., passing by in seconds from space contrasted by her experience of crossing the lake on a commercial airplane: "that was the type of stuff that always startled me. I always wasn't quite far ahead on the globe and it took a good portion of the mission to catch up to that". Story Musgrave and Robert Thirsk cited the greatest distances from Earth as powerful outer space perspectives: "I think the most powerful pictures are the Voyager pictures of Earth a billion miles away, now that is outrageously powerful" (Musgrave), and "when I see images from Cassini, it's a personal evocation of our vulnerability, of the fragility of nature, of our civilization […] that can certainly create an overview effect in some as well" (Thirsk).

Objectivity-subjectivity

A distinct pattern emerged from participants discussing the outer space perspective of Earth in terms of objectivity and subjectivity. The majority of participants described the perspective as either emotional or as both emotional and scientific. Jay Apt said "it has nothing to do with science, it's an artistic and emotional image", Robert Thirsk said "it's more of a personal perspective", while Al Sacco said "it was truly much more of an emotional event, I mean, although I'm a scientist, it's so awe-inspiring and overwhelming to realize there's not that many people that have seen it from this perspective". Even Walter Cunningham, who previously discussed crewmates in the context of their military backgrounds, said "when you do get to see the surface of the Earth, I think some of the guys at the time did have an emotional reaction to it". Franz Viehbock's experience with both is representative: "I think when you see the Earth from outside, both directions are working. You see it with a lot of emotions of course, but also, at least in my case, the scientific brain is also participating". The anonymous participant, however, described it as an objective perspective, citing his prior astronaut training in Earth Observation that made him a more objective, educated observer.

4.1.1.2 Distinct environmental dimensions

Spaceship Earth

Besides the Overview Effect, another well-known concept emerged from the interviews: without being specifically prompted, five participants used language and conceptual framings akin to the Spaceship Earth metaphor to make sense of their changed

relationship with the Earth from an environmental perspective. Loren Acton said "the thing that impressed me the most is that the Earth is a very finite spaceship […] and as the only creatures that can appreciate this, it's up to us to take care of it", while Dorothy Metcalf-Lindenburger described how air supply in a space suit and on the ISS is a matter of life and death, meaning "it makes you very aware of why you appreciate not having to think of it back on Earth, and therefore, how do you protect it?". Richard Garriott said, "traveling to space requires you to have created a system which is, by definition, zero impact […] and so designing for survival beyond the surface of Earth is designing for living in balance and harmony with the Earth itself". Finally, Nicole Stott said that her telling any audience she speaks to that "we need to be crew, and not just passengers, on Spaceship Earth" has prompted strong and positive reactions from the public, who often tell her afterwards "they'll say, I learned in science class, but I never think about the fact that I'm actually on a planet. Just raising that consciousness, that awareness, I think is really huge".

Physical views: Aesthetic beauty

One of the key outcomes of the interviews are the accounts of the physical views of the Earth that prompted environmental responses in participants: these being the aesthetic beauty of the Earth, including colours; the thinness of the atmosphere; and the visible changes on the surface of the planet as a result of human activity. Most participants mentioned the unexpectedly crystal-clear view of the planet from above that results from the lack of atmospheric distortion. Participants used words such as "overwhelming", "impressive", and "beautiful" to describe the aesthetics of their view, including: "[the surface] seemed quilted, like it reminded me of a quilt […] I remember this lighting storm over Australia, it looked like it was a dance of light in the clouds, it was so beautiful" (Dorothy Metcalf-Lindenburger). Richard Garriott said, "your view is so spectacular, and the detail you can see and what you believe you're learning just by watching is so compelling, that you are glued to this slowly moving map of the earth that is rotating below you".

Physical views: Colours

Half of the participants specifically mentioned colours as part of their outer space view of Earth. Astronaut Nicole Stott said "I did not expect the Earth to just glow the way it does, it was crystal clear, iridescent, translucent, all the colours that you know Earth to be but in the most brilliant way", while astronaut Al Sacco's description of the black background of space is typical: "it's a beautiful blue, hanging in the blackest black, surrounded by billions of stars".

Astronaut Jim Wetherbee described the colours as "bright and vibrant […] the blue of the ocean is a much deeper blue, much more brilliant blue than you could ever imagine, than I've ever seen either on the Earth or in pictures". Participants also mentioned the intensity of the blue colours as contrasted by the red, brown and orange colours of North Africa and the white and grey colours of the clouds. Participants also mentioned the night-time view of lit-up cities and the night-time green glow of the atmosphere known as airglow or nightglow. Additionally, astronaut Jim Wetherbee contrasted the blackness of space with the view of other stars: "The number of stars you can see blows your mind – it looks like you can see a million stars, none of them twinkle and all are different colours, mostly white, some yellowish, some bluish, some brownish, some reddish".

Physical views: Atmosphere and environmental fragility

The thinness of the atmosphere from space also had a prominent emotional effect on some participants' experiences. Six astronauts mentioned how seeing, as opposed to just intellectually knowing, the physical thinness of the atmosphere from space was "startling" (Dorothy Metcalf-Lindenburger). Loren Acton said "the thing that impressed me immediately is how thin the atmosphere is. The breathable atmosphere is only about eight miles thick on top of an 8,000-mile-diameter Earth, and so you really appreciate the finiteness of the layer of life on the planet", while Robert Thirsk similarly said "the difference between life on Earth and no life was just this incredibly thin layer of atmosphere […] sometimes I'd be in space looking out the window at Earth and I would imagine some hypothetical fantastic giant coming by and blowing the Earth's atmosphere away and all life on Earth would cease to exist". The words of Jeff Hoffman and Robert Thirsk summarize participants' comments about intellectually knowing versus physically seeing: "When you go out on a nice sunny day and you look up at the big blue sky, you don't feel emotionally how thin and limited the atmosphere is, but when you go up in space, you look down at this tiny, thin blue line around the horizon" (Hoffman), and "We've seen the pictures before the flight, but until you actually see it, it doesn't really register with your heart as well as your mind, so seeing that made a difference in me" (Thirsk).

Physical views: Visible anthropogenic changes and environmental fragility

The majority of participants emphasized visible changes on the surface of the planet resulting from human activity as being a significant part of their outer space view of the Earth. Participants expressed it as follows: "the impact of humanity is everywhere" (Richard Garriott), "the environmental impact is easily seen from space" (Robert Thirsk) and "there's a

lot of impacts of human civilization on the Earth which are now visible from a cosmic perspective and that's pretty scary" (Jeff Hoffman). Numerous participants mentioned directly seeing deforestation in the Amazon and clear-cut forestry around the world, coral bleaching and dead zones in the oceans, topsoil erosion near Madagascar's Betsiboka River, retreating glaciers and ice caps, air pollution over industrial regions, pollution plumes from oil fields, and smoke rising and spreading across other regions from burning areas. Robert Thirsk said the surface often looked like a "checkerboard" due to deforestation, which is not as evident from the surface but is evident from space, as well as "seeing the impact of global warming on glaciers and ice caps", including the shrinking ice cap on Mount Kilimanjaro between his two missions. Jay Apt and Franz Viehbock, who both flew for the first time in 1991, cited the Aral Sea between Kazakhstan and Uzbekistan as an example, saying it was "almost non-existent" (Viehbock) and "in just the few years that I flew in space you could see how it shrank" (Apt).

Participants also described seeing air pollution: Walter Cunningham described his surprise when saying "for the whole 11 days, we really never got to see the surface of China because there was always smog", and Robert Thirsk similarly mentioned always being asked about whether the Great Wall of China is visible from space but never being able to answer that question since he never got to see China during his missions due to the poor visibility. Jim Wetherbee said of flying in the U.S. Navy that "you used to be able to see for 300 miles very clearly and these days you can't because there's pollution in the atmosphere".

Participants often expressed that seeing visible physical changes on the surface of the planet reinforced their impression of the Earth as a single interconnected planetary system: "You can see the Earth as an interconnected system, […] you can see the scale of ecological disaster, […] and those kinds of things are emotional" (Jay Apt). These comments were echoed by Robert Thirsk and Franz Viehbock: "You see nice and beautiful things on Earth, and then you see areas or places or things where humans have destroyed the environment, and this always goes very deep and affects you […] and this of course amplifies it somehow, because you've seen it" (Viehbock). Citing smoke plumes of a forest fire in Siberia traveling across the Pacific Ocean to North America and the Japanese nuclear reactor failure affecting not only Japanese but water systems around the planet, Thirsk said: "Everything on Earth is connected. Everything is one on Earth. We're all connected, and spaceflight showed that to me".

Usefulness

Due to the significant environmental responses triggered by the physical view of the planet from outer space, participants were asked whether they thought the perspective could be

used to advance positive environmental goals on the surface, with most participants expressing the potential usefulness of the outer space perspective of Earth as ranging from moderate to significant. The following patterns emerged from this topic of discussion: (1) usefulness in terms of demonstrating the visible changes on the surface of the planet from space; (2) usefulness in terms of interconnectivity messaging; (3) usefulness in terms of being a conversation starter; (4) and other – more minor – forms of usefulness.

A few participants said the outer space perspective of Earth is useful but not in an overwhelming way (Loren Acton), while two participants said its effect on changing peoples' attitudes or behaviours was questionable, given the evidence of the intensifying ecological crisis despite the Apollo images' effect on the broader public (Jeff Hoffman and Anonymous).

On the other hand, some participants found the perspective "a very powerful message" (Ron Garan), "very useful" (Franz Viehbock), saying "we need to do a lot more of that" (Robert Thirsk) and it is "the key" to improving environmental messaging to the public – "we want everybody to have their Earthrise moment" (Nicole Stott). In terms of (1) visible changes to the surface, Richard Garriott said "space travel allows you to see in a compelling way what's happening with the environment and what role human causes have in it", while Al Sacco talked about showing visual imagery from orbit of anthropogenic physical changes on the Earth's surface from the past 50-60 years during his presentations to various audiences: "I say, you need to know what's going on and here's an example. So when you do this, recognize what you're doing, because this is going to impact everybody".

Participants also expressed the usefulness of the outer space perspective (2) in driving home messages of the interconnectivity of all socio-ecological systems on the planet. As summarized by Ron Garan: "We tend to treat environmental issues as individual standalone problems, whether it's biodiversity loss or global warming or ocean acidification and I think that's a mistake, because in reality, they are all symptoms of the underlying root problem, which is that we don't see ourselves as planetary. […] We live on a living, breathing, interconnected and interdependent biosystem called Earth and we need to treat things holistically and understand that what happens on one side of the planet affects everything else". Robert Thirsk expressed similar sentiments, adding: "It's not an individual, a community, or even a nation that's going to be able to solve the problem", indicating the problem is of planetary magnitude.

Some participants said the outer space perspective is useful (3) as a conversation starter on environmental issues, both as the connection the perspective prompts in people caring about the planet they live on (Dorothy Metcalf-Lindenburger) and the spaceflight experience serving

as "a kind of hook you can hang things on, a very useful entrée to discussions about these kinds of issues," including "environmental understanding and appreciation" (Loren Acton). Ron Garan said "when people talk about environmental issues, they start from a foundation of fear, but starting from a foundation of awe and wonder opens the mind and makes you accepting of different perspectives and ideas and partnerships and collaborations and it is a much more effective way to discuss these issues".

Other forms of usefulness were expressed as (4) possible technological advancements of space exploration resulting in transitioning to cleaner energy sources quicker in the future and the inspiration that space provides to students to pursue scientific and engineering degrees who then help contribute to solving environmental problems (Jim Wetherbee).

Recreation on Earth

The final subcategory to emerge in this category relates to the possibility of recreating the Overview Effect and specifically its environmental effects on Earth. Participants were asked whether they thought it was possible to recreate the same or similar effect on the surface. The main consensus to emerge among participants was that (1) spaceflight was a qualitatively different enough experience to any other awe-inducing experience on Earth to make recreation opportunities of the exact same kind limited on the surface; but on the other hand (2) being an educated observer of nature enhanced the intensity of awe-inducing experiences on the surface.

On the first point (1), Richard Garriott said that from space "you see science playing out on a grand scale that you can only possibly perceive from space", similar to Loren Acton saying one does not appreciate the finiteness of the layer of life from the surface as one does looking down from space. Al Sacco said that "the beauty of [Earth] has never been really captured with the film that you get, even though it gets better and better", echoing Robert Thirsk, who said there is a significant qualitative difference between seeing pictures and seeing it in person, until which point "it doesn't really register with your heart as well as your mind". Two participants specifically used the Grand Canyon to illustrate their views. Richard Garriott made the point of experiencing the canyon in person versus a virtual environment: "I don't think the two would have the same effect on you as a human. When you hike something for real, you get a sense of the actual scale, the physicality of it, compared to a human. Your immediate feeling of deep time that was required to [form the canyon] is extremely meaningful when you're at the real one". This was reiterated by Jeff Hoffman, who also made the point that the Grand Canyon is "an overwhelming experience, but maybe not as overwhelming as being in space, just because space is so different from anything on Earth".

On the second point (2), participants said that being an educated observer of nature on the Earth's surface was sufficient to induce enhanced awe and wonder experiences. Loren Acton said "I do not think you need to go into space. If you simply study the reality of life on Earth and open your eyes, you can understand these same things", while Jim Wetherbee said "I can see the same things down on Earth. For example, when I look at a tree, I think to myself, wait a minute, you're telling me that water comes up through the roots, up the trunk, out the branch, goes into the leaf and combines with chlorophyll and the sun's energy to create life sustaining energy – are you kidding me?".

Some participants made the point that they did not believe an individual had to go into space to get similar experiences and emotional reactions. While Nicole Stott did make the qualitative distinction between space and any other awe-inducing experience on Earth, she also said "I think the response to the experience can be had in other ways", citing scuba diving and musical experiences as producing similar feelings, just not at the "grander scale" of space. For Story Musgrave, the Cassini spacecraft's picture of Earth as a small dot under Saturn "is more powerful than any spaceflight I took […] and I did not have to go there to see that picture. That really puts it into perspective as to who we are, who we should be, and how […] we should look after the planet". Similarly, Robert Thirsk said that while media and films, especially IMAX films, are not as good as being in space, they're "the next best thing in creating an Overview Effect" on the surface. However, citing his example of being able to see visible anthropogenic changes *from* the surface as well, he recalled visiting the Columbia Icefield in Banff National Park in Canada as a child when the icefield came down to the roadside, but now visitors having to take a bus to get to the edge of the glacier because it has retreated so much.

Finally, the theme of intellectually knowing versus emotionally experiencing emerged again: two participants said the uniqueness of the outer space perspective is what allowed them to emotionally experience the finiteness of the Earth as a planet and its limited carrying capacity (Jeff Hoffman). In the words of Nicole Stott: "Intellectually, I knew we lived on a planet, I knew we were in space, […] I knew the way water recirculates and our oxygen is created, but there wasn't a conscious awareness of them in my daily life. Now there is. I mean, there's not a day goes by that it's not in the front and the back of my mind".

4.1.2 Discussion

Results both expected and unexpected emerged from this category, which is the category that has been the most extensively covered by the existing literature. One of the key findings is that, within the unique context of the outer space perspective of Earth, participants

placed strong emphasis on the environmental fragility of the Earth – especially in relation to the thinness of the atmosphere and visible anthropogenic changes from space – as well on the interconnected and planetary perspective of the Earth as encompassed by ecocentric concern. These two issues – environmental fragility (#6) and ecocentric concern (#11) – from Milfont and Duckitt's scale measurements (2010) have emerged as crucial themes in investigating and identifying a distinguishable ecological significance of the Overview Effect.

The results largely confirmed prior observations about the Overview Effect and EVAs. The majority of participants described moderate to intense emotional experiences linguistically akin to the Overview Effect described by White (2014). As expected, most participants reported experiencing the cognitive shift in awareness that results from the effect, including the line in White's description hinting at an environmental dimension: "a renewed sense of responsibility for taking care of the planet" (2014, 2). Some of the dimensions of the Overview Effect that participants highlighted were the experiences of awe and wonder, feelings of interconnectivity and unity, and understanding the true planetary dimension of the Earth's biosystems and the species contained therein. However, the extent of the Overview Effect did not seem to be as dependent on the distance and duration of the mission as posited by White (2014, 11), given for example that Walter Cunningham, who spent 10 days in space, and Franz Viehbock, who spent 7 days in space, had strongly contrasting experiences – with the former being the only participant who seemingly did not experience the effect at all, while the latter having a strong experience of the effect. Notably, Cunningham mentioned that his view from the spacecraft was obstructed by increasingly poor visibility due to the deterioration of the aircraft's windows, and as such it is possible he did not experience any significant version of the Overview Effect due to this limiting factor. Additionally, while only two participants discussed their EVA experiences, the outer space view of Earth specifically did appear to be at least somewhat different from viewing the Earth from within a spaceship or station, taking the intensity of the experience "one dimension further" (astronaut Ron Garan). This somewhat confirms White's argument that EVAs are a different experience from the other (2014, 34).

Physical distance was an unexpected theme to emerge from the interviews and demonstrated the diversity of experiences in how astronauts perceived their outer space perspective of Earth on the spatial scale. Variation on the spatial impressions ranged from Richard Garriott's surprise at being 240 miles above the surface of the Earth in reality not appearing as high up as he expected it to be, to Story Musgrave's and Robert Thirsk's

invocation of the power of the Voyager and Cassini pictures of the Earth taken billions of miles away from the planet as the most powerful images. Astronauts Dorothy Metcalf-Lindenburger and Walter Cunningham compared the variation in physical distance to being in an airplane, invoking the inherent similarities but also the key differences in visibility and scale between the two flight types. Their comments resonate with Richard Garriott's: "The altitude you're orbiting at is about 10 times higher than an airplane, but only 10 times higher. It's interesting that you simultaneously feel intimately close to the Earth, as well as very separated from any direct assistance from Earth, so you have this interesting position of both feeling isolation as you drift above the Earth, but also this sort of firehose of information that is pouring into your mind just by looking out the window at this amazingly captivating view".

Participants' views of the Earth from orbit therefore indeed appear to satisfy the physical requirement of vastness in inducing awe and wonder experiences (Silvia et al. 2015; Yaden et al. 2016; Shaw 2017). Also, the perspective shift that resulted from seeing familiar landmarks, such as the Great Salt Lake for Dorothy Metcalf-Lindenburger, appeared to indeed elicit conceptual awe due to seeing it from a completely different visual orientation, as posited by Yaden et al. (2016, 4). This finding is potentially significant for utilizing the outer space perspective of Earth to improve environmental messaging to the public, and as such it should be further investigated how seeing familiar landmarks in an immersive way from the grander perspective of space could have the potential to elicit both conceptual awe and emotional experiences that could further help people 'relate the local to the global' from an environmental perspective. As such, people seeing their respective localities from the context of a planetary perspective could potentially elicit both perceptual and conceptual themes of awe and wonder, which in turn is known to influence beliefs and change one's general perspectives towards the world and themselves (Schneider 2009).

Additionally, themes of subjectivity and objectivity that unexpectedly emerged from the interviews also appear to confirm that the unique perspective of outer space is an intensively emotional and awe-inducing perspective (Silvia et al. 2015; Shaw 2017), reinforcing the potential of the outer space perspective and image of Earth in prompting positive and intense emotional reactions from observers. Participants emphasized both objective (scientific) and subjective (imaginative or emotional) connotations of the outer space perspective of Earth that indeed helped them generate new ideas and ways of thinking by the first-hand planetary point of view indeed 'making new connections visible', as predicted by the literature pertaining to

strong global environmental images (Grevsmühl 2016). As such, the scientific and environmental image of the Earth from outer space was indeed shown to trigger both objective and subjective connotations in direct observers, which further reinforces the potential utility of using the perspective for enhanced environmental messaging and outreach towards the public.

One of the key outcomes of this study pertains to what physical factors triggered environmental responses in participants as part of their spaceflight experience: these factors being views of aesthetic beauty, of colours, of the thinness of the atmosphere, and of the visible anthropogenic changes on the surface of the Earth. Whereas the literature already states that aesthetics can be a strong catalyst in inducing the Overview Effect and awe and wonder experiences (Shaw 2017), and separately that aesthetics can provide a strong basis for an environmental ethic (Brady 2006; Mahoney 2016), the specific role that these physical views play in astronauts' relationship to environmental issues has not been previously explored. Participants' comments pertaining to the aesthetic beauty and intense colours of the planet confirm that the awe and wonder sentiments produced by these two factors contribute to the emergence of positive environmental responses in relation to the planet. Both the aesthetic and colour aspects of the outer space perspective of Earth appear to indeed emphasize perceptual themes of awe, such as the physical beauty of nature or Earth from space (Yaden et al. 2016).

As expected, conceptual themes of awe, such as the fragility of life from space (Yaden et al. 2016), were also emphasized by participants, but unexpectedly, these were emphasized specifically in relation to participants' environmental sentiments. Jeff Hoffman's comment is representative: "On an emotional level, you appreciate the finiteness of the earth as planet, that there is a limited carrying capacity and that we can't just keep putting anything we want to up in the atmosphere and expect it's not going to have any impact" (Hoffman). Therefore, a key takeaway is that while, as stated in the literature, both perceptual themes (the aesthetic beauty of the planet) and conceptual themes (the fragility of life on Earth) play a significant role in awe-inducing experiences such as spaceflight and the subsequent Overview Effect, these themes also extend to playing a specific role in contributing to increased *environmental* awareness and feelings of concern among participants. In short, the aesthetic beauty of the Earth from space and the thinness of the atmosphere unexpectedly triggered environmental, and not just awe and wonder, responses in participants.

Perhaps even more significantly, visible anthropogenic changes on the surface of the Earth were unexpectedly brought up and emphasized by numerous participants, without being asked about this specifically or whether they noticed anything negative from space more generally. The contrast between perceptual themes of awe that emphasize positive physical views of Earth (aesthetic beauty of the planet) and perceptual themes that emphasize negative physical views of Earth (visible ecological destruction) is a surprising outcome of the interviews. Evidence of ecological destruction had a deeply emotional impact on participants that "amplified" (Franz Viehbock) their environmental concern. This is specifically the result of seeing ecological destruction on a grander scale of such vastness that is otherwise awe-inducing and unique to the outer space perspective. The duality and juxtaposition of both positive and negative perspectives of Earth can be said to have amplified positive environmental responses produced by awe and wonder experiences in participants, and especially amplified feelings of environmental awareness and concern. This finding is potentially significant for ways in which visible ecological destruction, as viewed from the outer space perspective, could be utilized in targeted environmental messaging and outreach to the public – as later suggested by the participants themselves under 'usefulness' – and the potential ways in which visual experiences of both awe and destruction could be utilized in concert to increase environmental awareness and concern in observers.

Besides showing visible anthropogenic changes on the surface, as discussed in the paragraph above, participants also said the perspective and experience was useful for driving home the message of interconnectivity, and hence the need for planetary-scale management, as argued by White (2014) and Garan (2016) as well, especially environmental planetary-scale management. Participants also made the point that the perspective and experience can be useful as a conversation starter on environmental issues. This is an interesting finding, given some pushback in the environmental community against 'planetary' language that posits that the perspective masks local issues and complex realities on the ground (Boes 2014; Collins 2016; Garb 1985; Strong 2013). The experience of participants from Low Earth Orbit (LEO), however, appears to show the contrary: issues such as deforestation in the Amazon rainforest, the disappearance of the Aral Sea in Asia, retreating ice caps of Mount Kilimanjaro in Kenya, and the water depletion issues with center pivot irrigation systems in the Sahara Desert suggest the perspective does not entirely mask local issues. Therefore, while outer space perspectives of Earth from greater distances, such as the Apollonian perspective, may indeed not display visible signs of anthropogenic ecological destruction (Boes 2014), the views from the vicinity

of the planet are effective in displaying, and thus communicating, anthropogenic ecological destruction. Besides amplifying environmental responses in astronauts as direct observers, this finding has implications for sub-orbital and orbital space tourism operations in the future, in which the perspective could be used to purposefully amplify environmental responses.

Some participants unexpectedly made sense of their post-flight changed relationship with the Earth from an environmental perspective in language akin to the Spaceship Earth concept, with Nicole Stott even using the words directly. This finding suggests some participants' environmental conceptualization of the Earth has already previously been at least partially influenced by Buckminster Fuller's metaphor. Stott suggests "we need to be crew, and not just passengers, on Spaceship Earth", which parallels language from the 1970s about living more environmentally ethically in terms of the general public trying to live more like astronauts (Anker 2005). Stott said her message always strongly resonates with her audiences, which indeed reinforces that in terms of usefulness in communicating environmental messages to the wider public, "perhaps this old metaphor, in a new age of geopolitical and ecological crisis, is ready for a second launch" (Deese 2009, 75).

The perspective's usefulness in amplifying environmental awareness and concern among participants prompted interesting discussions of recreation opportunities on the ground. Participants placed varying levels of emphasis on the importance of the personal nature of the outer space experience versus the physical distance required from Earth in triggering or amplifying environmental responses. Some participants' answers indicate that the first-hand experience of spaceflight and the outer space perspective of Earth are qualitatively at least somewhat significantly different from awe-inducing experiences on Earth, such as hiking the Grand Canyon, which suggests that the outer space perspective brings a new and additional element to environmentalism, rather than just having a reinforcing effect on terrestrial elements of environmentalism. As such, the spaceflight perspective appears to be pivotal in triggering or amplifying environmental responses specifically on a grander scale that is unique to the outer space perspective. Furthermore, as suggested by Ron Garan, the outer space perspective also has the potential to shift the basis of environmental conversations from negative emotions of fear to more positive emotions of awe and wonder, enabling a more optimistic and productive wider reach for environmental messages based on the latter. For recreation opportunities on the surface, while the experience cannot be exactly recreated for obvious reasons, technology such as VR simulations have already proven to be able to elicit awe-

inducing experiences (Quesnel and Ricke 2017; Chirico et al. 2018), with simulations specifically to induce the Overview Effect in participants underway (Stepanova et al. 2019), and as such the opportunities for triggering or amplifying environmental responses among the wider public using simulations of the outer space perspective, especially EVA experiences, needs to be further investigated. Finally, future astronaut missions and commercial spaceflight operations should pay more deliberate attention to the opportunity that the mission provides in increasing environmental responses among its spaceflight participants.

4.2 Category 2: Environmental attitudes

In the Environmental Attitudes category (Category 2), two subcategories emerged that can be grouped into attitude change (4.2.1.1) and attitudes towards ecological issues (4.2.1.2), the latter of which subcategory utilizes the specific scale measurement categories developed by Milfont and Duckitt (2010).

4.2.1 Results

4.2.1.1 Attitude change

The table below (Table 4.2) was made based on the author's interpretation of participants' statements about their pre-spaceflight and present environmental attitudes.

	Participant name & year of first spaceflight	Pre-spaceflight environmental attitudes	Present environmental attitudes (in 2019)	Level of change
1	Nicole Stott (2009)	Moderate	Strong	Strong
2	Richard Garriott (2008)	Moderate	Strong	Strong
3	Ron Garan (2008)	Moderate	Strong	Strong
4	Robert Thirsk (1996)	Moderate	Strong	Strong
5	Al Sacco (1995)	Moderate	Strong	Strong
6	Franz Viehbock (1991)	Moderate	Strong	Strong
7	Jeff Hoffman (1985)	Moderate	Strong	Strong
8	Dorothy Metcalf-Lindenburger (2010)	Moderate	Moderate/Strong	Moderate
9	Anonymous (–)	Moderate	Moderate/Strong	Moderate
10	Jay Apt (1991)	Minimal	Moderate	Moderate
11	Story Musgrave (1983)	Strong	Strong	Minimal
12	Loren Acton (1985)	Moderate	Moderate	Minimal
13	Jim Wetherbee (1990)	Moderate (anti-pollution)	Moderate (anti-pollution)	None
14	Walter Cunningham (1968)	Minimal (anti-pollution)	Minimal (anti-pollution)	None

Table 4.2: Changes over time in participants' environmental attitudes

Past

The majority of participants expressed having moderate pro-environmental attitudes prior to their first spaceflight, which attitudes were most often influenced by (1) family

upbringing, (2) historical context, and (3) the participants' educational background in science. Between the two ends of the past attitudes' spectrum, one participant described having relatively minimal pro-environmental attitudes in the past about the specific issue of pollution: "I've always had a little bit of concern about our environment, not so much for environmental issues. I was 17 years old growing up in the Los Angeles area, and we had an entire summer where we never really got to see a clear sky" (Walter Cunningham). Another participant described already having strong pro-environmental attitudes even prior to spaceflight, emphasizing a long-standing love of nature and animals (Story Musgrave). The majority of participants, however, had moderate levels of positive attitudes towards the environment prior to their spaceflight. Robert Thirsk's comment is representative of most participants' past attitudes: "I was attuned to the environment, I knew it was a priority for humanity to address, but I didn't think it was the top priority".

Citing (1) family upbringing, participants expressed thoughts such as "my parents were scientists and naturalists in a broad sense, but I don't think we were cutting edge in any sense of the word on environmental issues" (Richard Garriott), and "I've been outdoors since I was a kid. I think around middle school, I became aware of the environment and how it's changing due to human actions" (Dorothy Metcalf-Lindenburger).

Citing (2) historical context, Jim Wetherbee cited the late 1950s and 1960s "big cultural push" in the U.S. to not pollute and dump garbage in public spaces as the origins of his existing anti-pollution environmental attitudes. Two participants mentioned growing up near the first Earth Day in the U.S. as influential, (Jeff Hoffman and Anonymous), while a third participant, Nicole Stott, cited later Earth Days as well as her upbringing in proximity to nature, as influencing factors on her past environmental attitudes. Robert Thirsk mentioned the Apollo images and subsequent movement by Canadian universities to provide environmental courses, of which he said he took one. Two participants mentioned the publication of Rachel Carson's Silent Spring in 1962, while (3) three participants mentioned their scientific background as influential in their post-flight attitudes: "I was raised in the country and travelled a lot and understood things like the water cycle and weather cycle, and so I really had the basic factual knowledge about how the planet works, and so the flight didn't change my attitudes and my appreciation all that much" (Loren Acton), while Ron Garan highlighted reading future environmental predictions in the 1977 book The High Frontier: Human Colonies in Space by Gerard K. O'Neill as influential in his "launching into space with the belief that we have a responsibility to leave the planet a little bit better than we found it".

Present & Change

The majority of participants expressed having mostly strong pro-environmental attitudes in the present, which characterization and interpretation of their attitudes must be understood in the context of their past, pre-spaceflight attitudes. Six participants showed strong changes in attitudes that they related directly to their spaceflight experience, which they expressed with the following or similar terminology. In the words of Al Sacco, "by the time I finished the flight, I was a lot more environmentally conscious than I ever was before. We used to say, if you weren't a tree hugger before you went up, you were a tree hugger when you got back […] When I came back, I thought of it a lot more and became much more associated with the sustainability issue", saying of his present attitudes: "I think I'm very environmentally conscious", therefore directly indicating strong changes in attitudes directly as a result of spaceflight. Ron Garan said: "I think now I'm a lot more conscious of [environmental issues] than I was at the time, so there was definitely a change in that respect". Robert Thirsk said, in relation to thinking in the past the environment was important but not the top priority, that: "Climate change is the number one issue we should be dealing with […] Viewing the problem from afar, you become attuned and you can see the magnitude of the problem". According to Nicole Stott: "Before, there wasn't a conscious awareness of [environmental issues] in my daily life. Now there is. I mean, there's not a day goes by that it's not in the front and the back of my mind". Finally, Jeff Hoffman said of his current environmental attitudes: "it's a lot more critical".

Using the following terminology, other participants described their spaceflight experience as having an "enriching" (Story Musgrave), "enhancing" (Loren Acton), "sensitizing" (Jay Apt, Franz Biehbock), "cementing" (Anonymous), "reinforcing" (Dorothy Metcalf-Lindernburger, Ron Garan, Al Sacco), "awareness-raising" (Dorothy Metcalf-Lindenburger, Franz Viehbock), and "amplifying" (Franz Viehbock) effect on their environmental attitudes. According to Franz Viehbock: "In the past, I was not as engaged. The awareness was not as high as afterwards, certainly spaceflight increased the awareness of the whole thing". Even Loren Acton, who said spaceflight results in an "enhancement of understanding and appreciation" but does not "change a person all that much", displayed some change in his attitudes based on his own language: when asked about the past, he said he was "absolutely" concerned with environmental issues "but not in any kind of extreme way", and of the present, he said "I think environmental issues are extremely important", using the word 'extreme' to contrast his past and present attitudes. Some participants did not attribute their change in environmental attitudes directly to spaceflight, but rather, made the case that the

spaceflight experience contributed positively to an already pre-existing or ongoing change in attitude. Participants expressed this sentiment in the following terms: "Spaceflight did definitely cement the idea that you only have one habitable planet that you depend on, but I already had that idea before I went up there" (Anonymous participant), "space didn't teach me, it just enriched me" (Story Musgrave), "[Environmental awareness] was a part of who I was prior to flying in space" but "[spaceflight] did have an enhancing and reinforcing" effect because of which the participant said she now finds it "very significant to give back" (Dorothy Metcalf-Lindenburger).

Two participants indicated no changes in environmental attitudes; of these two participants, both interpreted the term 'environmental issues' to narrowly mean pollution, as both expressed a disbelief in ongoing anthropogenic ecological issues. Of these two participants, one did not have any detectable Overview Effect reaction (Walter Cunningham), while the other did experience the effect at least somewhat (Jim Wetherbee). Despite the lack of change in attitudes, both indicated having somewhat positive environmental attitudes concerning pollution: "Seeing impressive sights from space didn't really change my opinion of the beauty of the Earth or the belief and the faith that I have that this universe was created by a supreme being […] My attitude hasn't changed, I've had that attitude my whole life, that it's bad to pollute and to dump our garbage on the side of the street and it's equally bad to dump garbage into the atmosphere […] People think that humans are causing climate change and I think it's the sun that's causing the climate change […] If it were 99% caused by the sun and 1% caused by humans, it doesn't change my opinion that we ought to try to decrease our impact on the environment" (Jim Wetherbee). Also citing pollution, Walter Cunningham said: "I think we have a personal responsibility to try to keep our environment okay".

Participants talked about their present attitudes towards environmental issues with language expressing concern, importance and urgency. Franz Viehbock said: "I think we are moving in the wrong direction. It looks to me like the speed we are destroying our environment at is higher than we are trying to rescue or save our environment. Altogether there's huge damage done on our environment", while Loren Acton said: "I understand very deeply what's going on with respect to pollution and global warming and I have great concern about that." The Anonymous participant emphasized the importance of environmental issues, adding: "Most notable is the possibility of warming the planet considerably, without any real full understanding of what that could do. […] I feel very strongly that a new energy economy is something that's important for us to continue living on the planet effectively. I definitely am concerned about those kinds of issues".

Future

Participants expressed both optimistic and pessimistic attitudes about the future in relation to environmental issues. Participants who expressed both described their attitudes in the following terms: "I think in the short term we're already in deep trouble […] if you look at the rate of carbon increase in the atmosphere, the rate of temperature increase, the rate of the melting polar ice caps and the recession of glaciers, there is effectively nothing that can be done to not expect substantial pain in my own children's lifetimes […]" Richard Garriott said, while also citing increased storms, flooding, migration, disease and armed conflict as future scenarios, but adding "I'm more optimistic when it comes to a little bit longer time frame". Robert Thirsk similarly said: "I'm hopeful but I don't see any reason for being hopeful right now". Other participants expressing both sentiments said: "I'm pessimistic when I look at the policies around the world that are not doing a very good job either with conventional pollutants or greenhouse gas pollutants […] But on the other hand, when I talk to my students, I'm optimistic because they're bright and they're very committed" (Jay Apt), and "I have a real mix of optimism and worry" (Anonymous), indicating optimism about past environmental issues that have been solved, such as the ozone hole and about existing green technology, but pessimism about the lack of commitment to carry out necessary changes. Participants Story Musgrave, Jeff Hoffman, and Franz Viehbock expressed more pessimistic sentiments, with Hoffman and Viehbock also both citing the lack of will by humans to carry out necessary changes. "You can get pretty pessimistic when you look at all the things facing us in the next couple of generations. I don't think I'll live to see the real consequences of that, but I'm very concerned for my grandchildren". Participants Loren Acton, Walter Cunningham, Ron Garan, Nicole Stott and Al Sacco expressed more optimistic sentiments about the future, with both Stott and Sacco expressing optimism due to what they said is increased environmental consciousness and movement in the younger generation (Sacco) and at the local, grassroots levels of society (Stott).

4.2.1.2 Attitudes towards ecological issues

Enjoyment of nature (#1)

Participants who expressed attitudes about nature expressed extremely positive attitudes towards the enjoyment of nature, with enjoyment being due to both recreational activities and habitat proximity. Positive sentiments about the enjoyment of nature were expressed as follows: "When I'm in the midst of nature is probably my most fulfilling time on

Earth" (Robert Thirsk), "I always feel relaxed […] I like going to spaces that are open and untouched and more pristine" (Dorothy Metcalf-Lindenburger), "I'm a nature person. I've been totally immersed in nature" (Story Musgrave), and "I very much enjoy spending time in nature, I think it's really valuable." (Anonymous). Other participants also expressed their enjoyment of nature due to their habitat proximity. Jim Wetherbee said "We now live in a place where we have a beautiful view of mountains […] you can go anywhere on the earth and just be, I think, astounded at the beauty of the place", while Dorothy Metcalf-Lindenburger said "We moved back to Seattle, to the northwest, because we love the environment, we love mountains and being outdoors, so it puts us back with the mountain ranges all around us and the water, and the city is very environmentally active".

Support for interventionist conservation policies (#2)

Some participants broadly expressed support for interventionist conservation policies in the form of government regulation and international climate accords. In terms of the former, Al Sacco expressed support for existing government regulation that mandates environmentally conscious future construction activities, while Richard Garriott emphasized the need for more government regulation: "We really have to legislate a number of these solutions, because until we start to mandate the use of biodegradable garbage bags and until we put a tax on non-reusable plastic, the motivation won't be there to drive that solution to the same level or better standards than we have on others". Robert Thirsk said, "The decision-makers on Earth are not adequately addressing these issues, even though the survival of society, of civilization, is not guaranteed, and you see that from space", emphasizing the need for better leadership. Some participants also expressed support for UN climate protocols, saying they are an important part of meeting global environmental goals. In contrast to their support, however, participants expressed pessimistic attitudes towards countries' ability to meet such protocols: "It discourages me when our country withdraws from [the Paris Agreement] because of course we are a global contributor to that carbon at a very high level. I think it makes us better people when we're trying to engineer and think about how to make Earth better for the next generation" (Dorothy Metcalf-Lindenburger), "neither the US nor any other country is likely to be able to meet its commitments under the Paris Accord. All the countries that signed the Paris Accord are well behind where they need to be to meet those, so I'm pessimistic on that" (Jay Apt). Robert Thirsk similarly said: "We're all going to blow through our Kyoto Protocol limits and Canada, among many other nations, is a big transgressor there. So I'm not really optimistic".

Conservation motivated by anthropogenic concern (#4) & Altering nature (#7)

Most participants expressed concern motivated by anthropogenic factors, such as **climate change, pollution, land use, biodiversity loss, plastics, water usage and transportation**. In expressing conservation motivated by anthropogenic concern, Dorothy Metcalf-Lindenburger and Robert Thirsk's comments are representative: "I like having dark skies so that people can actually see the stars and the constellations and experience that not with the human impact. We need to protect those" (Metcalf-Lindenburger), while Thirsk mentioned other anthropogenic changes, such as seeing from space that "there's not a scrap of significant vegetation left in the Indian subcontinent of 1 billion people". Ron Garan's overall support for and involvement with numerous organizations looking to solve anthropogenic environmental issues is illustrative: "I'm involved with the UN on a number of things, I support the Sustainable Development Goals and the Convention on Biodiversity. There are many different efforts that I'm working with, like global warming mitigation programmes".

Participants expressed some conservation-related efforts motivated more specifically by **climate change**: Dorothy Metcalf-Lindenburger said she used her role as a high school teacher to make her students aware of the issue: "I was very passionate about it and wanted students to understand that global warming is happening, what that means, and to understand that we get all our resources from the Earth but that doesn't mean that we can just keep taking and taking", while Nicole Stott said: "what we tend to struggle with when we talk about climate change is that, from the standpoint of how humans impact our planetary systems, it's not good for us and it's not good for the planet either. There's nothing about climate change that isn't connected in some way to biodiversity that isn't connected in some way to my choosing to use a plastic straw versus not use a plastic straw. I mean, all of these things are interconnected. And I think maybe that's the complexity in it too, in that it just seems so overwhelmingly impossible to deal with."

Indeed, most participants expressed strong concerns on the topic of climate change, except two participants who expressed doubt about climate change being caused by anthropogenic factors. In expressing anthropogenic concern, the Anonymous participant said: "You can actually see the CO_2 content in the atmosphere has gone up since I started working in science". Loren Acton said he had "great concern" about global warming, while Jeff Hoffman expressed concern about future warming scenarios such as "an exponential runaway of global warming", saying "if the methane deposits in the permafrost up in the Arctic tundra ever get released into the atmosphere, it may have consequences much more serious than just the carbon dioxide that most of the environmental models today are producing". Hoffmann

cited the planet Venus where "global warming was first discovered" as an example of a thermal runaway of the greenhouse effect, expressing deep concern that something similar could happen on Earth given that the political and economic levels of society are not yet "dealing with these global problems". In expressing doubt, Jim Wetherbee said "I think the climate is changing, but I don't think humans have any idea how or why. I think […] the anthropogenic change is much smaller than what people attribute to it […] I think it's the amount of radiation coming from the sun that's causing climate change", while Walter Cunningham said "human-caused global warming from human-produced CO_2 is one of the most ridiculous things I've ever heard".

In terms of **pollution**, however, both Cunningham and Wetherbee expressed support for conservation efforts motivated by anthropogenic concern. In their own words: "We ought to be attempting to control pollution. […] Take a look at your car, for example, a lot of our driving we don't do with the best kind of gas you can get for it, and that does have an impact on the atmosphere" (Walter Cunningham), and "People used to throw garbage out the window of their cars as they were driving down the road and nobody thought anything of it, because there were not many people and the Earth was a big place, but now we can't keep polluting the atmosphere or dumping garbage on the street, that's just wrong" (Jim Wetherbee). Participants Loren Acton, Richard Garriott and Al Sacco also expressed concern about other forms of pollution, saying it is "a worldwide problem that we have to deal with as a planet" (Sacco). In addition to his attitudes about pollution, Walter Cunningham also expressed concern over land use: "We put farms instead of just having the raw land and we allow the ocean to get blocked up […] and things like that do in fact impact the environment".

Biodiversity loss alongside the alteration of nature was another anthropogenic concern some participants expressed conservation efforts and concern about, such as "saving wild species is very important" (Richard Garriott). Three participants discussed the issues in relation to aquatic habitats: "Our electricity mostly comes from hydropower, but that doesn't mean it doesn't come at a cost, and that cost is salmon because of how we put dams on rivers that used to run free. So there's a trade-off and I'm very aware of the salmon lifecycle too" (Dorothy Metcalf-Lindenburger). Robert Thirsk also used the exact same example: "Something like damming rivers that provides us with electrical power is having an impact on Chinook salmon, which is having an impact on orcas, which is having an impact on the circle of life in the marine environment". Richard Garriott similarly said: "Most species of fish have either literally gone

extinct or we're already had a profound impact, for example on the size of tuna because the giants of the species have been fished out, so we're already had a significant impact on the natural productivity". Garriott also expressed strong support for seed banks and biodiversity banks that store genetic diversity of crops and animals for the future, saying "we're losing biodiversity faster than almost any other time in history […] so we need to store as much of that [genetic code] as we can right now", as well as support for the strategy of buying land and saving it as a wilderness area for the benefit of biodiversity.

Plastic and water usage were also prominent anthropogenic concerns participants emphasized. Participants Richard Garriott and Jim Wetherbee expressed the greater need for biodegradable plastics, while Dorothy Metcalf-Lindenburger and Jeff Hoffman expressed concern about single-use plastics, saying "I look at all the packaging material that we throw out every week and it appals me, but you can't buy things that are not packaged in plastic and I wish there was something we could do about that" (Hoffman). Al Sacco also expressed the importance of buying items that have been repackaged, because "if you can recycle it rather than take more, you don't have to dump it in the ocean or anywhere else". In terms of water usage, Richard Garriott expressed strong concerns about meat production and aquifer-draining irrigation, while both Dorothy Metcalf-Lindenburger and Al Sacco highlighted the contrast between freshwater and saltwater availability due to the view of oceans from space, emphasizing the need to 'take care' of freshwater and groundwater utilization.

Finally, in terms of **transportation**, the topic of electric cars was frequently brought up by numerous participants. Some participants, including Ron Garan and the Anonymous participant, emphasized owning and driving electric vehicles due to the belief about "the importance of using electricity when we can generate that electricity with renewable sources" (Richard Garriott). However, some participants who otherwise expressed strong pro-environmental attitudes about anthropogenic concerns, such as Story Musgrave and Franz Viehbock, expressed concern over electric cars doing more damage to the environment than a diesel car (Viehbock) or other regular oil cars (Musgrave). Jim Wetherbee drew a parallel between electric cars and environmentalism, saying: "People are not thinking about the entire input and output, they're only thinking about the cleanness of the immediate moment as they drive the electric car down the road". Finally, Loren Acton expressed the desire to transition to an electric vehicle due to concern over his "fairly old vehicles burning a lot of gasoline" and causing damage to the environment.

Confidence in science and technology (#5)

Participants expressed very high levels of confidence in science and technology alongside their training and occupation as a scientist or engineer, although the individual interpretation of what constitutes good or valid science varied in two individuals. For the majority of participants, Loren Acton's comments are illustrative: "You can't believe in things like climate change if you don't have the scientific background to understand how the system works, so you learn more about the trapping of energy because of the greenhouse effect, and that helps you take it seriously […] I consider myself a reasonably well-educated environmentalist". Richard Garriott also expressed high confidence in science based on his upbringing: "Being in a science and nature-oriented household tends to lead you to pay attention to the data on the subjects, and I think the data clearly shows that pollution is bad". Two participants expressed confidence in science as something that has helped them improve their environmental behaviours: "There's a lot more actions I'm taking because of the awareness is different as different researchers publish information and as we hear about the impact of our actions" (Dorothy Metcalf-Lindenburger), and "information was learned about the [environmental] impact" (Ron Garan). Numerous participants mentioned their scientific background as justification for their pro-environmental attitudes and behaviours, such as: "I'm a scientist and an engineer and I look at factual ways to do things to clean the environment and make sure things run properly […] I'm a great believer, because I'm a chemical engineer, in recycling" (Al Sacco).

However, Jim Wetherbee and Walter Cunningham both expressed strong doubts about mainstream scientific evidence about anthropogenic climate change and biodiversity loss. Cunningham said: "To me, it's coming from people who are not bright enough to check the source of what they're using as an excuse for what they're saying.", while Wetherbee said: "I don't see the downside of the planet getting slightly warmer, which I think is mostly caused by activity from the sun. I still think nobody is explaining to me what the downsides of climate change are. It seems like it's better for people and plant production on Earth, because it's a little bit warmer so it's not as extreme. I do a lot of research and a lot of reading".

Human dominance over and utilization of nature (#9-10)

With regards to the human dominance over, and the utilization of, nature, most participants discussed the topic in terms of development and the economy by expressing the need to balance the two. In the words of Jeff Hoffman: "In the developed parts of the world, it's been an unwillingness to deal with the economic consequences of cleaning up our

behaviour […] maybe we will learn to get resources from other parts of the solar system, but I don't think that's really going to solve our problems on Earth", implying that the root problem is humans' status quo approach to nature. The Anonymous participant expressed that "it's a challenge that we face as people that we have to be able to have a great economy and have great lives but also do it in such a way that we're not harming the planet we live on". Story Musgrave made the point that the Western-style of living and utilization of nature is unsustainable in the long-run: "It's about development. We have to live within the bounds. The Earth can only support so many people at a certain standard of living". However, Jim Wetherbee expressed the lack of need to balance the two, by speaking of transitioning to sustainable energy sources in the near future: "When our economy can absorb these kinds of changes, go for it, but don't spend an exorbitant amount of money which will damage the economy and decrease the lifestyles of people".

Support for population policies (#12)

Some participants, in discussing population changes on Earth during the past century, expressed support for population policies aimed towards managing growth. Participants expressed it in the following terms: "We have grown to the point where just our being on the planet has an impact on it. It's not possible for us to just live as if it didn't matter. We need to be conscious of it and to manage it properly, as there are more and more people on the planet and more and more things that we're doing" (Anonymous participant). Jeff Hoffman said: "When I was a little boy, the population of the Earth was 2 billion people. If there's anything that we've learned, it's that exponential growth cannot continue". Story Musgrave, Robert Thirsk and Richard Garriott talked about the challenge of living "within the bounds" of the planet (Musgrave) at the current standard of living balanced against the growing global population, which population is "still growing very, very strongly" (Walter Cunningham). Robert Thirsk also mentioned the struggle resulting from rapid growth in "developing" countries such as India and China, saying: "Large countries are not going to be conductive to scaling back on their environmental behaviours and emissions".

4.2.2 Discussion

Results both expected and unexpected emerged from this category, with new findings pertaining to how spaceflight and the Overview Effect changed environmental attitudes in participants and some surprising findings pertaining to participants' present attitudes about specific ecological issues.

Unsurprisingly, the majority of participants already possessed some pro-environmental attitudes in the past prior to their first spaceflight, most likely as a result of their higher awareness of scientific issues such as environmental issues due to their scientific education, which sometimes also extended to coming from a scientific family background or growing up in close proximity to nature. Some participants also mentioned growing up during the environmental movement of the 1970s, which was galvanized by the Apollo images and which period included the first Earth Day and the creation of the EPA in the U.S., which also influenced their attitudes about environmental issues prior to their first spaceflight.

In terms of participants' change in attitudes between the past and the present, three distinct patterns emerged from the interviews: (1) a strong positive change in environmental attitudes directly connected to the participants' experience of spaceflight and the Overview Effect; (2) a more moderate change in environmental attitudes in which spaceflight had a reinforcing and amplifying effect on participants' existing environmental attitudes; and (3) minimal to no change in the environmental attitudes as a result of spaceflight specifically. In terms of the first two categories, 10 out of 14 participants experienced moderate to strong changes in their environmental attitudes following spaceflight: this attitude change either resulted directly from spaceflight or the spaceflight experience positively contributed to and reinforced pre-existing and ongoing processes of self-described attitude change in participants. In terms of the latter, for some participants such as Dorothy Metcalf-Lindenburger, a more minimal attitude change still resulted in more action and engagement post-flight, which will be later investigated in the Environmental behaviours section (Section 4.3). Participants' responses indeed showed both preservation and utilization dimensions and evidence of fluctuation over time in their environmental attitudes (Gifford and Sussman 2012, 65). These findings confirm the much broader findings of the literature that astronauts experience long-term changes in personal outlook and attitudes towards their relationship to the Earth (Yaden et al. 2016, 5-6), as indeed numerous participants who reported moderate to strong changes in their attitudes flew in space many decades ago. However, this new finding specifically suggests that spaceflight, which contains psychological experiences of the Overview Effect and the visual experiences of the outer space perspective of Earth, resulted in more positive *environmental* attitudes in the majority of participants, which is significant because positive changes were experienced by even those coming from a position of prior enhanced environmental awareness.

As stated in the literature, the majority of participants did experience "an abiding concern and passion for the well-being on Earth […] and the recognized need for a stewardship perspective" (Cox 2014, xvi), and therefore this study confirms those existing interpretations of the possible ecological dimensions of the Overview Effect. However, this study shows that those interpretations are also limited, and as such there exists a more significant ecological dimension to the Overview Effect that has been merely implied before and that goes beyond just astronauts experiencing a "renewed sense of responsibility for taking care of the planet" (White 2014, 2). Indeed, the majority of participants did experience a higher-level viewpoint "involving new awareness and consciousness", however, this study shows that participants specifically experienced an ecological version of this, more specifically involving new *environmental* awareness and consciousness. And while some participants did experience a reinforcement of their pre-existing environmental attitudes, the "renewed sense", which confirms White's definition, half of the participants experienced much stronger changes in their environmental attitudes than what is suggested by White, meaning that the utility and applicability of the spaceflight experience in increasing pro-environmental attitudes is much more significant than has been previously assumed.

In terms of the third category, of those four participants who experienced minimal to no change in their environmental attitudes, three participants (Story Musgrave, Walter Cunningham, Jim Wetherbee) had minimal to no experience of the Overview Effect, and therefore it seems highly possible that moderate to stronger experiences of the Overview Effect are necessary as a precondition to trigger positive changes in participants' environmental attitudes. This is merely a possible hypothesis that should be further investigated in subsequent research utilizing, for example, large-scale survey methods. Story Musgrave already launched into space with untypically strong pro-environmental attitudes and as such reported to have returned with minimal change, while both participants (Walter Cunningham and Jim Wetherbee) who understood environmental issues to narrowly mean 'pollution' were among the four who reported minimal to no changes in environmental attitudes. Finally, both Story Musgrave and Loren Acton reported minimal levels of change in their environmental attitudes but attributed this specifically to learning more about environmental issues back on the Earth and in no way related to their spaceflight experience.

In relation to environment attitudes towards the future, which also constitute a new finding in this study, most participants expressed a mixture of both optimism and pessimism,

which is somewhat surprising given that most astronauts are known to possess "an optimism that comes from going into space" (Anonymous participant), meaning the optimism that comes from the achievement of successful spaceflight that inevitably involved major scientific efforts and international cooperation that is somewhat unprecedented on the surface. Additionally, numerous astronauts who expressed some level of pessimism expressed a dissatisfaction with the current level of political will and commitments to carry out necessary economic and societal changes to meet environmental targets in the near future. This has important implications for possibly sending decision-makers, politicians, and wealthy members of society into space in the near future with the specific goal of inducing the Overview Effect and subsequently, more positive environmental attitudes in them. In the words of Jeff Hoffman, "maybe if they get the same feelings that we astronauts have gotten, it will have some sort of an impact".

The second larger category analysed under Environmental Attitudes were participants' attitudes towards specific ecological issues (Section 4.2.1.2). The findings from this section also constitute a new contribution of this study, as astronauts' environmental attitudes towards ecological issues have not been measured or described before as such. The section utilized the measurement categories created by Milfont and Duckitt (2010) qualitatively to assess the extent and depth of participants' environmental attitudes towards specific ecological issues.

Unsurprisingly, astronauts expressed a deep enjoyment of nature, which could be reasonably expected given the high number of participants coming from scientific and sometimes even naturalist backgrounds. Perhaps a little more surprisingly, the participants who brought up the topic of nature were most often those participants that experienced moderate to no changes in their environmental attitudes, meaning, those participants that either already had moderate pre-existing levels of environmental concern and awareness (moderate change) and those participants that either had very strong pre-existing pro-environmental attitudes (minimal change – Story Musgrave) or narrowly pro-environmental attitudes (no change – Jim Wetherbee). This finding possibly implies that the enjoyment of nature played an at least somewhat significant role in the development of pro-environmental attitudes in those who started their spaceflight with already existing positive attitudes, and therefore for whom the spaceflight constituted merely a 'reinforcing' experience rather than a strong change in attitudes. Therefore, the enjoyment of nature can possibly be seen as a precursor to developing pro-environmental attitudes on the ground, without having to go to space first, and as such this preliminary hypothesis should also be further investigated in subsequent research.

Participants expressed strong support for interventionist conservation policies in the form of government regulation and international climate accords, a finding which must be understood in the context of astronauts' high public profile and visibility in international affairs. On one hand, participants' attitudes appear to confirm prior findings that the Overview Effect results in "the recognized need for a […] global participatory management of the planet" (Cox 2014, xvi). On the other hand, in the context of participants' experience of witnessing the Earth from an *outer* space and *planetary*, 'big picture', point of view, their expressed support for top-down solutions – such as UN climate accords – is significant but mostly unsurprising. As such, it should also be further investigated how astronauts could lend further credibility and political clout to top-down solutions, such as UN conventions and agreements, as exemplified by Ron Garan and Robert Thirsk, by more vocally expressing support and partaking in such solutions as a way to increase such solutions' visibility and credibility with the wider public. Given astronauts' 'hero status' and positions of credibility (White 2014), they are arguably in a unique position to do more to promote greater awareness of, and concern for, environmental issues among the wider public.

As expected, all participants expressed concern for the environment and environmental issues as part of their environmental attitudes (Gifford and Sussman 2012, 65), these including, for the majority of participants, deep concern about climate change, pollution, biodiversity loss, plastic and water usage, and transportation emissions. Only two participants expressed anthropogenic concern exclusively about pollution, as opposed to all other environmental issues. However, a significant finding of this study is that astronauts who did express pro-environmental attitudes about a broad range of issues ranging from climate change to water usage – meaning, not the two participants who disagreed with anthropogenic warming – often conceptualized and understood various environmental issues as interconnected, meaning, participants emphasized the need for a 'bigger picture approach' to various environmental issues that takes into consideration the interconnectedness of all socio-ecological systems, as opposed to addressing issues separately as if isolated from one another. These sentiments were expressed explicitly by both Robert Thirsk and Ron Garan: "biodiversity loss or global warming or ocean acidification […] are all symptoms of the underlying root problem that we don't see ourselves as planetary. We need to treat things holistically and understand that what happens on one side of the planet affects everything else" (Garan), as well as more implicitly by Dorothy Metcalf-Lindenburger discussing the interconnectivity between the sustainability of her home's energy source (hydropower) versus its effect on local biodiversity (salmon).

Overall, the majority of participants expressed high levels of environmental concern due to anthropogenic factors. As such, this study contributes the finding that participants expressed more positive environmental and conservation attitudes following spaceflight not only due to the planetary perspective and interconnectedness that the Overview Effect provides (positive emotions), but also due to concerns motivated specifically by anthropogenic factors (negative emotions), part of which are the visible anthropogenic changes that participants witnessed on the surface of the planet from space, as analysed in the previous discussion section (Section 4.1.2). This implies that witnessing anthropogenic impacts – whether experienced by participants spatially from the distant perspective of space or temporally by observed changes in their surroundings on the surface – played a significant role in increasing environmental concern and awareness in participants.

Unsurprisingly, participants expressed very high confidence in science and technology, which makes sense given their scientific backgrounds and the scientific and technological achievements that are inherently part of spaceflight. However, a surprisingly contentious issue proved to be the usage of electric cars, which some participants thought were environmentally more positive than diesel and gasoline cars, while other participants, even those who otherwise expressed strong concern about anthropogenic factors, thought were environmentally more damaging than other cars. This shows some levels of disagreement over what constitutes mainstream scientific evidence, although participants did not express a lack of confidence in science in technology itself. Even the two participants who denied anthropogenic factors underlying current temperature warming and biodiversity loss did not express a lack of confidence in science, but rather appeared to seek out scientific opinions and positions that confirmed their pre-existing attitudes. According to spaceflight participant Richard Garriott, "astronauts bring to this profession the same biases they had from before they were an astronaut", which implies that spaceflight, and if experienced, the Overview Effect, do not always result in more positive environmental attitudes in participants, especially when participants arrive with strongly held preconceived ideas towards specific environmental issues. As such, confidence in science and technology seems to play less of a role in increasing pro-environmental attitudes as part of spaceflight than strongly held unscientific biases do.

On the themes of human dominance over nature, human utilization of nature, and support for population policies, the majority of participants expressed strong concern about the human dominance over, and utilization of, nature, making the point that human development

and economic exploitation need to go hand-in-hand with sustainability and the carrying capacity of the planet. Some participants expressed support for population policies aimed towards managing growth, especially within the context of maintaining current standards of Western-style living. This is somewhat surprising given how the link between population growth and environmental destruction are disputed, although perhaps less so given the historical context in which many of the participants grew up, which past decades were often characterized by 'limits to growth' and 'overpopulation' debates.

4.3 Category 3: Environmental behaviours

In the Environmental Behaviours category (Category 3), three subcategories emerged that can be grouped into: Behavioural change (4.3.1.1); and then dimensions of environmental behaviours based on the Milfont and Duckitt (2010) scale, these being Environmental movement activism (4.3.1.2) and Personal conservation behaviour (4.3.1.3).

4.3.1 Results

The table below (Table 4.3) was made based on the author's interpretation of participants' comments about their pre-spaceflight and present environmental behaviours.

	Participant name & year of first spaceflight	Pre-spaceflight env. behaviour	Present env. behaviour (in 2019)	Level of change
1	Richard Garriott (2008)	Minimal	Strong	Strong
2	Robert Thirsk (1996)	Minimal	Strong	Strong
3	Al Sacco (1995)	Minimal/Moderate	Strong	Strong
4	Jay Apt (1991)	Minimal	Strong	Strong
5	Franz Viehbock (1991)	Minimal	Strong	Strong
6	Dorothy Metcalf-Lindenburger (2010)	Moderate	Strong	Moderate
7	Nicole Stott (2009)	Moderate	Strong	Moderate
8	Ron Garan (2008)	Moderate	Strong	Moderate
9	Jeff Hoffman (1985)	Moderate	Strong	Moderate
10	Story Musgrave (1983)	Moderate	Strong	Moderate
11	Anonymous (–)	Moderate	Strong	Moderate
12	Loren Acton (1985)	Minimal	Moderate	Moderate
13	Jim Wetherbee (1990)	Minimal	Minimal	None
14	Walter Cunningham (1968)	Minimal	Minimal	None

Table 4.3: Changes over time in participants' environmental behaviours

4.3.1.1 Behaviour change

Participants were asked to describe their environmental behaviours before their first spaceflight, and then separately, in the present. Prior to their first spaceflight in the past, all participants described having at least some environmental behaviours.

Compared to the present, five participants demonstrated strong levels of behavioural change compared to the past, with all five participants partially or fully attributing the change to the spaceflight experience. This change was expressed in the following terms by select participants: "Before my spaceflight, I was talking the talk, but not walking the walk. That's what really changed after the spaceflight" (Richard Garriott). In discussing his behavioural change, Robert Thirsk said: "Spaceflight and seeing the state of the Earth from space certainly changed my perspectives and priorities", citing that in the past, he resisted environmental changes proposed by his wife and daughter, while after the spaceflight "I'm a colleague on their side. I'm quick to adopt their suggestions". Franz Viehbock said: "I didn't do [environmental engagement], I was not very active in demonstrating or fighting for our environment, but I didn't purposefully pollute. But certainly, with the spaceflight experience, this awareness was much more increased and I'm doing much more conscious decisions in terms of the environment now".

Compared to the present, half of the 14 participants demonstrated moderate levels of environmental behaviour change compared to the past, with participants expressing the following variations in what they attributed their behavioural change to: (1) their spaceflight having a reinforcing effect on change they felt they were already beginning or undergoing; (2) learning more about the environmental impact of their behaviours as scientific evidence become more widespread over time after their spaceflight; (3) their status as an astronaut giving them a uniquely far-reaching and public platform to speak out about environmental issues.

Participants expressed these variations, sometimes overlapping, in the following terms: Ron Garan said that before his first spaceflight, he already founded numerous organizations relating to renewable energy and clean water, saying "I think the spaceflight experience reinforced what I had already been on a path to understand". Story Musgrave said: "I would have thought I might have done [present environmental behaviours] anyways, but spaceflight was a different perspective and it enriched the whole thing". According to Jeff Hoffman, his past environmental behaviour was "mostly educational", and while he described numerous pro-environmental behaviours that he practices in the present that he did not practice in the past, he said "I didn't do these [changes] because of spaceflight. Intellectually, I understood these things long before I went up into space and got a view down to the Earth […] going up to space gave all of that a much more immediate and emotional impact", describing a reinforcing, but not causal, effect of his spaceflight. Loren Acton and Dorothy Metcalf-Lindenburger, the latter

who for example started following a vegetarian diet already back in high school, expressed that spaceflight provided them with the opportunity to be heard more widely about issues, including environmental issues, also adding that "because of my spaceflight, I find it very significant to give back" (Metcalf-Lindenburger), therefore expressing more minimal attitude change but more moderate behavioural change post-flight. Nicole Stott said, in expressing how the spaceflight experience helps her sustain her environmental behaviours: "Everything I do is related to [environmental behaviour], both in a direct and indirect way. […] I think when I start to feel lazy about it, that's when it always being in the front and the back of my mind comes in, and I say to myself, you need to be part of the solution", meaning that her spaceflight experience directly contributes towards Stott sustaining her pro-environmental behaviours.

Even Walter Cunningham, who expressed no change in environmental behaviour, expressed positive attitudes towards pro-environmental behaviour: speaking in terms of pollution, he said "I try to keep my home in good shape, I try to do what is right". While Jim Wetherbee, the other participant who did not experience any change in behaviour, said "I do not currently engage in any kind of outreach regarding the environment or global warming or climate change or any of that", he did express support for pro-environmental behaviours related to pollution control such as recycling and the safe disposal of hazardous waste material.

4.3.1.2 Environmental movement activism

Participants' environmental movement activism in the present can be grouped into the following four subcategories: involvement with (1) a business or organization; (2) teaching; (3) outreach; and (4) politics.

Six participants said they were or are involved with businesses or organizations that relate specifically to environmental causes, of these, both Ron Garan and Nicole Stott work with the organization called Constellation (www.constellation.earth). According to Garan, the founder, the organization brings together a coalition of international astronauts to motivate people to take more positive environmental and social actions. On its website, the organization describes itself as being directly inspired by the awe and wonder of the Overview Effect, with the goal to support planetary stewardship through immersive storytelling experiences. According to Stott, the organization is now also partnering with the National Geographic Society and the UN Convention on Biodiversity to create "this whole campaign for nature where we are going to act as the voice for that campaign to say, we want everybody to have

their Earthrise moment, we want everybody to click in again to what that image has done for us". Additionally, Garan also described his involvement with the UN on numerous issues, such as the Sustainable Development Goals (SDGs) and the Convention on Biodiversity, and has founded the collaborate platform Fragile Oasis (www.fragileoasis.org). Dorothy Metcalf-Lindenburger said she is part of the Board of Directions of the organization NatureBridge (www.naturebridge.org), which does science and environmental education for children in national parks: "I see [nature] as an amazing classroom that we want to protect". Additionally, Richard Garriott described his long-standing involvement with the Nature Conservancy, Robert Thirsk discussed his long-standing donation habits to environmental organizations, especially in relation to oceans, while Story Musgrave described creating a sustainable landscaping architecture business that "turned around 300,000 cubic feet of biowaste a year, turning it into manure". Robert Thirsk also described recently joining the Royal Canadian Geographical Society's campaign called 10,000 Changes to stop the usage of single use plastic.

In terms of teaching, Musgrave described currently teaching sustainable landscaping to various industries and corporations, while Al Sacco and Jay Apt described using academic teaching as a form of activism: "What I do is I try to always teach my students and teach my family and everybody else how to be environmentally conscious of everything that they do. That's how I make my contribution to the environment" (Sacco), and "I'm spending most of my scientific time studying ways to reduce pollution from the electric power industry. Before I came to Carnegie Mellon University, I was the head of a large research museum, the Carnegie Museum of Natural History, and we turned that from a descriptive museum of stuffed ducks in glass cases, to a museum that showcases the long history of the Earth and both the natural and human caused changes" (Apt).

Eight participants said they actively engage in environmental outreach in the present, in the forms of lectures and presentations, art, and publishing. Numerous participants mentioned the opportunity that their status as an astronaut has provided in gaining an audience: "[Spaceflight] made it possible for me to travel to a lot more places and talk to more people on a platform about why I care about those places. I end up being a role model. I was talking to college students last fall and I pointed out a very conscious decision to get our broken TV fixed instead of buying a new one. I didn't want the TV in the waste cycle stream. So you're speaking up with people and I think it gives them a chance to think about the decisions we make" (Dorothy Metcalf-Lindenburger). Loren Acton expressed similar sentiments: "Because I have

flown in space, people want to talk to me and give a lot of credence to what I say. I give hundreds of hundreds of talks, a lot of them to schoolkids, […] and so what spaceflight provided was the opportunity to be heard on these issues".

Nicole Stott and Franz Viehbock also talked about the increased visibility that comes with being an astronaut, saying that as a member of the International Association of Space Explorers – "an organization with heavy impact on decision-makers on the political and industrial society levels" (Viehbock) – astronauts "bring to the public and those decision makers environmental issues which we see from space. When you show these people pictures from space and the damages humans are doing, we've had quite an impact" (Viehbock). Others have engaged in other forms of outreach, for example Nicole Stott's renowned artwork in space and work with the Space for Art Foundation that "raises awareness and consciousness" among children (Stott). Jay Apt has published the photography book called *Orbit* in which Apt, alongside other authors, discussed human-caused visible changes on the surface of the planet, such as river pollutants or deforestation: "Being an avid photographer on each of these missions made me well aware of the importance of visual imagery has in changing peoples' attitudes towards the kinds of human-caused change we can see from space" (Apt). Finally, Al Sacco, Robert Thirsk and Jeff Hoffman said they engage in environmental outreach in the form of public lectures during which they always "include the environmental message" (Thirsk) and utilize outer space photos of Earth to show anthropogenic changes and as such to increase environmental awareness among participants, "because, somehow, people are willing to listen to an astronaut talk about these things in a way that they might not attend the lecture of a university professor" (Hoffman).

Finally, two participants (Loren Acton and the Anonymous participant) said they have run for public office, with the latter saying that a new energy economy was part of his programme and while serving on the board of his town, he did support the town moving towards renewable energy sources.

4.3.1.3 Personal conservation behaviour

Participants gave extensive insight into their current personal environmental behaviours, which broadly include environmentally-conscious waste disposal methods, transportation methods, energy consumption, water usage, shopping habits, dietary and voting habits.

Waste disposal

All participants said they are conscious of their method of waste disposal, with all participants who mentioned specific disposal methods practicing recycling and proper disposal of hazardous waste, and some participants even practicing composting (Dorothy Metcalf-Lindenburger and Nicole Stott). Most participants said they use the recycling system in their cities and towns, but Franz Viehbock said he also delivers separated extraordinary garbage to a special sorting place in his village. Al Sacco and Richard Garriott both pointed out that waste disposal is still where they're "the worst abuser" (Garriott) or a "hypocrite" (Sacco), with Sacco citing his two homes, one in Texas and one in Massachusetts: "In Massachusetts we separate everything, but in Texas you have to go through hoops to separate everything, so I don't separate things. But at the university, I put in a policy, which I'm allowed to do as Dean of the College of Engineering, to separate everything, papers, glass and plastics." As the most extreme case, Loren Acton has said he has gone outside to pick up trash himself.

Transportation

In terms of transportation methods, ten participants mentioned driving cars, of which five cars are electric vehicles, these including a Tesla and a Chevy Volt plug-in hybrid (Richard Garriott, Jay Apt, Anonymous, Ron Garan, Nicole Stott), with Garriott making a point about the importance of using electricity generated by renewable forms of energy for charging electric cars. Of those driving non-electric cars, two expressed the desire to transition to electric cars but mentioned their living place as a limitation: "Living in Montana, electric cars aren't really practical" (Loren Acton) and "I'm a Dean in the state of Texas and that's oil and gas country and they frown on us having electric cars. But even having said that, I'd get one anyways, I've been trying to save money to get one" (Al Sacco). Robert Thirsk mentioned wanting to use the public transportation system more frequently from the suburbs but it still being inconvenient in Ottawa, Ontario. Franz Viehbock mentioned driving a diesel car due to his belief that it is the most efficient in terms of CO_2 pollution, while Story Musgrave talked about renting a smaller economy car whenever possible. Three participants mentioned biking (Nicole Stott, Dorothy Metcalf-Lindenburger, Jeff Hoffman), with Hoffman saying: "I ride a bicycle to work every day. Wherever possible, we try to live ecologically". Both Viehbock and Metcalf-Lindenburger also mentioned walking whenever possible, while the latter also talked about riding the bus, as well as the environmental impact of her flights: "I end up flying a lot of places because of speaking to people and doing outreach, so I would hope that I'm trying to offset that by the impact of what I'm trying to tell them".

Energy usage

Seven participants talked about their energy consumption, with some expressing the lack of control they feel over this factor given their place of living (Anonymous, Nicole Stott, Al Sacco). Stott mentioned plans "to go off the grid as possible" in the near future while the Anonymous participant said "I try to do my part in order to live in concert with what I think we should all be doing, so I try to be more conscious of my energy use". Jay Apt and Al Sacco both said they heat with natural gas "which is pretty clean" (Sacco). Franz Viehbock and Richard Garriott expressed the strongest behaviours, with both mentioning solar panels, and the former saying: "I'm very consciously trying to protect the environmental in many ways, starting from using solar energy to produce my own electricity and heating the water". Garriott discussed putting electric probes on every circuit in his home following spaceflight: "I switched all my lighting to LED because it's better for the Earth, but buying a more efficient air conditioner, changing the setting on your conditioner, putting in a smart thermostat, those things make a far bigger difference". Due to the electric probes, Garriott said he was able to learn he needed to change the water circulation settings for his pond and his pool, "which made exactly no change in the quality of my life but made a 50% impact on my electrical footprint".

Water usage

Seven participants discussed being highly conscious of their water usage. Besides Garriott, Nicole Stott mentioned using an additional small metre that tracks water consumption and reclaimed water from the city to water her garden – which has also meant she has never had to use fertilizer in her garden – while Franz Viehbock also mentioned saving and collecting rainwater to water his garden and to flush the toilet. Viehbock also added he does not use "any poisonous stuff in the garden for killing bugs and weeds" in order to be more organic. Robert Thirsk mentioned turning off the tap while toothbrushing and turning off the shower water while using soap: "it's a consciousness". Ron Garan, Walter Cunningham and Al Sacco all mentioned their "responsible" (Cunningham) and "low" (Garan) water usage, with Sacco also mentioning the use of bottled water as being both bad due to the plastic and good because "it doesn't drain the aquifers around here which are in bad shape".

Shopping habits

Eight participants expressed more sustainable shopping habits, including paying attention to plastic usage and reusable items. All eight participants (Hoffman, Anonymous, Thirsk, Metcalf-Lindenburger, Garan, Stott, Sacco, Viehbock) mentioned using canvas, cloth

or paper reusable bags during groceries, many emphasizing their imperfect but sustained usage of such bags. Participants also added the following considerations: "We also always try to do one trip that covers the whole week instead of making multiple trips" (Dorothy Metcalf-Lindenburger), "I buy repackaged things whenever possible" (Al Sacco), and "Even if we forget our reusable bags at home, we buy paper bags" (Nicole Stott). Some participants additionally discussed their efforts to minimize their use of plastic: for example, Ron Garan mentioned not using plastic straws, saying he recently learned about their impact alongside the environmental impact of eating beef. Robert Thirsk and Dorothy Metcalf-Lindenburger both mentioned always carrying reusable drink containers due to Thirsk's 10,000 Changes challenge and Metcalf-Lindenburger's recently increased awareness of single use plastics, adding her family and herself have also switched to using cloths and beeswax for packing their lunches. Robert Thirsk also mentioned frequently shopping at second-hand stores such as Value Village since moving to Ottawa: "Five years ago I never in a million years would have considered buying a used clothing item, but it's a big deal for us now".

Diet

Nine participants discussed switching to more sustainable diets, these ranging from flexitarian diets (low-meat) to plant-based diets. Many participants also mentioned locally grown and organic food being important to them. Ron Garan classified his diet as low-meat, while Dorothy Metcalf-Lindenburger mentioned not eating red meat. The Anonymous participant discussed moving towards a vegetarian diet, with hopes of fully transitioning in the future. Richard Garriott mentioned "dabbling with plant-based diets" but still being an omnivore, citing his awareness of "I do actually think that growing meat consumes both water and vegetable mass at a high rate and has by-products like methane. Plus, you could also say, the lack of desire of wanting to kill animals. So there are obvious negatives with meat" he added, also mentioning "watching with great intent" companies such as Beyond Meat and Impossible Foods and supporting attempts "to artificially culture direct mammalian cells". Robert Thirsk said he and his family have cut back on meat, with his daughter being a vegetarian also being influential. On the other end of the spectrum, Story Musgrave mentioned following a sustainable Mediterranean diet, adding that he eats natural and "lives on" fruits, vegetables, nuts, grains and fish, while Nicole Stott mentioned her family transitioning to a vegan diet and going "as plant-based as we can". Al Sacco said he "knows enough about chemistry" to know whether a product is truly organic, and mentioned reading labels very closely and making a decision on a case-by-case basis, while Franz Viehbock mentioned only

eating meat grown in his home country of Austria and only eating exotic fruits when he is visiting countries where those fruits are grown. Finally, Dorothy Metcalf-Lindenburger mentioned regularly attending farmers' markets to also purchase locally grown produce.

Voting

Three participants mentioned voting as part of their personal conservation behaviour, with Loren Acton saying "I try to vote right and I care", and Dorothy Metcalf-Lindenburger saying "I do talk to people about these issues and I do make sure to vote. These next 10 years are very important".

4.3.2 Discussion

Results both expected and unexpected emerged from this category, with this category encompassing the newest findings, given that the environmental behaviours of astronauts have never been qualitatively explored before. Key findings pertain to how spaceflight and the Overview Effect influenced environmental behaviours in astronauts and some surprising findings pertaining to participants' specific environmental engagement.

All participants described at least some level of pre-spaceflight environmental behaviours, which, similarly to environmental attitudes, is not surprising given participants' scientific backgrounds and higher-than-average awareness of scientific issues, including environmental issues.

Overall, 11 out of 14 participants demonstrated moderate to strong levels of behaviour change between the past (pre-spaceflight) and the present, which demonstrates the significant breadth and depth of behavioural change over time. Similarly to environmental attitudes, three distinct patterns emerged here: (1) spaceflight had a direct impact on environmental behaviour; (2) spaceflight indirectly led to or partially contributed to long-term behavioural change; (3) in a few cases, minimal to no change was practiced as a result of spaceflight.

To interpret these results: More infrequently, spaceflight had a direct impact on post-spaceflight environmental behaviours (Richard Garriott and Franz Viehbock), but more often, the spaceflight was more likely to lead to a change in environmental attitudes that led to an enhanced level of openness to, and awareness of, environmental issues that later played a role in participants' gradually making changes to their environmental behaviours. This is consistent

with the academic literature, which states that environmental attitudes often determine behaviour that increases or decreases environmental quality (Gifford and Sussman 2012, 65), with consideration also needed to be given to social norms, the cost and benefits of behaviour, individuals' emotions, values, and morals, and contextual factors for lasting behavioural change (Steg and Vlek 2009), which have been captured due to the qualitative nature of the interviews. As such, a major finding of this study is that for the majority of participants it was a change in their environmental attitudes, and not the spaceflight experience directly, that led to later behavioural change following their spaceflight. As such, it can be said that attitude change resulting from spaceflight played the most significant role in increasing positive environmental attitudes and subsequent positive behaviours in participants. However, besides the spaceflight experience, the interviews indicate that other – terrestrial – factors may also be influencing the observed change from pre-flight environmental behaviours to present behaviours. This is to be expected but must be kept in mind as a limitation in interpreting the results pertaining to spaceflight's direct or indirect role in behavioural change specifically.

Participants showed very high engagement in environmental movement activism (#3) and in their personal conservation behaviour (#8). In terms of the former, unsurprisingly, most participants said they are involved with numerous organizations and outreach activities, but the relatively high extent to which these activities relate to environmental issues and awareness-raising was unexpected, especially as numerous participants mentioned their personal motivation in discussing environmental issues during their outreach activities. Participants Al Sacco and Jeff Hoffman mentioned utilizing images of visible anthropogenic changes to the Earth's surface during their presentations and outreach activities, which reinforces the effect that perspective and those images have not just on astronauts, who directly observe them, but also on the more general public who view it second-hand. This reinforces the potential of using the outer space perspective of Earth, especially when showing anthropogenic ecological destruction, in enhanced environmental outreach towards the public. Additionally, while numerous participants said they were engaged with some form of environmental outreach, based on their interviews, there appears to be no overarching, comprehensive international effort or organization that makes use of the potential of astronauts' credibility with the public to inspire increased environmental awareness and concern among the public, and as such this potential remains underrealized to date. This is especially surprising given the high number of participants that mentioned their unique status as astronauts in giving them more credibility and visibility in the eyes of decision-makers as well as the public.

Besides public activism and outreach, participants also demonstrated very high engagement with environmental issues in their personal lives pertaining to their personal conservation behaviours. While some behaviours were mostly unsurprising given the extensive scientific background of participants, such as all participants recycling and disposing of hazardous waste material properly, findings in terms of transportation and diet for example were more unexpected. While electric vehicles proved controversial with some participants, who expressed negative environmental attitudes towards them, a relatively high number of participants – from those who expressed positive attitudes towards them – were electric vehicle owners. A surprisingly high number of participants mentioned transitioning to more sustainable diets, which is somewhat surprising given that diets have only recently entered public consciousness in terms of their environmental impact. Overall, most participants showed a greater breadth of positive environmental behaviours, with most participants making changes in their daily habits such as using reusable shopping bags and paying attention to energy and water usage, while some participants also demonstrated a greater depth of positive environmental behaviour, from picking garbage, collecting rainwater for gardening and toilet flushing, turning off the shower tap, to following a nearly completely plant-based vegan diet.

Overall, most participants experienced lasting behavioural change in the context of their social norms, emotions, values, morals, and the costs and benefits of their behaviour (Steg and Vlek 2009). Most participants expressed placing a high value on the well-being of the environment and the importance of conducting their public outreach and personal lives according to those values. Numerous participants expressed this valuation in deeply emotional terms, often saying that even if spaceflight did not directly influence their environmental behaviours, it gave their pre-existing environmental attitudes a much stronger basis upon which they could later act. Participants often engaged in increased environmental behaviours, both when this was seen as positive within their home's social norms, such as Dorothy Metcalf-Lindenburger living in the highly environmentally conscious Seattle, as well as when this was seen as more negative, such as Al Sacco wanting to switch to an electric vehicle and starting a recycling program at his university despite these not being the social norms in Texas. In terms of the costs and benefits of behaviour, numerous participants expressed trying their best in terms of their diet or bringing reusable bags to the grocery store but expressing limitations to their behaviour due to persistent inconveniences in the lack of greener choices – for example, Al Sacco not having access to recycling in his personal home in Texas or the poor design of biodegradable garbage bags compared to conventional bags for Richard Garriott.

4.4 Discussion: Summary

The following table (Table 4.4) compares the author's interpretation of participants' qualitative comments pertaining to the intensity of their experience of the Overview Effect, and their changes in environmental attitudes and changes in environmental behaviours from prior to their first spaceflight compared to the present (2019).

	Participant name & year of first spaceflight	Intensity of the Overview Effect	Change in env. attitudes	Change in env. behaviours
1	Richard Garriott (2008)	Strong	Strong	Strong
2	Robert Thirsk (1996)	Strong	Strong	Strong
3	Al Sacco (1995)	Strong	Strong	Strong
4	Franz Viehbock (1991)	Strong	Strong	Strong
5	Nicole Stott (2009)	Strong	Strong	Moderate
6	Ron Garan (2008)	Strong	Strong	Moderate
7	Jeff Hoffman (1985)	Strong	Strong	Moderate
8	Dorothy Metcalf-Lindenburger (2010)	Strong	Moderate	Moderate
9	Jay Apt (1991)	Moderate	Moderate	Strong
10	Anonymous (–)	Moderate	Moderate	Moderate
11	Loren Acton (1985)	Moderate	Minimal	Moderate
12	Story Musgrave (1983)	Minimal	Minimal	Moderate
13	Jim Wetherbee (1990)	Minimal	None	None
14	Walter Cunningham (1968)	None	None	None

Table 4.4: Comparison of participants' Overview Effect experience and changes in environmental attitudes and behaviours from prior to spaceflight to the present

Overall, it can be said that the majority of participants in this study experienced the Overview Effect and subsequent changes to their environmental attitudes and behaviours at considerable levels (moderate to strong). Based on participants comments, it appears that the majority of them had moderate to strong experiences of the Overview Effect, which experience appears to be a prerequisite in either (1) triggering more positive environmental attitudes and behaviours in participants as a direct result of the spaceflight experience, or in (2) reinforcing and amplifying pre-existing positive environmental attitudes and behaviours that result in more moderate but still long-term attitude and/or behavioural change. This establishes that the Overview Effect, and by extension the outer space perspective of Earth, have an unexpected and important ecological significance that, beyond just the mere ability to "renew" one's sense of responsibility in taking care of the planet (White 2014, 2), has the ability to significantly *change* participants' environmental attitudes and behaviours, resulting in a new *environmental* awareness and consciousness. In most cases, the spaceflight experience led to a direct or indirect (amplifying) change in participants' environmental attitudes, which subsequently resulted, more rarely in immediate change and more often in gradual change, in participants' environmental behaviours. It is important to note here that other factors too, such as scientific

advancements and information learned about environmental impacts, played a role in some participants' gradual change in environmental behaviours.

The potential of utilizing the outer space perspective of Earth and the Overview Effect to intentionally increase pro-environmental attitudes and behaviours is significant and remains underrealized despite the possibility of its wider societal applicability. Besides the well-established perceptual and conceptual themes of awe and wonder experiences that play the key positive psychological role in inducing the Overview Effect, negative perceptual views of visible anthropogenic ecological destruction on the surface of the planet appeared to also substantially contribute to triggering significant environmental responses in participants. As such, the juxtaposition of both positive and negative perceptual views of the Earth appear to play an important role in triggering the ecological significant version of the Overview Effect that subsequently results in environmental attitude and behavioural change in most participants.

These findings are especially notable in the context that all participants described having at least some levels of positive environmental attitudes and behaviours prior to spaceflight as a result of their scientific background and unique occupation. This means that the Overview Effect still demonstrated a strong ecological significance even when participants came from an enhanced position of scientific and environmental concern, and therefore the outer space perspective's potential ecological effect on the wider public – including space tourists – could potentially be even broader and more intense than what is experienced by astronauts. This point is reinforced by the continuous criticism that astronauts, by virtue of their profession and training, are not known not display a lot of excitement (White 2014, 28) and are often too laconic in describing their experiences (White 2014, 7). This suggests that any experience of the Overview Effect, and by extension, any ecological significance of the Overview Effect, may be weaker or more muted, or even just less acknowledged, by astronauts than it would be by the general population, and thus it is possible that the interview outcomes may even underplay this ecological significance of the Overview Effect to some extent.

The outer space perspective of Earth proved to be a deeply emotional perspective for participants, however, variation in the importance of the personal nature of the spaceflight experience versus the physical distance from the planet required to trigger a direct (Low Earth Orbit [LEO] or the Moon) or indirect (Voyager and Cassini images) Overview Effect shows that these factors resonated differently across various participants, and hence future research

and recreation attempts for the wider public must further test and take these variations into account. The strongest ecological dimension of the Overview Effect was evoked from LEO, from where participants could: (1) first-hand observe anthropogenic ecological destruction on the planet's surface; (2) perceive of said ecological destruction from a grander scale that is unique to outer space; and (3) undergo an at least somewhat qualitatively different awe and wonder experience compared to anything that exists on the planet's surface. These indicate that the outer space perspective brings a new and additional element to environmentalism that goes beyond just having a reinforcing effect on terrestrial elements of environmentalism. Therefore, it is suggested that the wider environmental community take into consideration using not only enhanced 'planetary' language and messaging towards the wider public that makes use of the ecologically significant dimensions of the Overview Effect, but as suggested by Ron Garan, also consider using the positive emotions of awe and wonder triggered by outer space, as opposed to fear, as the basis for future environmental messaging and debates.

Participants expressed significant breadth and depth in their present knowledge of environmental issues and in their pro-environmental practices, and as such, this study shows the majority of participants hold stronger than average pro-environmental attitudes and behaviours. Most participants expressed very strong concerns about various environmental issues – including climate change, biodiversity loss and pollution – and about their anthropogenic origin, emphasizing the need for a more ecocentric approach to human development that balances economic wellbeing and the carrying capacity of the planet. Participants expressed a notable mix of optimism and pessimism about humanity's ability to solve the environmental crisis in time, with the greatest source of pessimism originating from the perceived lack of international political will and commitment to meet necessary environmental targets. A deep enjoyment of nature emerged as an unexpected theme among numerous participants who already held strong pro-environmental attitudes prior to their first spaceflight, which suggests nature plays an important role in shaping participants' attitudes. Participants' environmental attitudes were also markedly influenced by their experience of the outer space perspective of Earth, given that: (1) participants expressed unexpectedly high awareness of the interconnectedness of different ecological issues, which interconnectivity they said was uniquely visible from space; (2) participants highly supported top-down policy solutions at the global / international level, such as UN climate accords, which makes sense given the planetary perspective outer space provides; and (3) participants strongly emphasized

concern over anthropogenic environmental damage, which makes sense given the visible ecological destruction on the surface of the planet visible from space.

Participants demonstrated much higher than average public outreach and engagement activities, which is unsurprising given their unique occupation and public visibility as astronauts; however, the extent to which these activities specifically involved environmental outreach and activism, often as a result of participants' individual motivation to include environmental issues in their activities, was surprising and significant. Overall, participants can be said to be relatively highly engaged in both public and private environmental behaviours, ranging from public environmental outreach to, for example, recycling and more sustainable dietary preferences. Most participants placed a high value on the well-being of the environment and the importance of conducting both their public and personal lives according to those values, even when they had to balance the costs and benefits of their environmental behaviours and regardless of whether their environmental behaviours were perceived as positive or negative within their social norms. While most participants showed a greater breadth of pro-environmental behaviours, some also demonstrated a greater depth through more intense and uncommon practices such as garbage picking, flushing the toilet with rainwater, wrapping lunches in cloth or beeswax, or following a nearly completely plant-based vegan diet.

CHAPTER 5
Conceptual Discussion

Building on the existing literature (Chapter 2) and empirical data analysis (Chapter 4), this chapter aims to advance theoretical discussions about the Overview Effect and astroenvironmentalism in a way that advances the usefulness of these concepts for environmentalism. The following discussions will employ Hay's ecological impulse concept as the main theoretical framework for this conceptual analysis. As such, these conceptual discussions seek, for the first time in the academic literature, to connect the ecological impulse concept to the environmentalism-outer space literature and explore through discourse analysis to what extent they discuss identical or similar phenomena, with the goal being to investigate the utility of employing the ecological impulse concept in theoretical formations of the Overview Effect and to reinterpret and expand current definitions of astroenvironmentalism.

Certainly, images of space exploration – and specifically images from outer space looking back at Earth such as the Apollo images – have shaped past attitudes and actions towards nature, as discussed in Chapter 2 as part of the Apollo images' effect on the environmental movement of the 1960s and 1970s. However, as part of the more recent historical evolution of this ecological impulse, it is also worth conceptually investigating whether activities of space exploration – and specifically human space exploration as exemplified by astronauts – can trigger such an impulse and shape attitudes and actions towards nature as part of this impulse, as hypothesized by Hay. Answering these questions utilizing discourse analysis and the data analysis from Chapter 4 will help demonstrate that the outer space perspective holds renewed relevance in recruitment for the modern-day 'green cause'.

5.1 The Overview Effect and the Ecological Impulse

The following issue was raised in Section 2.3.2: Is the Overview Effect a modern update to, or version of, Hay's ecological impulse? To repeat, the Overview Effect is "a cognitive shift in awareness" in astronauts and cosmonauts that, according to White, leads to a "renewed sense of responsibility for taking care of the environment" (2014, 2). According to Hay, the ecological impulse is a pre-rational – and not theoretical or intellectual – trigger of emotion that results in a 'green commitment', given that "most people come to a position of green identification in the first instance via some trigger of impulse" even if such a commitment is

later "justified via recourse to an intellectually generated system of ideas" (Hay 2002, 2). Hay defines this pre-rational emotional response, or ecological impulse, as "a deep-felt consternation at the scale of the destruction wrought, in the second half of the twentieth century, and in the name of a transcendent human progression, upon the increasingly embattled lifeforms with which we share the planet" (2002, 3).

Based on the data analysis in Chapter 4, the question above requires a necessary reformulation: Is the *ecologically significant dimension* of the Overview Effect a modern update to, or version of, Hay's ecological impulse? I argue that the ecological significance of the Overview Effect can be understood as a modern version of the ecological impulse and that this conceptualization of the Overview Effect's ecological significance is useful for advancing philosophical formulations of how spaceflight affects environmental attitudes.

For one, the data analysis established that the Overview Effect's ecologically significant dimension is deeply emotional in nature and results in new *environmental* awareness and consciousness in many astronauts, which linguistically and conceptually parallels Hay's definition of the ecological impulse as an emotional, "deep-felt" response that brings people to a position of green identification. It also linguistically parallels expectations of an "ecological transformation due to a cognitive 'overview effect'" (Crook 2018, 7, referencing Lazier 2011) resulting from spaceflight. While all participants in this study had some level of pro-environmental attitudes prior to spaceflight, which was expected, some astronauts experienced strong changes in their environmental attitudes, which philosophically can be interpreted as the spaceflight experience constituting what Hay calls their first instance of a trigger of an ecological impulse. Astronaut Ron Garan also uses the same terminology: "Seeing Earth from the vantage point of space not only provides a unique perspective but also can trigger a response that leads to a desire to make the world a better place for all its inhabitants" (2015, 49).

This trigger, in my interpretation of Hay, either activates or awakens a dormant, subconscious or subdued environmental concern that indeed leads to a new level of environmental awareness and consciousness, which is what many astronauts experienced. This meaning can be derived from astronaut statements such as "if you weren't a tree hugger before, you'll be a tree hugger after you go into space" (Al Sacco) or "Before I went to space, I knew we needed to keep the water and the air clean […] but the beauty of experiencing Earth from

space, the way I did, it had become a part of me, I feel like it's in me, like I have an obligation" (Nicole Stott).

Additionally, even astronauts who experienced more moderate changes in their environmental attitudes, the change resulting from spaceflight can be understood as a more muted ecological impulse reaction in which their spaceflight experience constitutes not the first instance, but a reinforcement and/or amplification, of their green identification. Many astronauts experienced a reinforcing or amplifying effect of spaceflight on their environmental awareness and concern and these participants often indirectly expressed already having come "to a position of green identification in the first instance via some trigger of impulse" prior to their first spaceflight. Participants' comments, such as Dorothy Metcalf-Lindenburger's and Story Musgrave's long-standing and deep love of nature since childhood, or Ron Garan's "pivotal" moment of reading a book about future environmental predictions in his youth, in this sense can be interpreted as their first trigger of an ecological impulse that spaceflight then later reinforced or amplified.

I also argue the ecological significance of the Overview Effect can be interpreted specifically as a *modern* version of the ecological impulse because, based on the finding in Chapter 4, the outer space perspective brings a new and additional element to environmentalism that goes beyond just having a reinforcing effect on terrestrial elements of environmentalism. First, I argue it constitutes a modern version due to the technological advancements of the past few decades, meaning human space exploration, that have enabled humans to experience first-hand the outer space perspective of Earth, and therefore, an ecological impulse triggered or amplified by the outer space perspective specifically. Second, the modern environmental movement, according to Hay, is the second historical expression of the ecological impulse and is triggered "by a deep-felt consternation at the scale of destruction wrought, in the second half of the twentieth century, in the name of transcendent human progression" (2002, 3). This linguistically parallels comments by astronaut Nicole Stott, who during her interview said of the same time period that the Apollo images' impact on the modern environmental movement and the first Earth Day "were triggered by this collective consciousness of us being on this planet in space that depends on its life support system". Bryant has also termed this an "ecological consciousness" (1995, 44).

Third, Hay also defines the ecological impulse as the "instinctive dismay at the observed impact of technological advance upon the earth's non-human denizens" (2002, 18), which dismay I argue can be interpreted as the significant environmental responses triggered in astronauts as a result of seeing first-hand from space the scale of visible anthropogenic ecological destruction on the surface of the planet. Therefore, the Overview Effect's ecological significance can also be understood as a *modern* version of the ecological impulse due to the qualitatively at least somewhat different response the outer space perspective triggers in observers. This interpretation is reinforced by the uniqueness of the grander scale perspective of ecological destruction that outer space provides, as well as by the uniqueness of the awe and wonder psychological experiences that outer space provides.

Two more propositions support the usefulness of utilizing the ecological impulse concept to philosophically interpret spaceflight's effect on environmental attitudes: emergent ecocentrism and subjectivity from the outer space perspective. On the one hand, ecocentric concern is one of the 12 measures on Milfont and Duckitt's environmental attitudes scale (2010) utilized for analysis in Chapter 4, in which Section 4.1.2 demonstrated that astronauts placed strong emphasis on ecocentrism through expressions of environmental concern utilizing planetary language and "interconnected" and "oneness" conceptualizations of the planet. Hay argues that one of many interpretations of what constitutes a "green identification" has been ecocentrism, meaning "that the key ecological insight of the interconnectedness of life should inform conceptions of what is 'good behaviour'" (2002, 18), which certainly parallels some astronauts' call for an ecocentric approach to environmental problems on the planet. In the words of Ron Garan: "We live on a living, breathing, interconnected and interdependent biosystem called Earth and we need to treat things holistically and understand that what happens on one side of the planet affects everything else". Additionally, ecological consciousness has been said to result in "broader and wiser knowing" (Morris 2002, 584), and therefore astronauts' ecocentric formulations of environmental issues can also be understood as part of their new environmental awareness and consciousness resulting from the distinctive ecological significance of the Overview Effect.

On the other hand, Hay also submits that perhaps the "most compelling" expression of what he terms this pre-rational ecological impulse was made by Canadian naturalist John Livingston as follows: "There can be no 'rational' argument for wildlife preservation, just as there can be logical explanation of quality experience. […] There is no 'logic' in feeling, in

experiencing, in states of being" (1981, 117). While Livingston expressed this idea in the specific context of wildlife preservation, his words linguistically resonate with astronauts' encounter with the outer space perspective of Earth, which most participants described in strongly emotional terms: "It has nothing to do with science, it's an artistic and emotional image" (Jay Apt) and "it was truly much more of an emotional event" (Al Sacco). These expressions reinforce the intensively emotional nature of the Overview Effect's ecological significance and imply this significance can indeed be interpreted as a pre-rational – meaning emotional – triggering or amplifying ecological impulse, as posited by Hay and Livingston. As such, the deeply emotional nature of the outer space perspective further supports the usefulness of utilizing the ecological impulse concept to philosophically discuss and interpret spaceflight's potential effects on environmental attitudes.

Based on the above points, I have argued that the ecological significance of the Overview Effect can be understood as a modern version of the ecological impulse and that this conceptualization of the effect's significance is useful for advancing philosophical discussions of how spaceflight affects environmental attitudes. Interpreting and discussing this subject in conceptual terms is important because, as Hay argues, (1) discerning the historical evolution of this impulse is important for understanding our current and future attitudes and actions towards nature, and (2) as environmental activists will remain outcome-focused, the act of "instinctive ecological compassion" that Hay called the ecological impulse "will remain the most potent source of green recruitment" (Hay 2002, 18). This further reinforces the need to fully realize and utilize the Overview Effect's ecological significance in increasing pro-environmental attitudes and behaviours in decision-makers and the wider public. In the midst of our dangerously intensifying ecological crisis, we should already be utilizing and maximizing this potent source of green recruitment to its full extent.

5.2 Redefining astroenvironmentalism

To put it in a nutshell, the Overview Effect's significant ecological dimension – a dimension which can philosophically be understood as a modern version of the ecological impulse – can be conceptually summarized as a distinct form of environmentalism; a form of environmentalism that results from the Overview Effect, or even more broadly, from seeing Earth from the 'astro' perspective, meaning the unique grand-scale perspective of outer space. Therefore, the Overview Effect's ecological significance is such that it can conceptually be

understood to contribute to an 'astro'-form of environmentalism in astronauts. However, based on the current academic literature, this is not what the term 'astroenvironmentalism' signifies.

Section 2.1.1 raised the issue that Miller's definition of the term suggests an environmental approach *towards* outer space (Environmentalism → Space), meaning for example, space debris pollution or the protection of planetary wildernesses (Miller 2008, 245). This definition, however, is limited, lacks wider utility for the environmental community and applicability to currently pressing environmental issues on Earth, and thus warrants a more extensive conceptual discussion through which an expanded redefinition is proposed. While part of Miller's definition of astroenvironmentalism, which states it is an "umbrella term" and "component" of debates about the environment, leaves more room for interpretation, it does not expand the definition's otherwise narrow *outwardly* focus towards outer space (Figure 5.1).

Miller's definition	**Suggested expanded definition**
Environmentalism → Space	Space → Environmentalism → Space

Figure 5.1: Conceptualized representation of Miller's astroenvironmentalism versus the expanded definition of astroenvironmentalism

I propose the current definition of astroenvironmentalism can be re-interpreted and expanded to encompass the ecological significance of the Overview Effect and to provide much greater utility to current mainstream environmental discourses. Miller points out that there is no 'Mars First', 'Venus First', 'Greenspace' or 'Spacepeace' organizations, even acknowledging that "most environmental groups are focused on more immediate issues and are more concerned with immediate and down-to-Earth issues" (2008, 247). Miller, however, does not critically examine why this is the case, and as such in its current iteration it is no surprise the concept has not gained a larger audience and has failed to contribute to mainstream environmental discourses in a meaningful way.

In addition to the outward focus towards outer space, I hereby advance an additional *inward* application of the concept of astroenvironmentalism that can be interpreted as the distinct form of environmentalism that results from the outer space – 'astro' – perspective of looking back at Earth (Space → Environmentalism). After all, the outer space view of Earth is "still a view from somewhere, taken at some time, made possible by a particular assemblage of certain humans and machines" (Bimm 2014, 43). In this sense, the ecological significance

of the Overview Effect – meaning detectable changes in environmental attitudes – and thus the distinct form of environmentalism that results from seeing Earth from the outer space perspective could more simply be interpreted and termed as a form of astroenvironmentalism – an environmentalism still distinct from other forms of terrestrial environmentalism but still an environmentalism about Planet Earth.

Looking both *outwardly* towards outer space and *inwardly* from outer space suggests a two-way perceptual gaze. This is not a new idea: the "outward" response of space exploration has been contrasted with the "inward" or "return-to-Earth" response of environmentalism (Weber 1985), including in the context of the Apollo images (Bryant 1995, 48). According to White: "space exploration, like the Roman god Janus, has two faces, one looking inward and the other outward. On the one hand, it makes us more conscious of Earth, our home. On the other, it opens our minds to the whole system of which Earth is only a part" (2014, 109). To further expand on this idea and apply it to the concept of astroenvironmentalism, the 'astro' in astroenvironmentalism could therefore serve as both the inward-looking point *from which* perspective we view our planet (Space → Environmentalism) as well as the outward-looking point *from which* perspective we form an environmentalism towards outer space and other planetary bodies, as originally defined by Miller (Environmentalism → Space). Since both these directions co-exist simultaneously, and to some extent may even interact, they can also be visually conceptualized as: Space → Environmentalism → Space.

Using the singular term of 'astroenvironmentalism' to express the complex psychological and philosophical changes resulting from the ecological significance of the Overview Effect could facilitate more straightforward discussions on the topic and make this phenomenon and form of environmentalism more accessible to the wider public. This is relevant not only to future space tourism operations, which inevitably will only cater to a select number of wealthier individuals, but to advanced media technologies such as virtual reality that are currently being tested for recreating and potentially triggering an Overview Effect (Stepanova et al. 2019), or similar awe and wonder experiences (Quesnel and Ricke 2017; Chirico et al. 2018), in participants from the wider public. In the context of planned future manned missions to the Moon by the U.S., China, Russia, and Japan, it is therefore important to keep in mind that "images of the more distant planetary bodies are unlikely to provide such a fundamental boost to the planetary environmental movement" (Williamson 2006, 257), and as such, this expanded definition of astroenvironmentalism could provide useful to the wider

environmental community in making use of future material of Earth from the Moon, whatever its impact in the 21st century may be. As Jeff Hoffman suggested during his interview: "When we go back to the Moon, I think the message to try to get across is that the Earth is the only place in the universe that we know of that can support life and so it's pretty special. We should try to keep getting the message out that this is our home and we better take care of it". Certainly, an inward-looking astroenvironmentalist sentiment born out of humanity's return to the Moon and visit to Mars in the 21st century could provide a much-needed boost to the modern-day 'green cause'.

CHAPTER 6
Conclusion

6.1 Summary

This study has demonstrated that the Overview Effect has a distinct and prominent ecological significance that goes beyond what the existing academic literature currently contains. Astronauts interviewed for this research expressed experiencing a higher-level viewpoint involving a new *environmental* awareness and consciousness, resulting in a change to their pre-spaceflight environmental attitudes and behaviours. In most cases, the spaceflight experience led to a direct or indirect (reinforcing or amplifying) change in participants' environmental attitudes, which subsequently resulted in more gradual and indirect environmental behavioural change. This suggests that the spaceflight experience, and the outer space perspective view of the Earth contained therein, has the potential to significantly contribute to the formation of more positive environmental attitudes and behaviours in astronauts, and as such, this aspect of spaceflight needs to be further explored and made use of in future government spaceflights and commercial space operations.

One of the major findings of this study is that negative perceptual views of visible anthropogenic ecological destruction on the surface of the planet from Low Earth Orbit appeared to have substantially contributed to triggering significant environmental responses in astronauts. As such, the juxtaposition of both positive and negative perceptual views of the Earth from outer space appears to have played an important role in triggering the ecological significant dimension of the Overview Effect in participants, which then contributed to changes in their environmental attitudes and behaviours. Additionally, as suggested by astronaut Ron Garan, the perspective could also be used to base environmental messages and debates on the positive emotions of awe and wonder, as opposed to fear, to make those messages and debates more effective and productive. These findings should be further investigated and developed for applicability to VR simulations and environmental communication that aim to increase environmental awareness and concern among decision-makers and the wider public.

Another major finding of this study is that the outer space perspective of Earth was shown to add a new and additional element to environmentalism that goes beyond just having a reinforcing effect on terrestrial elements of environmentalism. The conceptual argument was

put forward that the ecological significance of the Overview Effect can be understood as a modern version of the ecological impulse, which theoretical interpretation of this phenomenon is useful for advancing conceptual formulations of how spaceflight can influence environmental attitudes, and subsequently, environmental behaviours. It was also suggested that this distinct form of environmentalism be termed astroenvironmentalism – interpreted hereby in its redefined and expanded form – in order to facilitate more straightforward discussions on the topic and make this phenomenon and form of environmentalism more accessible to a wider audience.

Besides investigating the change in astronauts' environmental attitudes and behaviours resulting from the ecologically significant dimension of the Overview Effect, a major contribution of this study has been to qualitatively map the breadth and depth of astronauts' present environmental attitudes and behaviours, which has not been done prior to this study. On average, participants were found to hold strong pro-environmental attitudes that often, but not always and not perfectly, translated to strong and more moderate pro-environmental behaviours in both their public and private spheres of life, albeit with some limitations due to costs and tensions in social norms. Overall, participants were shown to hold stronger-than-average pro-environmental attitudes and behaviours and demonstrated a much higher extent of public environmental outreach and environmental engagement activities than expected. Additionally, many expressed significant pessimism about what they perceived as a lack of international political will and commitment to meet necessary environmental targets set out in various UN climate accords. These findings suggest, among others detailed in Chapter 4, that astronauts are an under-utilized but extremely promising resource for environmental outreach and environmental communication at the international level, and as such could be more consciously and systematically recruited to participate in environmental campaigns aimed towards decision-makers and the wider public.

In expressing significant breadth and depth in their present environmental awareness and anthropogenic concern about issues including climate change, biodiversity loss and pollution, most participants, with the exception of two anthropogenic-change deniers, placed a qualitatively high value on the well-being of the environment and the importance of conducting both their public and personal lives according to those values. While most participants expressed a greater breadth of pro-environmental behaviours, some also demonstrated a greater depth through more intense and uncommon practices such as garbage picking or flushing the

toilet with rainwater. Numerous participants clearly reflected the historical era of the Apollo images and environmental movement in which they grew up, emphasizing conceptual framings of their worldview with the Spaceship Earth metaphor and the Earth's carrying capacity. However, overall, participants emphasized the need for a more ecocentric approach to human development, thus expressing the need for a more ecocentric system of ecological values that could indeed be used to influence the psychological basis of the ongoing ecological crisis.

In short, this research demonstrated that the Overview Effect has an ecological significance that can be conceptualized as a modern version of the ecological impulse and termed as a form of astroenvironmentalism and that, for one, leads to detectable and durable positive changes in astronauts' environmental attitudes and behaviours, and two, shows a significant qualitative breadth and depth in the present, even many years after spaceflight.

6.2 Importance

This study has demonstrated the promising and significant potential of utilizing the Overview Effect, and more broadly the outer space perspective of Earth, to increase awareness and concern about ecological issues by positively influencing environmental attitudes and behaviours. In very broad terms, this constitutes a new contribution on how human space exploration can contribute to environmentalism back on Planet Earth, but with utility and applicability to the modern environmental movement and the wider public. In the midst of the sixth mass extinction (Ceballos et al. 2017) and intensifying climate change that must be limited to a maximum of 1.5 degrees Celsius in the next decade (IPCC 2018) – among numerous other urgent ecological issues – this research demonstrated how the outer space perspective and the Overview Effect can be used to increase pro-environmental attitudes and behaviours and to enhance environmental messaging and outreach towards the wider public in both (1) bottom-up and (2) top-down approaches. In terms of the former (1), given recreation opportunities on the ground, including recent immersive technologies such as VR, there is now an unprecedented and increasing opportunity to start utilizing and applying these findings to the wider public, especially as the research has also indicated that the distinct form of astroenvironmentalism resulting from the Overview Effect and outer space perspective of Earth may even be more intensively and deeply triggered in non-astronaut participants. In terms of the latter (2), findings suggest that astronauts are a systematically underutilized but extraordinary resource for environmental outreach and communication towards the public, as they could lend further visibility and credibility to the environmental movement, and through

sharing their experiences, could help inspire increased environmental awareness and concern among the public. Furthermore, the inward-looking astroenvironmentalist sentiment born out of humanity's expected near-future return to the Moon and visit to Mars in the 21st century could be utilized by space agencies' communications and outreach operations to justify continued human space exploration activities by providing a much-needed boost to the modern-day 'green cause'.

6.3 Future research

Further research is suggested to quantitatively measure changes in environmental attitudes and behaviours in astronauts over a more extensive period of time, for example comparing pre-flight survey data, post-flight survey data, and survey data from a few years following the spaceflight. This could especially be significant, for example, for the NASA astronauts who will be selected in the near future to return to the Moon in the year 2024, or in later years. Additionally, as commercial spaceflight operations become more viable, the changes in the environmental attitudes and behaviours of non-career astronauts resulting from spaceflight would also provide interesting data on how individuals, closer to the general public than career astronauts, are affected ecologically by spaceflight, and whether commercial space tourism could somewhat offset its emissions by at least contributing to positive changes in participants' environmental attitudes and behaviours.

Further research is also suggested to further test and experiment with VR simulations and other recreation opportunities on the ground, to explore the extent to which the positive ecological outcomes of spaceflight could be achieved without participants having to go to space. This potentially would be even more significant than researching space tourists, as effective recreation on Earth has the largest potential utility and applicability to the largest number of people, and as such, has the highest potential to reach the critical mass of people needed to truly transform the dominating anthropogenic consciousness that indeed serves as the psychological basis of the current ecological crisis (Biriukova 2005, 34).

Finally, further theoretical research is suggested on the topic of astroenvironmentalism, as in its currently expanded form it has greater potential to meaningfully contribute to mainstream environmental discourses.

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Appendix

Appendix I: Interview questions

1. Would you like to be identified by name or be anonymous?

2. What made you want to become an astronaut?

3. Let's go to the moments of your spaceflight(s) in [year] when you looked out and saw Planet Earth from your vantage point in outer space. Please describe what you saw and what was going through your head.

4. Do you think a person needs to go to space to get that experience, or can it somehow be recreated on Earth in other ways? If yes, how so?

5. Since your return to Earth, has anything in you changed that could said to be resulting from your spaceflight experience?

6. Please try to go way back and remember, to the best of your ability, before your flight: how would you characterize your thoughts about environmental issues, if you had any? Is it something that was on your mind at all or something you were actively engaged with?

7. What do you currently think about environmental issues? Do you currently engage in any activities in your public life or personal life that relate to environmental issues?

8. Do you think the outer space perspective of Earth can be useful for communicating global issues such as environmental to the public, and if yes, how so?

9. Do you think space travel / exploration and environmentalism / environmental issues are connected in any way, and if yes, how?