Communicating science through entertainment television: How the sitcom *The Big Bang Theory* influences audience perceptions of science and scientists

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Declaration

This thesis is an account of research undertaken between February 2011 and October 2015 at the Australian National Centre for the Public Awareness of Science, The Australian National University, Canberra, Australia.

Except where acknowledged in the customary manner, the material presented in this thesis is, to the best of my knowledge, original and has not been submitted in whole or part for a degree in any university.

Two academic papers were published on this topic which I co-authored with the chair of my supervisory panel, and some of the sections of these papers have been reproduced in parts of Chapter 3. Acknowledgements of these two academic papers are written in the footnotes following the relevant sections.

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I would like to end the acknowledgements by referencing a dialogue between Sheldon and Penny from an episode in *The Big Bang Theory*. This is one of my favourite conversations in the show that I've held close to heart, and always made me laugh during the tough time:

> **Sheldon:** Leonard is upstairs right now with my arch-enemy.
>
> **Penny:** Your arch-enemy?
>
> **Sheldon:** Yes. The Dr. Doom to my Mr. Fantastic. The Dr. Octopus to my Spider-Man. The Dr. Sivana to my Captain Marvel...
>
> **Penny:** Okay, I get it, I get it...
>
> **Sheldon:** You know, it's amazing how many super villains have advanced degrees. Graduate schools should do a better job of screening those people out.
>
> *The Codpiece Topology* (S02E02)

Abstract

This study aimed to explore whether entertainment television can increase the public's engagement with science. The motivation for the study was the 2010 *Inspiring Australia* report, a national strategic plan to engage the Australian public with science. One of the 'key principles' stated in *Inspiring Australia* was the need to strengthen the media's role in communicating science, including entertainment television. However, there has been little empirical research into how adults engage with the science content in entertainment television shows to validate (or to refute) the effectiveness of this key principle. In order to investigate whether and how entertainment television has influenced audiences' perceptions of science and scientists, I chose the American sitcom *The Big Bang Theory* as a case study since it is scientifically accurate and its main characters are scientists. Data were collected using 18 focus groups with 74 regular viewers of the show.

Overall the program made science seem less dry and more interesting to the participants, and made scientists seem less socially isolated, humanising them. It positioned science and scientists as part of society rather than separate from it. With respect to whether the show influenced people's information seeking behaviours related to science, and science knowledge, personal experiences had a larger impact than watching *The Big Bang Theory*. However, the show did stimulate some people to find out more about the science information the show presented, and responses demonstrated that people can learn about aspects of the nature of science from watching entertainment television. Participants felt the scientist characters in *The Big Bang Theory* both conformed to and contradicted their preconceived images of scientists and their understanding of scientist stereotypes. They were surprised the characters had personal lives and romantic relationships, and as a result, felt scientists were more approachable. Participants indicated their frustration that the female scientist characters were introduced and written as love interests, but appreciated that they were shown as successful scientists too. People had mixed feelings about them being mainly in the biological sciences (rather than being

physicists and engineers, like the main male characters), but indicated that on television, good value entertainment was more important than portraying gender balance in science.

Although the participants indicated that the science content in *The Big Bang Theory* was an important contributor to their enjoyment of and interest in the program, they also asserted that relatability, characters, humour, and geek culture references were equally or sometimes more important. However, people cared strongly about scientific accuracy even if the science was being treated as secondary or used as a backdrop of the show.

In summary, some audiences of *The Big Bang Theory* engaged actively with its science content and changed their views of scientists. Therefore, it is possible to use entertainment television to reach people who are not actively seeking science-related content, because if it doesn't just focus on science it makes the show - and therefore the science - more accessible for the public.

Contents

Introduction

In January 2015, the Chief Scientist of Australia, Professor Ian Chubb, specified the use of the popular television show *The Big Bang Theory* to make science attractive to students. He argued that "while we really need to make sure we increase the attractiveness of science, we can't make it compulsory so we have to make it so compelling students want to study it" (Vonow, 2015, para.7). Furthermore, Chubb claimed that shows such as *The Big Bang Theory* "are certainly examples of the sorts of things that encourage students to believe they could be like characters in TV shows" (Vonow, 2015, para.3). This statement stems from a concern for the current state of Australia's science education, where our students are 'falling behind' in science (Vonow, 2015). The possibility that television shows like *The Big Bang Theory* could make physics compelling was supported by a 2014 UK study. In the survey of 1500 UK students (aged 14-18), "nearly half of the young people admitted that these shows [*The Big Bang Theory* and *The Gadget Show*] made the subjects [science, technology, engineering and mathematics] more appealing" (Gurney-Read, 2014, para.1). This prompted the former president of the UK's Institute of Physics, Professor Sir Peter Knight, to assert that physics "had benefited from its 'geek-chic' image, promoted by television presenters such as Brian Cox and shows such as the Big Bang Theory [sic]" (Gurney-Read, 2014, para.5).

Even though these news articles focused specifically on science education, they alluded to the fact that television shows like *The Big Bang Theory* can make science compelling, presumably not just to students but to the wider public. This idea was discussed in the Australian government's science engagement report *Inspiring Australia*, where one of the recommendations focused on the role of science and the media.

In 2010, the Australian government released the *Inspiring Australia* report which introduced a national strategy to effectively engage the Australian public with the sciences. The aim of *Inspiring Australia* was to broaden the scope of communicating science by incorporating suggestions from consulting participants outside the immediate science disciplines (i.e., natural and physical sciences), such as the humanities, arts and social sciences (Department of Innovation, Industry, Science and Research, 2010). Consultants were selected from different industries, including the government, academia, business and public institutions. The resulting report was a five-year plan that included various agendas and accompanying recommendations of ways to achieve a scientifically engaged Australia.

One of these agendas specifically stated the need to strengthen the media's role in communicating science, and addressed a recommendation based on Bubela and colleagues' (2009) article in *Nature Biotechnology*:

> Science engagement initiatives should investigate new forms of digital media and film, moving beyond traditional popular science outlets, including finding ways online to create opportunities for incidental exposure among key audiences not actively seeking science-related content (Department of Innovation, Industry, Science and Research, 2010, p.36).

Inspiring Australia responded to this recommendation and asked that a "short-term working group be established to review mechanisms for further developing Australian science media content" (Department of Innovation, Industry, Science and Research, 2010, p.37). As a result, an expert working group was gathered which consisted of "experts from the research, entertainment, news, magazine, new media, education, and science communication sectors" (Expert Working Group, 2011, p.4). Their report was released in early 2011, where one of their key findings was:

> Science is not well represented in general programming, being under-represented in factual and documentary programming and missing-in-action from most Australian drama, comedy and reality TV (Expert Working Group, 2011, p.v).

In order to mitigate this issue, the expert working group recommended:

> That a general programming supplementary fund be established to encourage television and film content that includes factual science, fictional science (i.e. superhero science), science concepts or characters (Expert Working Group, 2011, p.11).

More specifically, they suggested that this supplementary fund could be used to "access and utilise the science information and expertise needed", such as hiring science consultants, to help "research ideas and develop programs" that include science content (Expert Working Group, 2011, p.11). A number of television shows from various genres were identified in the report to highlight the various ways to include science content. One example was based on the reality show *The Biggest Loser* (2006-present) where they had a doctor as the medical host. Another example was the inclusion of scientists as the protagonists or main characters in fictional shows like *Numb3rs* (2005-10), and of particular interest for this study, *The Big Bang Theory* (2007-present). They also noted the potential of incorporating scientist characters or science information in long-running soap operas, like *Home and Away* (1988-present), and dramas, like *Blue Heelers* (1994-2006) (Expert Working Group, 2011, p.11).

The expert working group also suggested an implementation strategy, where a pilot television program is to be developed and launched, and then subsequently evaluated for its success before seeking further funding. However, it must be noted that even though experienced television writers and producers can create a successful show, it is uncertain whether the science content in a new show will also successfully engage viewers with science. Therefore, this study is an attempt to shed light on this issue by collecting empirical data to determine whether and how fictional television shows can effectively communicate science and engage the public with it. I chose to use focus groups to gather data relevant to this aim, and specifically looked at the fictional television show *The Big Bang Theory*.

The Big Bang Theory[1] is an American situation comedy (sitcom) whose pilot episode aired on September 24, 2007, and which is expected to air its 10th season in 2016-17. It includes scientifically accurate and up-to-date science information (Hewitt, 2009; Lloyd, 2010; Ludovice, Hunt, & Saltzberg, 2010), and mainly focuses on the social lives of scientists (Thomas, 2010; Ludovice et al., 2010). The show's creators, Chuck Lorre and Bill Prady, originally came up with this idea from Prady's experience as a computer programmer in New York. He worked with "very intelligent [people] but who were completely lost when it came to the mundane things in daily life" (Thomas, 2010, p.12). The characters were later changed from computer programmers to physicists because "there is just something fascinating about a show that looks at the world through physics and mathematics. These guys are trying to unravel the secrets of the universe – that's pretty big" (Thomas, 2010, p.13). The use of whiteboards by physicists contributes to the visual sense of the show and Prady stated that they "realized this is a better way to show somebody working with their mind" (Heyman, 2008, p.741).

Having scientifically accurate information on television is very uncommon (Thomas, 2010), and this makes *The Big Bang Theory* different from other sitcoms with a scientific basis. Lorre has argued "it is those [scientific] details that colour the tone of the show and contribute to its popularity" (Thomas, 2010, p.12). The accuracy of the science information in *The Big Bang Theory* is accredited to the efforts of the show's science consultant – Professor David Saltzberg from the University of California, Los Angeles (UCLA). He prepares the science information in scripts and attends the taping every week. Saltzberg acts as the bridge for the crews to meet and understand the lives of physics graduate students and post-doctoral researchers by giving tours of UCLA and bringing one of his students to the taping each week (Lloyd, 2010).

Saltzberg acknowledged the impact *The Big Bang Theory* has on the public by expressing that "as a physicist, the idea of getting 11 million people to tune in to watch physicists every week is a remarkable opportunity. The fact that they show these scientists, these people, as so passionate, has to be helpful" (Humphries, 2009, para.4).

[1] Lorre, C., Prady, B., & Molaro, S. (Producers). (2007). *The Big Bang Theory* [Television Series]. Burbank, CA: Chuck Lorre Productions and Warner Bros. Television.

A year later, Saltzberg added to his previous comment that "with 13 million viewers watching a sitcom that references current physics research, maybe the show will do for physics what Indiana Jones did for enrolment in archaeology departments" (Thomas, 2010, p.12). However, these comments can only be considered as the science communities' hopes and desired outcomes since not all the audiences of *The Big Bang Theory* will retain or be stimulated by the science content to take further action (see Chapter 3, section 4 for detailed discussion). Nonetheless, the latter comment about physics enrolments appeared to be coming true in the UK in 2011, where *The Big Bang Theory* was "the latest factor behind a remarkable resurgence of physics among A-level and university students" (Townsend, 2011, para.1).

Saltzberg receives the scripts a month in advance to fill in spaces that say "science to come" (Hewitt, 2009; Thomas, 2010; Ludovice et al., 2010). He fills these spaces with science from real experiments and also corrects words that physicists don't use, such as 'trials' which is replaced by 'data runs' (Hewitt, 2009), or correcting scientific errors, such as changing 'cosine' to 'sine' (Lloyd, 2010). Saltzberg indicated the science mainly includes "something new, so people can learn about recent discoveries. It functions as a news outlet in some sense" (Hewitt, 2009, para.7). This includes iconic experiments and theories. An example is the 'lunar ranging' in the episode *The Lunar Excitation* (S03E23). In this episode, some of the scientist characters bounced a laser beam off the retro-reflector on the Moon and the signal shown on their oscilloscope proved that the Apollo astronauts landed there. This experiment highlights the significance of using entertainment to support and encourage public science awareness (Kakalios, 2010), as well as inform and challenge science deniers by depicting a way to demonstrate that the iconic moon landing was real.

In addition to communicating iconic science experiments and theories, *The Big Bang Theory* also has the ability to remind viewers of what they learnt in physics classes and how these principles and concepts have real-world applications (Humphries, 2009). An example is the episode *The Big Bran Hypothesis* (S01E02) where the characters were moving a box up the stairs; Saltzberg asserted "Pushing a box up an inclined plane takes less force than just lifting it straight up. That's the first week of any physics class"

(Hewitt, 2009, para.10).

Not only does *The Big Bang Theory* have the ability to remind the audience of the physics they learnt in school, it can also correct misunderstandings of physics concepts. An example is the episode *The Fuzzy Boots Corollary* (S01E03) where one of the physicist characters, Leonard, and a non-scientist, Penny, were on a date and Leonard showed how an olive can spin in an upside-down glass. Saltzberg described it as follows: "the character's date says, 'It's centrifugal force' [...] the other character launches into a description saying 'It's actually centripetal force, and here's why,' and it's a completely correct description" (Hewitt, 2009, para.14-15).

The show also has the potential to stimulate the curiosity of the viewers with science. An example is in the same episode *The Fuzzy Boots Corollary* where a character explained to his friends that the Earth didn't move, apart from the 383 miles that it was going to, after he kissed his colleague. Saltzberg explains, "I got an e-mail from a high school student ... from outside Chicago ... [who] tried to calculate the 383 miles based on the five-second kiss and how fast the Earth was turning" (Hewitt, 2009, para.16).

One notable fan of *The Big Bang Theory* is Neil deGrasse Tyson, the director of the Hayden Planetarium of the American Museum of Natural History, who also appeared in the show as a cameo in the episode *The Apology Insufficiency* (S04E07). Saltzberg indicated that Tyson once wrote on Twitter: "banter of [these] fictional characters, 95% accurate. Evening news, somewhat less" (Ludovice et al., 2010). The writers are so ambitious with getting the science correct that they take into account the date that episodes with specific experiments and expeditions are going to be aired on television, so they will fit in with a specific time of the year. An example is the season two finale, *The Monopolar Expedition* (S02E23), in which some of the characters prepared to leave for an Arctic expedition during summer in America (Ludovice et al., 2010).

Since then, the science in the show has caught the attention of many audiences, and people want to know how the science behind the show works. This encouraged Saltzberg to start a blog explaining the science in the show which he called 'The Big Blog Theory'

(Thomas, 2010; Ludovice et al., 2010). Aspects other than the science have also been noted by scientists where they were stimulated to conduct research. One example was the game 'Rock-Paper-Scissors-Lizard-Spock', which is an expansion from the classic rock-paper-scissors.[2] By incorporating the game into the show, it has contributed to the popularity of the game itself, as well as created the opportunity to explore the spatial patterns of the game through computer simulations (Hawick, 2011).

However, even though Saltzberg endeavours to get the science correct, his efforts are not appreciated by everyone because "no matter how right you get the science, there's going to be some fraction of people who think it's wrong" (Heyman, 2008, p.741). Occasionally, there will be inaccurate scientific information appearing on the show. An example of the inaccurate science is discussed in a paper presented by Davis, Tilley, and Hague (2011). They investigated the scene where a physicist used an oxygen iodine laser to heat up a cup-of-noodles in the episode *The Fuzzy Boots Corollary* (S01E03). In their experiment, Davis and colleagues found that the heat produced by the laser would effectively heat up the cup-of-noodles but would also destroy the container before the water boils, rendering it pointless.

Nonetheless, various educators have already been using scenes from *The Big Bang Theory* to teach different aspects of science. For example, the psychological concept of operant conditioning in the episode *The Gothowitz Deviation* (S03E03) has been used by high school and college teachers as a tool to engage students (e.g., Korek, 2011; Jen, 2012; Follert, 2015).[3]

[2]The expansion of the game rock-paper-scissors was invented by Sam Kass and Karen Bryla to decrease the probability the players will end in a tie. Kass stated that when two players know each other well enough, there is a 75-80% chance they will tie in a game, but this probability decreases when two more variables are added – lizard and Spock. For further information, refer to: Kass, S. (2012). *Rock Paper Scissors Lizard Spock.* Retrieved from: http://www.samkass.com/theories/RPSSL.html

[3]Operant conditioning is a concept that describes the learning process of using reinforcement and punishment to change behaviours for a desired outcome. This concept is based on the works of Edward Thorndike and B. F. Skinner. In the episode, Sheldon uses *positive reinforcement* to change Penny's behaviour by giving her chocolates when she did something he deemed desirable. In contrast, Sheldon uses *positive punishment* on Leonard by spraying water on him when he refused to let Sheldon 'condition' Penny, in an effort to change Leonard's objection (i.e., to allow Sheldon to continue 'conditioning' her). For further information, refer to: McLeod, S. (2007). *Skinner - Operant Conditioning.* Retrieved from: http://www.simplypsychology.org/operant-conditioning.html

As mentioned above, *The Big Bang Theory* is unique in that the majority of the main characters are scientists. More specifically, it is unique because it shows the life of scientists *outside* the laboratory with daily experiences such as interactions with people, attending parties and pursuing relationships. Lorre expressed that *The Big Bang Theory* not only attracts scientists' attention but also the non-science community because "it's not just a show about science. It's also about the characters' lives – their families, friends, hopes and romantic relationships" (Thomas, 2010, p.12). *The Big Bang Theory* revolves around the lives of four male scientists: Sheldon, Leonard, Howard and Rajesh, and a female actress/waitress, Penny. In addition to the male scientists, three female scientists (Leslie, Bernadette and Amy) have appeared in different seasons. Below is a brief description of each regular character:

Sheldon Cooper, Ph.D. (Jim Parsons)

Sheldon is a theoretical physicist at the California Institute of Technology (Caltech) focusing on string theory. He has an IQ of 187 and received his first PhD at the age of 16. He has multiple degrees: B.S, M.S, M.A, Ph.D. and Sc.D. The most notable quality of Sheldon is that he is extremely social inept and is sarcasm-, irony- and humour-impaired. Some audiences of the show have argued that Sheldon has Asperger's syndrome (Collins, 2009). As a result, some people have subsequently used Sheldon's image for an Asperger's syndrome support group poster (Appendix A), conducted research based on his behaviour (Walters, 2013), as well as used his behaviour to teach about Asperger's syndrome (McMahon-Coleman, 2013).

Leonard Hofstadter, Ph.D. (Johnny Galecki)

Leonard is an experimental physicist at Caltech where he works with lasers. He shares an apartment with Sheldon. Unlike Sheldon, Leonard yearns to be in a relationship with a woman. He tends to be more sociable and open to meeting new people even though he is socially inept. His work has constantly hit failure and been over-shadowed by other people.

Penny (Kaley Cuoco)

Penny lives opposite Sheldon and Leonard. She is a waitress at 'The Cheesecake Factory' while working towards an acting career. Unlike Sheldon and Leonard, Penny is not a scientist and is a community college drop-out. She is very sociable and

supportive with the guys even though much of the time she doesn't understand what they are talking about. Penny functions as the bridge for the male characters to social culture.

Howard Wolowitz, M.Eng. (Simon Helberg)

Howard is an aerospace engineer at Caltech. His work involves building parts for rockets, NASA's International Space Station, telescopes and other space-related projects. He is Jewish and often references it in the show. In the earlier seasons, Howard is often seen actively seeking women for the purpose of sex. In season 3, he was set up for a blind-date with Bernadette, who he proposed to in season 4.

Rajesh (Raj) Koothrappali, Ph.D. (Kunal Nayyar)

Raj is an astrophysicist at Caltech. He originally worked on compositions of trans-Neptunian objects which later was proved a dead end and he faced deportation due to visa violations. To avoid returning to India, Raj later decided to collaborate with Sheldon on a new research project. Raj is best friends with Howard and is often seen accompanying Howard to bars. Raj has selective mutism, a recognised medical disorder which prevents him from speaking to women unless he is drunk, but he was subsequently cured of this disorder in the season 6 finale. He enjoys socialising with new people (mainly women) but does not find love until the later seasons.

Leslie Winkle, Ph.D. (Sara Gilbert)

Leslie is an experimental physicist who shares a laboratory with Leonard. She was cast as a regular character for seasons 1 and 2, then a recurring character in the third season, then subsequently left the show. Her work is in loop quantum gravity. She frequently mocks Sheldon by calling him 'dumb arse' and once argued with him about whether string theory or loop quantum gravity is the future of physics. She was another of Leonard's love interests early in the series but the relationship did not last. Furthermore, various fan sites have made the assertion that Leslie is the counterpart of Leonard in terms of appearance (e.g., *"Leslie Winkle"*, 2016) and interest, but is ultimately different to him since Leslie "has more confidence, and is bossy and shallow" (e.g., *"Biography for Leslie Winkle (Character)"*, 2016).

Bernadette Rostenkowski-Wolowitz, Ph.D. (Melissa Rauch)

Bernadette is a microbiologist who received her Ph.D. at the end of season 4. She was set up on a blind-date with Howard by Penny and Leonard. She and Howard married in season 5. Bernadette worked with Penny at 'The Cheesecake Factory' when trying to put herself through medical school. She is a down-to-earth scientist who goes to bars with Penny but can also communicate with the male characters and occasionally contribute to the science dialogue.

Amy Farrah Fowler, Ph.D. (Mayim Bialik)

Amy is a neurobiologist/neuroscientist and was cast as a regular character in season 4. She is the female counterpart of Sheldon. Amy and Sheldon met through a dating site which Raj and Howard secretly signed Sheldon up for. Her research is mainly with monkeys such as stimulating the area in the brain of a Rhesus monkey for emotion studies and training a Capuchin monkey to smoke cigarettes for addiction studies. Amy considers Penny her best friend and, as a result, has become more open to social conventions such as drinking at bars and shoe shopping.

Even though one of the first criticisms about *The Big Bang Theory* that Saltzberg encountered was that the depiction of scientist characters was symbolic of people 'poking fun' at physicists, he asserted that "of the small number of complaints I hear, no one has ever complained it's an inaccurate portrayal. They sometimes complain that it's an unflattering portrayal, but never inaccurate" (Hewitt, 2009, para.2). However, this could be associated with *The Big Bang Theory* being a sitcom. In the words of an editorial in *Nature Physics*, since the "characters [are] for entertainment, of course they're exaggerated stereotypes", but they are portrayed "in exactly the ways that any non-physicist would expect a physicist to be" and "although a stereotype never matches any real individual, it is always based on an element of truth" ("Media Star", 2008, para.4). Ouellette (2011, p.98) proposed that the reason the humour in *The Big Bang Theory* "raises some hackles" is because to some extent, the comedy contains an element of truth. She continues by asserting that some of the scientists that people might have encountered during their lifetime tend to bear some of these stereotypical traits, such as scientists who:

fail to pick up on common social cues; who make inappropriate comments to attractive women; and who engage in animated, technical arguments on the

> difference between centrifugal and centripetal force, to the bemusement of any non-scientists who happen to be present (Ouellette, 2011, p.98).

During the early seasons, the people who were offended by the show were mostly concerned with sexism, such as having too few female scientists, and nerdism, like portraying the scientists as Klingon-speaking nerds (Heyman, 2008, p.740). In response to the audiences' criticisms, Prady stated that "if the scientific community is concerned with how we depict them, be gentle and be patient. We are you, we love you" (Heyman, 2008, p.740). One of the changes the producers has made in effort to address these criticisms was by including more female scientists as the main characters. However, studies such as those done by McIntosh (2014) and Weitekamp (2015) focusing on the female scientists in *The Big Bang Theory*, more specifically on Amy and Bernadette, have demonstrated to different extents that the inclusion of more female scientists does not equate to being less sexist (see Chapter 5 for detailed discussion). Nonetheless, the development of the show and its characters throughout the seasons provided a rare opportunity for researchers to analyse the portrayal of scientist characters, particularly in terms of a sitcom.

Now in its 9th season, the show itself and its influences on society have changed considerably. One major change was that real scientists are now actively seeking opportunities to present their work on the show. More specifically, they are pitching their latest results to Saltzberg so they can be written on the whiteboards in the show. Saltzberg indicated, "It's sort of become a thing to get on the whiteboards. Dozens of scientists are watching those boards" (Whitehead, 2014, para.2). This suggests the physics on the whiteboards has become an important contributor to some scientific audiences' enjoyment of the show, and that instead of being a tribute to physics in the earlier seasons, these whiteboards have become an avenue for scientists to communicate their research findings. This resonates with Kirby's (2003, 2011) research into how scientists use popular fiction as a mean of communicating their work.

The scientifically accurate and up-to-date physics still remains important to the authenticity of the science on *The Big Bang Theory*. Saltzberg asserted that recent discoveries like "The big discovery of gravitational waves, which indicated cosmological

inflation, got a special place" (Whitehead, 2014, para.2). This particular piece of scientific discovery "appeared on Stephen Hawking's board [and the science] was actually vetted by Hawking himself" (Whitehead, 2014, para.2), when Hawking made a cameo appearance in the episode *The Hawking Excitation* (S05E21).

Another major change was the establishment of the UCLA 'The Big Bang Theory Scholarship Endowment' in May 2015, which is a scholarship "to support undergraduate students at UCLA who are studying the sciences [. . . and] have gotten in on academic merit but need extra support to supplement their financial aid" (Alter, 2015, para.2). The supplement scholarship, which mainly goes to first year undergraduates (i.e., freshmen), was started and mainly funded by the Chuck Lorre Family Foundation, with help from the show's cast and crew and contributions from Warner Bros. and CBS (Hampton, 2015; Alter, 2015; Andreeva, 2015). Lorre recalled that:

> When we first discussed it, we realized that when *Big Bang* started, this freshman class were 10-years-old . . . some of them grew up watching the show, and maybe the show had influence on some of them choosing to pursue science as a lifetime goal. Wouldn't it be great if we can help (Andreeva, 2015, para.3).

In establishing this supplement scholarship, Lorre expressed:

> We have all been given a gift with 'The Big Bang Theory,' a show that's not only based in the scientific community, but also enthusiastically supported by that same community. This is our opportunity to give back . . . In that spirit, our Big Bang family has made a meaningful contribution, and together we'll share in the support of these scholars, scientists and leaders (Hampton, 2015, para.7).

In the realm of academia, *The Big Bang Theory* has attracted many researchers' attention, with the vast majority of the academic scholarship focusing on areas of linguistics and language (e.g., Groenen, 2011; Yin & Yun, 2012; Hu, 2012, 2013; Balirano, 2013; Ma & Jiang, 2013; Mahdalíková, 2014; Wilkes, 2014), cultural and social studies (e.g., Walters, 2013; Stratton, 2015), and stereotypes (e.g., Winston, 2014; Viscuso, 2015), with some specifically on the nerd stereotype (e.g., Cardiel, 2012; Cooper, 2014). Only

a handful of the academic scholarship has focused on the science, such as the science presentation/content (Davis et al., 2011; Hawick, 2011), or a content analysis of the characters as scientists (McIntosh, 2014; Weitekamp, 2015). However, one may argue that the nerd stereotype is a common scientist stereotype (see Chapter 4 for detailed discussion), therefore there is a lot of research interest in the portrayal of the characters being scientists.

Of particular note, in June 2015 a book called *The Science of TV's The Big Bang Theory: Explanations Even Penny Would Understand*, written by Dave Zobel, was published, and specifically discussed the science in *The Big Bang Theory*. Zobel argued that the characters on the show "never really explain the science and that's appropriate because it's a sitcom. It's not a TV show that is purporting to teach you anything. It's just trying to give you a good time" (C. Smith & Zobel, 2015, para.2). However, the science in the show stimulated him to "write a little book explaining some of those science references [... For example] what does it mean to use a laser. [Or] when [the character] talks about his noise cancelling headphones [...] how do noise cancelling headphones work?" (C. Smith & Zobel, 2015, para.2).

Even though this book pinpoints the science in the show for the purpose of discussing the science in more depth, it does not explore how the audiences of *The Big Bang Theory* perceive the science content. This was the same for much of the academic scholarship on the science and scientists of *The Big Bang Theory*. Therefore, the purpose of this study is to fill this gap by collecting human participant data in order to understand how audiences feel about the science and scientists in the show. These data will also address *Inspiring Australia*'s expert working group implementation plan, potentially contributing to pre-pilot studies by providing insight into how audiences see the show's science content, as well as how important the science content is to their enjoyment. In summary, the research question I will be answering in the thesis is:

Research Question: How does *The Big Bang Theory* influence its audiences' perceptions of and attitudes toward science and scientists?

Since there are many aspects of this question I wish to investigate in this thesis, I have divided this research question into four sub-questions. Each of my four substantive

chapters will address one of these sub-questions:

Sub-question 1: How has *The Big Bang Theory* influenced people's attitudes to science, information seeking behaviours related to science, and science knowledge?

Sub-question 2: How has *The Big Bang Theory* shaped peoples' ideas about who scientists are and what they do?

Sub-question 3: What do people think and feel about the presentation of female scientists in *The Big Bang Theory*?

Sub-question 4: How important is the science content in *The Big Bang Theory* to people's enjoyment of the program?

Data collected in focus groups were used to answer these sub-questions. The focus group participants included fans and regular viewers of *The Big Bang Theory.* These participants had different backgrounds, including age, gender, professional occupation and level of science education. Some of the demographic details proved important for understanding how the science and scientists in *The Big Bang Theory* affected people's perceptions and attitudes with respect to their various backgrounds.

In this thesis, I will first present a detailed summary of my method of data collection (Chapter 2). I then present my four substantive chapters, which comprise the main body of the thesis. Each of the substantive chapters incorporates its own literature review, results and discussion. Chapter 3 focuses on what the participants thought about the science information presented in *The Big Bang Theory* and whether they absorbed any science-related information from the show. Chapters 4 and 5 explore the participants' responses in regard to the main male and female scientist characters, respectively. In these two chapters, participants discussed scientist stereotypes, and how *The Big Bang Theory* reinforced or disputed these images. Chapter 6 reports on the factors that contribute to the participants' enjoyment, and the importance of enjoyment in determining whether people will watch the show. In Chapter 7, I draw on the four substantive chapters to give an overall conclusion for the thesis, and I address the implications of the data in light of *Inspiring Australia* and the wider science communication realm. I also discuss the limitations of this study, and offer some recommendations for future research.

Chapter 2

Methods

Since the aim of this study was to explore people's perceptions of the science and scientists in *The Big Bang Theory*, focus groups were chosen as the data collection method because they "actively encourage the examination of these social processes in action" (Kitzinger, 1994, p.117). Focus groups also involve "some kind of collective activity ... [they] are distinguished from the broader category of group interviews by 'the explicit use of the group interaction' as research data" (Kitzinger, 1994, p.103). This could not be achieved through individual or group interviews or using questionnaires. Although focus groups can include some qualities of open-ended interviews while also speeding up the sampling from one-to-one interviews, Lunt and Livingstone (1996) noted that:

> rather than regarding the group context of focus group discussions as a convenient (or contaminated) source of individual opinion, [...] the group context may itself be significant to the theoretical framework of the research (Lunt & Livingstone, 1996, p.85).

Focus groups encourage discussion, trigger memories and explore ideas that can only be reached through day to day conversations. This is especially important for finding out what people know, since:

> everyday forms of communication such as anecdotes, jokes or loose word association may tell us *as much*, if not *more*, about what people 'know'. In this sense focus groups 'reach the parts that other methods cannot reach' – revealing dimensions of understanding that often remain untapped by the more conventional one-to-one interview or questionnaire (Kitzinger, 1994, p.109; original emphasis).

This is especially true in communication studies where:

> the focus group emphasizes the social nature of communication and does not reduce social scientific research to the study of the individual, an important consideration in the context of media research, where mechanical conceptions of media effects are giving way to more social, semiotic, and diffusion-based conceptions of media processes (Lunt & Livingstone, 1996, p.90).

The social nature of focus groups was useful in this study because it allowed the participants to build ideas based on each others' responses as well as encourage each other to share their own experiences, thus providing insight into the reasons behind the participants' comments. Triggering memories was particularly important since I did not include screenings of any particular episode from the show. The purpose was not to discuss a specific science topic, but rather to discuss the overall presentation of science and scientists in *The Big Bang Theory*. Therefore, participants only had their memories from the show for discussion, which provided insight into what sort of situations were most memorable to them. This also allowed fellow participants to "ponder, reflect and listen to experiences and opinions of others. The interaction helps participants compare their own personal realities to those of others" (Krueger & Casey, 2009, p.12).

Focus groups also provide opportunities for the participants to interact with people who may hold different opinions. When these differences in a focus group surface, the 'argumentative interaction' takes place even if the focus group seems homogeneous (Kitzinger, 1994). This could not be achieved using questionnaires or individual interviews since:

> in both questionnaires and in individual interviews it is easy to assume that someone is giving the 'right' answer for the right reason. However, diversity within a group ensures that people are forced to explain the reasoning behind their thinking just as much when they give the 'right' answer as when they give the wrong one (Kitzinger, 1994, p.113).

In addition, focus groups have the potential to generate information that may cause a participant to change their point of view due to personal experience (Kitzinger, 1994). Therefore, a "focus group presents a more natural environment than that of an individual interview because participants are influencing and influenced by others" (Krueger & Casey, 2009, p.7).

2.1 Recruitment

After I was granted ethics approval[1], I started recruiting potential participants through various methods. Flyers were posted around the university campus as well as displayed at the tea room in the local science centre, Questacon – Australia's National Science and Technology Centre. The flyers stated that participants must have seen at least 50% of the episodes for seasons 1-4, and that an incentive in the form of a movie voucher would be given at the end of the session. Short presentations about the study were given at the beginning of two undergraduate science classes to recruit participants during the second month of the recruitment period. E-mails were sent to the administrators of eight physics research departments in the university and were circulated among their staff and research students. However, the most effective recruitment method was through the word of mouth from earlier participants in the study and their friends and family. The recruitment period began in the middle of September 2011 and ended in early May 2012.

Potential participants had to satisfy two requirements: (1) to be at least 18 years of age, and (2) to have seen at least 50% of the first four seasons of *The Big Bang Theory*. The reason for the latter constraint was due to the show being in the middle of production of its fifth season, thus I focused on seasons 1-4 because these were the only seasons available in their entirety at the time I commenced my recruitment process. In addition, this requirement was important because it was necessary for the participants to know the plot of the show and any changes in the representations of science through the seasons. In order to compare and contrast the way different people spoke about an issue when they had different levels of knowledge and backgrounds, participants were separated into specific categories (Krueger & Casey, 2009, p.21).

Due to the kind of questions asked, participants were allocated to groups depending on whether they had a science background (e.g., do they have a degree in science?), as well as their current occupation (e.g., are they studying? Are they working in a science-related field?). It was important to categorise the participants accordingly "instead of generalising about the effect of 'groups' [because] we need to pay close attention to the *composition* of

[1]Human Ethics Protocol: 2011/177. Approval date: 09/09/2011.

groups and how the characteristics of any *particular* group may influence what is said" (Kitzinger, 1994, p.112-113; original emphasis).

I controlled for possible effects of these backgrounds – science background and current occupation – since I anticipated they would have a major impact on the answers and discussions. In addition, similarities between focus group participants have the potential to engage shy participants in the discussions, allowing them to share ideas and opinions that they may be uncomfortable to talk about until another participant 'breaks the ice' (Kitzinger, 1994). Power differentials among the participants, such as the level of science understanding or university hierarchies, may cause some individuals to feel reluctant to participate in discussions. For example, non-scientists who work in the public sector may have different opinions to long-time practising scientists, thus may have been reluctant or even intimidated to voice their ideas about questions like whether they felt the scientist characters' representation in *The Big Bang Theory* accurately reflected their pre-conceived images. Similarly, if an undergraduate science student was placed in the same group with their tutor or lecturer, they may have felt shy or even pressured when asked if they've come to know of any scientific theory or concepts from the show. To overcome these issues, organising focus groups according to academic background and current occupation was important to encourage discussion and engagement, especially since:

> not only do co-participants help each other to overcome embarrassment but they can also provide mutual support in expressing feelings which are common to their group but which they might consider deviant from mainstream culture (or the assumed culture of the researcher) (Kitzinger, 1994, p.111).

2.2 Focus Groups

Participant distribution

I identified six categories of focus groups to distribute my participants according to their academic background and current occupation. The six categories were: science background undergraduates, science background postgraduates and academics, science background non-academic occupations, non-science undergraduates, non-science postgraduates and

academics, non-science non-academic occupations. The distinction of science and non-science relates to their university studies and the nature of their jobs. For example, an undergraduate biology student would be placed into a group of science undergraduate students, and a law professor would be allocated to the non-science postgraduates and academics group. In cases where an undergraduate student was undertaking a double degree, they were divided into a science group if one of their degrees was in science.

As for the non-academic occupation participants, their academic history and the nature of their jobs determined whether they would be placed in the science group or non-science group. It was more difficult to definitively allocate these participants as sometimes their academic history and the nature of their jobs crossed over the boundaries of the science/non-science line. In this case, a decision was made based on the match between the participant's academic background and occupation. For instance, one participant with a chemistry degree who now works in the public sector as an IT consultant was placed in the non-science group because he is not using his degree for his current occupation. Similarly, another participant who has a nursing background but works at Questacon as an administrator was not considered for the science group because her job is not related to communicating science even though her working environment is in a science centre. In contrast, one participant with degrees in science teaching and science education who is also currently working as an international advisor for a national science and research agency was considered for a science group because she is using her training in the same field. Appendix B shows the list of research participants, their academic background, current occupation and the type of group they attended. Appendix C provides further demographic descriptions together with a list of the sources the participants frequently used to gather science information.

A final number of 18 focus groups were conducted before saturation was reached in all categories, with a total of 74 participants. Of the 74 participants, 35 were men and 39 were women. The participants' age ranged from 17-59. However, since one of the pre-requisites for this study was that the participant must be 18 years old, the responses

from the participant who is 17 years old were not used for this study.[2] This meant the final number of participants was 73, with a gender distribution of 35 men and 38 women.

It is important to mention here the way I labelled the participants' responses in the following chapters. I used abbreviations to distinguish participants based on their demographic backgrounds, specifically their gender, age, academic background and current occupation. For example, a female participant who is 22 years old from a science non-academic group will be written as F22SNA. The purpose of using the demographic backgrounds to form the abbreviations was for the ease of identifying demographic trends. However, age was not often used as part of the discussions, rather it is used to better distinguish the responses between individual participants.

The participants who expressed their interest in participating in the study typically came from science backgrounds. The number of participants per focus group in my study varied from two to nine with the majority around four to five people. This was consistent with what Krueger and Casey (2009) stated as the optimal number of participants per focus group, but conflicted with other researchers who stated the optimal number is around six to ten (e.g., Lunt & Livingstone, 1996; Barbour, 2007). Nonetheless, I found that the ideal number of participants for a focus group in this study was four to five since the participants demonstrated enthusiasm and eagerness to express their opinions in discussions. This meant in a time limited two hour focus group, smaller numbers of participants allowed for each participant to express their thoughts and opinions wholly and effectively. This is consistent with the view of Krueger and Casey, who wrote that "smaller groups are preferable when the participants have a great deal to share about the topic or have had intense or lengthy experiences with the topic of discussion" (Krueger & Casey, 2009, p.67). In addition, the smaller focus groups would provide the participants who were either shy or afraid to speak a chance to contribute to the conversation. However, Krueger and Casey

[2]The inclusion of the 17-year-old participant was an oversight during the recruitment period. The two requirements for this study were clearly stated on the recruitment flyers. The participant did not raise the fact that she was 17 years old at any point during the recruitment period or during the focus group, and although the participants were required to fill in a demographic form upon arrival for the focus group session, the age of the participants were not checked prior to the focus group running. This issue was noticed later during the data analysis stage when extracting participants' responses. To overcome this issue, I chose to disregard the responses made by the 17-year-old participant while still using the responses from the other group member.

noted a few limitations, specifying that:

> small groups of four or five participants afford more opportunity to share ideas ... [but] the restricted size also results in a smaller pool of total ideas. These smaller groups ... have a distinct advantage in logistics ... [but] the quality of the discussion is greatly affected by the group size (Krueger & Casey, 2009, p.6-7).

This issue was evident in the focus groups consisting two to three participants. In order to overcome this problem, multiple focus groups were conducted until saturation was reached. Table 2.1 shows the total number of participants divided into categories according to academic background and current occupation.

Table 2.1: Distribution of participants (and group in brackets): Academic backgrounds and current occupation

	Science	Non-Science
Undergraduates	8 (3)	10 (2)
Postgraduates and academics	22 (4)	-
Non-academic occupation	10 (3)	24 (6)

Theoretically, three or four focus groups per each category would be ideal to determine whether data saturation has been reached (Krueger & Casey, 2009, p.21). This meant the total number of focus groups should be approximately 18 to 24 based on six categories, with an even distribution of number of focus groups in each category. However, theory does not always work in real life. Even though I conducted a total of 18 focus groups, these groups were not evenly distributed into the six categories. The lack of non-science postgraduates and academics may be due to the flyers specifying that the focus groups would be discussing the science and scientists in the show, and thus may have deterred some potential participants despite the fact the flyers were placed around common areas in the university like the food court. Furthermore, e-mails were not sent to non-science departments. Although there were three non-science postgraduates who expressed their interest in participating in this study, it was not possible to hold a focus group due to conflicting availabilities. However, future studies can potentially fill in this gap, perhaps with modified recruitment methods.

Pilot study

Before the formal data collection began, an initial pilot study was conducted to observe the flow of the focus group protocol and whether adjustments needed to be made (Krueger & Casey, 2009). The participants for the pilot study were second year science communication undergraduate students. This opportunity was offered by the chair of my supervisory panel who was the lecturer for the science communication course, and the pilot study was conducted during a two hour lecture slot. Since the estimated run time of the focus group was one and a half hours, the two hour lecture slot would have been sufficient. After the pilot study was completed, the initial run time of the focus group was changed from a straight one and a half hour session to a run time of two hours. I divided the time into two main sections of discussion with a 15-20 minute break in between. Questions were also rewritten to avoid misinterpretation by the participants, and will be discussed below.

Incentives

It is important to show appreciation for each participant's investment of time and effort, thus incentives were used in the focus groups (Barbour, 2007; Krueger & Casey, 2009). Refreshments were catered by a café located on the university campus, and were placed on a separate table and enjoyed before the focus group began as well as during the break. A movie voucher was also given to each participant upon the completion of the focus group.

2.3 Questions

I grouped the focus group questions into four main areas of discussion: general interest in science and in *The Big Bang Theory*, the science in *The Big Bang Theory*, cameo appearances, and the scientists in *The Big Bang Theory*. Within the four main areas, more detailed questions were written to pinpoint specific ideas but remained open-ended in order to explore the ideas behind the participants' answers (Krueger & Casey, 2009). The focus group questions script is presented in Appendix D. The first set of main questions explored the reasons behind participants' enjoyment of the show and what kind of sources they usually go to for their science information. The questions in this section were designed to be general in order to ease the participants into a discussion setting and "start thinking about their connection with the topic" (Krueger & Casey, 2009,

p.39). This led onto a section about their impressions of the science in *The Big Bang Theory* and whether their attitudes toward science were influenced in any way by the show.

It must be noted here that the word 'science' was used loosely in order to understand how the audiences interpreted science. In other words, I left the participants to help define what science is. This alluded to the different understandings and interpretations of science that the audiences held, as well as which aspects of the science in *The Big Bang Theory* they absorbed. The result was an identification of multiple definitions of science, including science facts, science knowledge, science methods, science experiments, everyday science and science culture. Throughout the thesis, I will use the term 'science information' or 'science content' as generalised terms that encompass all of these aspects of science that the participants have discussed.

After the first two sections were completed, we had a 15-20 minute break where the participants were encouraged to help themselves to the refreshments and have casual conversations with one another. A questionnaire and six photos of people who appeared as scientists in the show were placed on the table, some of whom made cameo appearances. The photos were of George Smoot (Nobel laureate), Neil deGrasse Tyson (astrophysicist/science communicator), Judy Greer (actress who played Elizabeth Plimpton), Mayim Bialik (actress who plays Amy but also a neuroscientist), Brian Greene (physicist) and Michael Trucco (actor who played David Underhill). This activity required the participants to identify who these people were, when they appeared in *The Big Bang Theory*, which were scientists in real life, and the reasons behind their choices. The purpose of this exercise was to help the participants return to a focus group setting by engaging with each other (Kitzinger, 1994) and get into the mindset for the next section of questions on scientists.

After the participants filled out the questionnaires, the group worked together to identify the cameo appearances in *The Big Bang Theory* and discussed the reasons behind their answers. This discussion was used as an introduction for the following section which discussed the portrayal of scientists, different stereotypes and the gender of scientists. This section shed light on the different ideas of stereotypes the participants held relative

to their occupational backgrounds and personal experiences with scientists, as well as whether the characters on the show had any impact on their pre-conceived images of scientists.

Specific to the questions focusing on the gender of the scientists, the purpose of these questions was to understand what the audiences thought about the portrayal of the female scientists in *The Big Bang Theory*. Ideally, the responses from the male and female participants would have been used to identify any differences in opinion between the two genders, and this was the original intention for analysing these responses. However, this was not possible in many instances due to the similarities between the participants' comments irrespective of their gender. Nonetheless, when an analysis based on gender was possible, it was included as part of the discussion.

2.4 Recording and transcribing

Two devices were used to record focus group discussions, an audio recorder and a video recorder. Even though researchers tend to avoid using video recorders due to concerns of atmosphere obstruction and logistical difficulties (Barbour, 2007; Krueger & Casey, 2009), it was used as a backup in case the audio recorder failed.

The audio recording was loaded into transcribing software called ExpressScribe which allowed control of the playback of the recording via a foot pedal while transcribing. The video was mainly used to check the transcript after it was completed since it recorded a different set of acoustics making the words or sentences sound different, sometimes clearer, from those heard in the audio recording. The video was also used to identify each participant and showed who was talking. This was especially important when there were participants who sounded very similar. Multiple copies of the recordings and transcripts were made and stored in different locations to prevent loss of data.

It is important to note here that since I did not restrict the potential participants to a particular ethnic background, I had participants who came from countries where English was not their first language. As a result, around 13 participants did not speak in

a fluent manner or use correct grammar. Even though this did not influence transcribing the focus groups in any significant way, it was difficult to quote their responses verbatim in the following substantive chapters (Barbour, 2007, p.100). As a result, I wish to clarify here that a number of these responses will have inserted square brackets to convey their meanings as closely as possible.

2.5 Analysing the data

I was inspired to use grounded theory as one of the methodological tools for this study since it complements focus groups. As Birks and Mills noted, focus groups generate "different perspectives and a broad range of experiences ... making them valuable for category development in grounded theory" (Birks & Mills, 2011, p.76). Grounded theory allows themes to emerge from the data, thus the concluding remarks can be built from the participants' perspectives and experiences (Birks & Mills, 2011). The reason why grounded theory was only used as an inspiration was due to the nature of this study. Even though grounded theory is beneficial for research that explores "areas where little is known about a particular topic" (Birks & Mills, 2011, p.16-17), the purpose of this study was not to generate a 'theory' to explain the results. Rather, the purpose was to explore the participants' perceptions of science and scientists, and whether these perceptions have changed after watching *The Big Bang Theory*. Therefore, only certain steps in grounded theory were used to assist in building codes and categories from the participant responses. I used the 'classic analysis' method noted by Krueger and Casey (2009) as the main method of analysis since it is commonly used for analysing focus groups. It is a manual 'cut and paste' method that identifies codes and categories through the grouping of similar ideas. This is the essence of grounded theory, where it breaks down the data into codes, and then reconfigures the codes to produce categories.

The steps where I used grounded theory were during the *initial coding*, *intermediate coding* and *identifying core categories* stages (Birks & Mills, 2011). As part of the classic analysis method, I performed *initial coding* by systematically analysing the focus group transcripts and extracting participant responses to ensure that all the relevant responses were acknowledged. In this process, the extracted participant responses were written

on coloured post-it notes so that it was easier to reorganise and reshuffle the responses to explore different running themes and potential categories later. Different colours were used for each focus group category for ease of identification between them. The extracted responses were then grouped together with like responses and given a code that represented the essence of the ideas. *Intermediate coding* was used to identify patterns and relationships between these codes produced during initial coding. With each relevant response written on a post-it note, it was easy to reshuffle and reorganise when looking for emergent themes and categories. In addition, by separating the individual focus groups on coloured post-it notes, it was easy to distinguish the number of responses made by participants from specific focus group categories, making it quicker to identify demographic trends and patterns. The responses on the post-it notes were then cross-referenced with the original quotes in the focus group transcripts to double check the exact context of the response and whether it was part of a conversation. The participant responses were then included in the substantive chapters as evidence. The process of extracting the original responses from the transcripts allowed for the codes and categories to be grounded in the data. *Core categories* were identified after intermediate coding when the analysis reached saturation. Since this study began with a main research question and predetermined sub-questions that made the substantive chapters, the core categories that were identified were written into the sections that went under the relevant thesis chapters.

The steps from grounded theory that were omitted were *concurrent data generation*, *theoretical sampling* and *advance coding and theoretical integration* (Birks & Mills, 2011). In *concurrent data generation*, the "researcher generates or collects some data with an initially purposive sample" (Birks & Mills, 2011, p.10), which is then analysed and coded before collecting more data. This step was omitted because I had pre-written focus group questions that I asked in every focus group in order to maintain consistency. As noted before, a pilot study was conducted before formal data collection began, and as a result, I used the feedback from the pilot study to modify the focus group questions accordingly. This could be considered as a one-off concurrent data generation, but I did not use the pilot study responses in this research since the purpose of the pilot study was not to generate data. *Theoretical sampling* refers to the continuous process of data collection through strategic decisions and planning in order to learn more about a code or category

from a particular group of participants. This was not possible for my study because it focused on analysing specific seasons of *The Big Bang Theory*, and there would be a high chance of data contamination if the audiences were to watch more episodes from the later seasons of the show. This was already evident in the later focus groups where participants often quoted episodes in season 5 as examples, or used these episodes as comparisons to the first four seasons. However, it must be noted here that when this occurred, I did not stop conversations since the references from season 5 demonstrated how the participants were eager to follow the newest episodes every week, as well as how they interpreted the most up-to-date science information. *Advanced coding and theoretical integration* was omitted because the purpose of this study was not to generate a theory from the data. Rather, the purpose was to generate data to answer the research question based on the responses from focus group participants.

Chapter 3

Presentation of science content

This chapter examines *The Big Bang Theory*'s effectiveness for communicating science, and discusses what the show can achieve in terms of engaging the audiences with science in general. Firstly, I discuss how the participants expressed their views of science in the show and whether their original attitudes toward science had been affected in any way after watching *The Big Bang Theory*. This is followed by a discussion about how the participants often compared the benefits and disadvantages of *The Big Bang Theory* as a science information source to those of documentaries, describing the differences in their communication styles and what an entertainment television show like *The Big Bang Theory* can potentially achieve that documentaries cannot. I then discuss whether the participants were stimulated to seek further information based on the science they encountered in the show. Lastly, I discuss whether they had learnt anything about the field of science from watching *The Big Bang Theory*. The question this chapter attempts to answer then becomes:

> How has *The Big Bang Theory* influenced people's attitudes to science, information seeking behaviours related to science, and science knowledge?

3.1 Previous studies on public engagement with science-themed fiction

Understanding how science-themed fiction has influenced the public's perceptions of and attitudes toward science in the past may reveal how *The Big Bang Theory* can potentially affect its audiences. This literature overview is essential since various researchers have shown that scientists and policy-makers have often asserted the media is a major hindrance to the public's science literacy skills (e.g., Hartz & Chappell, 1997; Nisbet et

al., 2002; National Science Board, 2006; Hughes, Kitzinger, & Murdock, 2008; Coyle, Chekar, & Kitzinger, 2008; Kitzinger, 2010). In the following I will argue that my data demonstrate that this is not the case, and that science-themed fiction can potentially have a positive influence on the public. I believe the results from my focus groups highlight the benefits of science-themed fiction on influencing audiences' perceptions of science.

The 2008 UK study conducted by Hughes and colleagues indicated that scientists and policy-makers criticised news media and journalists as well as science-themed fiction as major hindrances to viewers' science literacy:

> Typical criticisms focused on the shortage of space and time in the news media to explore the full complexity of issue[s], the problems of dystopian science fiction dramatisations of risk, and how some reporting by journalists without the appropriate training could be inaccurate and over-simplistic. Interviewees [scientists and policy-makers] were concerned with the media's tendency to present a 'black and white' contrast and ignore nuanced debate. They also criticised the media's penchant for dramatic headlines and images (Hughes et al., 2008, p.5).

However, Hughes and colleagues noted that scientists and policy-makers in different science areas had different assessments of how positive the media coverage of their area was. For example, scientists whose work related to genetic modification were extremely critical of the media, whereas stem cell scientists had a more positive view but were still concerned that the media portrayed misleading information (Hughes et al., 2008). More specifically, the stakeholders that Hughes and colleagues interviewed felt strongly concerned that "fiction, especially science fiction, contributed to the public fear of, and resistance to, scientific and technological innovation" (Hughes et al., 2008, p.24).

However, when analysing their focus group results consisting of participants who were among the general public, Hughes and colleagues found the way the participants used fiction was not how the stakeholders assumed they would. Rather, the focus group participants were less fearful of science after watching science fiction than the stakeholders expected, which was demonstrated when they used facts based on historical disasters and

news reporting rather than fictional story lines when expressing their concerns about the future of science and technology (Hughes et al., 2008). In addition, the participants did not consider the information in science fiction as fact, but rather used it with "humour, and irony as well as conviction" (Hughes et al., 2008, p.25). The only exception where the participants followed the scientists and policy-makers' assumptions was in one focus group (out of a total of 20 focus groups) (Kitzinger & Hughes, 2008). This particular focus group was different because they had not heard of the science topic before, thus could only refer back to fictional material rather than recalling information attained from non-fictional sources. In contrast, the other 19 focus groups did not follow the scientists and policy-makers' assumptions. In these focus groups, the participants would use fiction in different ways but always maintained a critical assessment (Kitzinger & Hughes, 2008).

Similar situations were happening in the US with scientists and policy-makers particularly targeting science fiction as a source that corrodes science literacy skills. Scholars like Kirby (2008) noted that the National Science Foundation specifically stated in their report *Science and Engineering Indicators 2006* (Chapter 7) that:

> Television and other media sometimes miscommunicate science to the public by failing to distinguish between fantasy and reality and by failing to cite scientific evidence when it is needed (National Science Board, 2006, p.3).

In the *Science and Engineering Indicators 2006* report, it was noted that even though television programs may spark public interest in fields such as forensic science through shows like *CSI*, and consequently motivate students to pursue a degree in forensic science, "entertainment television can also distort or mischaracterize science" (National Science Board, 2006, p.9).

However, in the most recent version of the report – *Science and Engineering Indicators 2014* – there is relatively little written about this problem of fictional entertainment television shows having a negative impact on science literacy. Rather, it only has a small paragraph which mentions entertainment television, and only states that entertainment media "can also shape views" (National Science Board, 2014, p.14). This version of the report is far less critical about the impact of entertainment television shows. It is unclear

why in the 2014 version the idea of fictional media having a corrosive influence on science literacy has been dropped. A reason may be that each version of the *Science and Engineering Indicators* reports are produced by different authors, and the views of these authors affect the amount of focus each report will devote to this issue. On the other hand, another reason may be that more research has been done in this area between 2006 and 2014. As Kirby noted, there was a lack of research in this area of science and cinema, or science and entertainment media in general, before the year 2000 because of the common belief among scientists that the public would conform to the deficit model, and:

> under the deficit model, movies are at best an unreliable means of increasing knowledge, and at worst a medium that significantly harms science literacy by disseminating misinformation (Kirby, 2008, p.41).

Therefore, in the 2006 version of the *Science and Engineering Indicators* report, there was presumably little research to call upon when trying to understand how the public interacts with the entertainment media and the affects associated with it. By the 2014 version, there was more research conducted in this area (e.g., Hughes et al., 2008; Kitzinger & Hughes, 2008), and it had found evidence that challenged the presumption that the public follows the deficit model.

Kitzinger (2010) summarised that these 'science fiction-induced fears' the scientists and policy-makers deemed as corroding the public's science literacy skills are unfounded, and listed four reasons where science fiction-induced fears are flawed. The first reason was what she called 'commonsense assumptions', where people are expected to use science fiction in predictably negative and selective ways, such as using hybrid words like 'Frankenscience' to make 'sensational tabloid headlines'. Kitzinger argued that "the problem with this [commonsense] assumption is that it ignores the fact that many evocations of science fiction scenarios are either metaphorical or are actually used in a dismissive way" (Kitzinger, 2010, p.77).

The second reason discussed how scientists and policy-makers tend to follow the deficit model when they make predictions about the way people use science fiction. Kitzinger disputed that "research which actually examines audience reactions shows that

stereotypes of the audience as passive are often not supported by empirical enquiry" (Kitzinger, 2010, p.79) and the research papers that were often used as supporting evidence of the negative impact on the public were few and used selectively.

Thirdly, scientists and policy-makers often focus on the negative impact of science fiction rather than the 'science fiction hopes' that may be used to the science community's advantage, such as popularising and promoting science which may influence funding priorities (Kitzinger, 2010). Lastly, Kitzinger discussed the 'boundaries between facts and fiction', where scientists and policy-makers are concerned about the public's confusion over what is scientifically possible and what is not. However, what Kitzinger noted was that positive stories about science's possibilities were often used by these scientists and policy-makers themselves to induce the public's excitement in science so it may help them progress further with their research, and that:

> the rhetoric of 'science fiction fears' as mobilised by those trying to promote scientific progress is sometimes used to dismiss fears as irrelevant and to avoid engaging with either the substance of those fears (e.g. what if reproductive cloning did become a possibility?) or their context (e.g. who controls the technology?) (Kitzinger, 2010, p.82).

Therefore, Kitzinger argued that the way scientists and policy-makers use positive stories and disregard the public's fear of science is a contributing factor to the confusion of the boundaries between facts and fiction itself. It may be disputed that scientists and policy-makers must produce positive stories about science in order to counterbalance the public's fear of science created by science fiction. However, judging by the arguments Kitzinger (2010) presented in the first three observations, there is little evidence to support that the public actually hold science fiction-induced fears.

The contrast between the scientists and policy-makers' assumptions and how the public actually interprets the science in fiction demonstrated that people engage with the science they encounter in fiction critically. This suggests that if the media was to strengthen its' role in communicating science, which is an aim in *Inspiring Australia*, then the public would engage with the science in a critical manner. This was demonstrated

through *The Big Bang Theory*, where some the fans critically engaged with the science presented in the show in positive ways, such as 'fact-checking' by repeating an experiment on the show (Davis et al., 2011) or calculating the distance the Earth has moved in the duration of a five second kiss (Hewitt, 2009). Other research and anecdotal evidence based on fiction also demonstrate how fictional television shows and movies can affect viewers in positive ways.

Many studies and anecdotal evidence about the relationship between fiction and public engagement with science have specifically focused on science disciplines rather than interest in science in general. In particular, much of the research has looked at the attitudinal and behavioural changes regarding biological or environmental matters (Elkamel, 1995; Brodie et al., 2001; Lowe et al., 2006; Czarny, Faden, Nolan, Bodensiek, & Sugarman, 2008), rather than more purely interest in science. More specifically, the streams of biological science that have been researched mainly relate to medical science and forensic science. Studies have investigated medical science topics ranging from sexual health (HIV/AIDS) (Do & Kincaid, 2006; Rideout, 2008) to cancer (Howe, Owen-Smith, & Richardson, 2002), as well as aspects like medical ethics (Weaver & Wilson, 2011), cloning (Kitzinger & Hughes, 2008; Donkers & Orthia, 2014) and various kinds of genetic-related research (Mulkay, 1996; Bates, 2005; Besley & Shanahan, 2005; Kitzinger & Hughes, 2008). As for forensic science, many studies and some anecdotal evidence have focused on more specific areas like the concept of the 'CSI effect' and its effects on different audiences (Shelton, Kim, & Barak, 2006; Schweitzer & Saks, 2007; Brewer & Ley, 2010; Weaver, Salamonson, Koch, & Porter, 2012), and also on forensic television shows' popularity affecting university enrolments (BBC News, 2003; Houck, 2006; Hannis & Welsh, 2009; Samarji, 2013).

Another area of studies and anecdotal evidence has investigated the effect of film and television on attitudes towards environmental issues, such as climate change (Leiserowitz, 2004; Lowe et al., 2006; Howell, 2011), but has also included space science and meteorology (Robertson, 1999; Mellor, 2007), and the future of science and technology, such as nanotechonology's effects on society (Bainbridge, 2002; Berne & Schummer, 2005; Kitzinger & Hughes, 2008).

Together these bodies of literature demonstrate that fiction influences people's attitudes toward different science-related matters in different ways and to varying degrees. For example, health messages in fictional medical science shows can have a strong impact on people's knowledge and behaviour, and stimulated some audiences to do further research or visit a clinic. In the case for environmental issues, people became more concerned about climate change after watching climate disaster-themed fictional sources, and some people were motivated to do something about it, such as changing individual behaviour or raising awareness among friends and family. However, in some of these studies which included a 'follow-up' data collection process, some people were observed to revert back to their original behaviour or have forgotten the information they learnt while watching the television show or movie (e.g., Lowe et al., 2006; Rideout, 2008; Howell, 2011).

Even though it would appear that fiction has a positive influence on public engagement with science, there is still a difference between a science that directly affects people (e.g., medical science and environmental science) and a science that people feel is quite detached from ordinary life (e.g., physical sciences). As a result, not many studies have been done on how viewers' attitudes and behaviours have changed after interacting with fictional depictions of topics like physics and engineering. The body of literature that does investigate how people feel towards these less discussed science topics has mainly been in formal education studies where fiction has been used in the classroom as a teaching source for the students.

Fiction is increasingly being used in classrooms to teach diverse aspects of science. In comparison to some traditional forms of classroom teaching, fiction can make science accessible and engaging for students (Dark, 2005; Efthimiou & Llewellyn, 2006; Laprise & Winrich, 2010; Milanick & Prewitt, 2013), and it can help develop critical-thinking skills (Barnett & Kafka, 2007; Knippels, Severiens, & Klop, 2009; D. Smith, 2009). Fiction also presents visually plausible case studies for exploring science-related questions (Fraknoi, 2003) like 'science in society' concepts such as science ethics, because by its nature it puts science in a social context, via characters, settings, plots, emotions, decisions and arguments (Rose, 2003; Brake & Thornton, 2003; Berne & Schummer, 2005; Segall, 2007). Other researchers have reported successful applications of fiction for teaching science

disciplines other than physics, including engineering, biology, chemistry, psychology and earth science (Rose, 2003; Eaton & Uskul, 2004; Liberko, 2004; Barnett et al., 2006; Segall, 2007). A number of books have also been published on the subject (Cavanaugh & Cavanaugh, 2004; Raham, 2004), including the seminal text by Dubeck, Bruce, Schmucker, Moshier, and Boss (1990). On the basis of such success stories, some research papers have provided lists of fictional material for teaching aspects of science (Fraknoi, 2003; Bixler, 2007; Frey, Mikasen, & Griep, 2012; Hirt, Wong, Erichsen, & White, 2013).

All of this suggests that the critical and strategic use of fiction texts in the classroom can have a number of pedagogical benefits. However, it must be noted that in many of these cases, the teachers were using snippets from films for specific purposes. These snippets of science are not educational by themselves, rather the teachers were *inspired* to use them in class by making them an educational learning tool through modification, suggesting this sort of learning using fiction only happens in classrooms. It must be noted then, that in informal learning situations outside the classroom students may not learn from fiction in the same way, since they will choose what they want to watch. This is the same for general audiences when they choose to watch television shows. The fact that people tend to choose specific genres of television shows has been shown in various studies. For example, Steinke and colleagues found that "drama programs were favored by adolescent viewers, both boys and girls, over [children's] cartoon and educational programs" (Steinke, Applegate, Lapinski, Ryan, & Long, 2012, pp.189-190). Also, Hawkins and colleagues demonstrated that adult viewers, specifically undergraduate students, tend to devote more attention to sitcoms in comparison to drama or news when they watch television (Hawkins et al., 2005).

However, what is more important than understanding the different genres people tend to select is that they are unlikely to watch snippets of a television show or a movie. Rather, they will watch an episode of television show or a movie in its entirety. This means if the science is presented only in snippets in these fictional sources, it is uncertain how much of the science a person would retain, especially if the snippet was not modified for particular purposes (e.g., educational purpose for classroom uses). However, this does not mean that it is impossible for people to retain different aspects of science or change their attitudes towards science by watching fictional sources. As noted before, fiction

does not only include science concepts but also puts science in a social context, and this includes the potential of portraying how science works as a discipline, or what is considered to be the nature of science. As I will explain later in this chapter, a number of my participants reflected on having learnt things of this nature about science from *The Big Bang Theory*, so it is worth discussing what is meant by 'the nature of science' here.

The nature of science (NOS) is an important topic in the field of science education and has been subject to decades of research. Organisations such as the American Association for the Advancement of Science and the US National Research Council have both asserted, through various reform documents, the importance of NOS for producing scientifically literate citizens who can critically engage in science, technology and mathematics (American Association for the Advancement of Science, 1990, 1993; National Research Council, 1996). R. L. Bell, Lederman, and Abd-El-Khalick (2000) summarised the five aspects of NOS most scholars talk about that are relevant to science education as: scientific knowledge is (1) tentative, (2) empirically based, (3) subjective and theory-laden, (4) partly produced by imagination and creativity, and (5) socially and culturally embedded (R. L. Bell et al., 2000, p.564). In addition, Bell and colleagues included two other elements in this list, but more as afterthoughts: science is (6) reliant upon observation and inference, and (7) constructed around particular ways of relating theories and laws. Bell and colleagues (2000) also noted that all these elements are interrelated rather than standing alone, so are not mutually exclusive.

Even though fiction has been frequently employed in the education domain to teach science concepts to students and develop their scientific understanding, very little work has been done that specifically looked at the use of fiction to teach NOS. The small body of literature related to using fiction to teach NOS includes a paper by Koehler, Bloom, and Binns (2013), where they propose a coding system that could be used by classroom teachers to identify representations of NOS in fiction texts. A study by Dhingra (2003) explored how secondary school students understood NOS after they were shown clips from four science-related television programs distributed among different genres (news, documentary, fictional programming and magazine format). Outside the science education realm, there is a lack of research that investigate how general audiences of

fictional television shows or films observe and retain NOS-type knowledge. This thesis will present some data on this topic, contributing to the NOS literature.

In the following sections, I will use the results to argue that, in agreement with the work of Hughes and colleagues (2008), *The Big Bang Theory* doesn't impact people's perceptions of science or their level of scientific literacy in a linear (and predictability negative) fashion. Rather, audiences will engage with the science information presented on the show in a critical manner, even if they are in an informal viewing environment.

I will first discuss participants' own views on whether their perceptions of science had changed. I will then discuss the participants' responses to identify whether they thought *The Big Bang Theory* is a 'learning' source that could be used to teach science, or an 'inspirational' source used to stimulate the audiences' interests in science. This is followed by a discussion of whether participants were prompted to find out more about the science in *The Big Bang Theory* by looking at participants' self-reported behavioural responses. Finally, I will show that, despite participants' resistance to the idea of learning from the show, many of them actually had learned something about science from it – specifically, something about the nature of science (as opposed to a scientific fact). I will use these results in an attempt to argue that while, in agreement with the work of Kitzinger, Hughes and colleagues, *The Big Bang Theory* doesn't impact people's perceptions of science or their level of scientific literacy in a linear fashion, it does have the capacity to inspire interest in science and to enable people to learn things about NOS in spite of their belief that it does not.

3.2 Participants' attitudes towards science

The participants' responses regarding their views and attitudes toward science demonstrated that individual participants reflected on their own interest in and experience with science before expressing any changes in their original beliefs. A few of the participants who "don't consider science as important, especially things like physics ... [and] don't think it's necessary" (F22NSU) would express that their attitudes weren't changed since they still felt that physics is unnecessary. There were also many participants who reflected on

their experience with science and asserted that "I always enjoy science, [so] I don't think it really changed [my attitude] after I watched it" (F21SU), and "I love science and I still do. [The show] doesn't make me love it more, it just makes it interesting" (F20NSU). For these participants, their personal interest and experiences with science had a more dominant effect on their views on science, thus their views generally weren't affected by *The Big Bang Theory*. This was the same for participants who may not have an in depth personal experience themselves but have experienced aspects of science through another person, such as family members and friends.

> My mum did research on hand surgery so I think that for most of her life she was a medical researcher. It was her day job, so for me it was sort of a usual thing that people will talk about it. And because I was interested in [physics] myself, so I've read a lot of stuff and watched documentaries, and so [the show] didn't really change my perceptions that much. (M18SU)

> I have friends that are research scientists and stuff like that, and so I kind of knew them before I started watching *The Big Bang Theory*. I've been to their labs or offices and stuff like that, and seen what Sheldon has on his office wall with all the maths and only being able to recognise a couple of the symbols on there. So I've kind of seen that and knew that I didn't know a lot of science. And I guess it didn't really change [my attitude], it may be reinforced it a little [though]. (M32NSNA)

An explanation as to why people would have difficulty changing their attitudes towards science was raised by a science postgraduate group, and two conclusions were reached. One was in regard to the age of the viewer, since as a participant noted, "because we're all older we probably already have thoughts about what science is, so maybe [by asking] the same question to a younger age group then it might change their view of what science is" (F29SP). The other conclusion was in regard to the amount of time the participant has spent in science since, as one participant expressed, the people who have been in science longer will not change their attitudes because "we already have our concept about science" (M30SP). This latter conclusion was supported by science participants where they expressed that they had "worked in science all my life so [my attitude is] pretty

damn positive" (M59SNA), and so "a little show like [*The Big Bang Theory*] is not going to change anything really ... [it] just reinforces what I thought" (F33SP). However, it is interesting to note that even though these participants did not change their attitudes toward science *per se*, the notion that the show has reinforced the participants' beliefs and attitudes toward science is an important concept. The reinforcement of these beliefs suggest *The Big Bang Theory* still has an effect on the audiences even if it's not a change of negative attitude to positive attitude. Rather, the portrayal of science in the show supports these audiences' existing views of science and leads to an entrenchment in their beliefs.

In contrast, many participants felt that the science in *The Big Bang Theory* had affected their attitudes toward science, more specifically in the way the show made science entertaining, accessible and "look fun" (M28SNA). This was mainly compared to the participants' previous experiences, in which they felt science was often presented as too remote: "before watching *Big Bang* I just feel like science is kind of another part of the world, it has nothing much that directly relates to me" (F26NSNA). However, *The Big Bang Theory* presented science in a way that surprised the participants. They indicated "I didn't think I realised that science could be funny" (F34NSNA) or "made that accessible and enjoyable" (M25SP). Therefore, "it's definitely changed my view on how you can present science. It doesn't have to be dry, you can make it interesting [for] people that don't have that natural bent towards it" (F34SNA), and this has been shown through the popularity of the show where, as a science postgraduate expressed, "it certainly changed my perception of the *public*'s perception of science" (M25SP).

> It seems more accessible somehow ... I don't think my attitude to science has changed as such. I can really talk about the Australia I've grown up in but I think we've been brought up with this very inherent respect for science that it's like "oh well, it's always there and it's a question of whether you're smart enough to understand it" kind of thing ... So I wouldn't say my attitude to science has changed, it probably doesn't seem quite as remote as it used to and I think that's good. (F23NSNA)

> I think it was more [an impression that] science can't really be fun. Like the

> physics and at that level they're discussing, it isn't funny. But when they actually portray it in the way [that], yes, it's very hyped up because it's in a media show or an entertainment show, but it actually made it kind of amusing. It did give me a couple of seconds where I thought "oh, maybe I can go into that." But then I've gone and done it in class and went "nah, nah." It has changed my opinion that some people can enjoy it so much that they're not just doing it because [they have to]. (F19SU)

It would appear that the science in *The Big Bang Theory* has changed some participants' attitudes toward science. However, when the participant was already interested in science or had an extensive amount of experience in science, the show may have difficulty with changing their attitudes toward science or may even lead to an entrenchment of their beliefs.

3.3 Is *The Big Bang Theory* a learning source or inspirational source?

When the participants were asked what they thought about the science in *The Big Bang Theory*, one of the first discussion points that was consistently mentioned by the participants was whether the science in the show could be used as a learning source. There were many avenues that the discussions followed, such as the various benefits and disadvantages of *The Big Bang Theory* for communicating science. *The Big Bang Theory* were often compared to documentaries, or other entertainment sources from different genres. Through the comparisons, it would appear that the participants felt *The Big Bang Theory* had specific benefits related to the show being a sitcom that were missing from other sources. However, as the responses indicated, there was a difference between being able to 'learn' science from the show and being 'inspired' by the science in the show, and the participants expressed that it's not possible to learn science from *The Big Bang Theory* for many reasons. The following response made a comparison between documentaries and *The Big Bang Theory* and alluded to two points that marked their differences.

> The main science thing I remember [from *The Big Bang Theory*] was a character dialogue where they were talking about string theory. They didn't talk

> about it for very long but it was on TV a few weeks after I've seen a documentary about it so it was interesting for me to watch and kind of listen to them bounce over the top of what was covered in the documentary, so I was kind of listening out for comparisons. (F29NSNA)

In this response, the two points that were mentioned that demonstrated the difference between *The Big Bang Theory* and documentaries was: (1) science discussions were usually *much shorter* in *The Big Bang Theory*, and (2) the science dialogue in *The Big Bang Theory* was usually *more advanced* than documentaries. These two issues limited *The Big Bang Theory* from becoming a learning source, and this limitation resonated with other participants. I will explore these two issues separately to emphasis how the participants felt these were important limitations to *The Big Bang Theory*'s potential for being a learning source.

Firstly, participants felt the way *The Big Bang Theory* communicates science is usually "not complete, it's just snippets" (F28SNA). Participants expressed that they recognised *The Big Bang Theory* included science information, but unlike documentaries, this information was usually presented in a "certain few points, or [a] few words even, about something [in science] but probably it's not really efficient, you can't see the whole picture" (M25NSNA).

> I think that *The Big Bang Theory* is too small snippets that you can't [learn] anything from that show. You can't learn anything, or get knowledge I think, except in very rare cases where you talk about bread in a fridge or out of a fridge. I think you can get knowledge that way but you can't learn anything about string theory. You can't learn anything about nuclear fusion or fission, or extrasolar planet detection. You can't learn that from *Big Bang Theory.* (F41SA)

> I think *Big Bang Theory* uses science kind of like rappers use cultural references. You're alluded to stuff and call out names and things but you couldn't take a whole rap song and learn anything from it as such. Like it's just "yeah I know that, I recognise that reference" so if you are in the science culture I

> guess it's kind of comforting. [Like] "oh yeah, I recognise those equations on the board, yeah." You wouldn't learn anything but it just makes you feel like you're at home. (M33SP)

By presenting science in snippets or short references, *The Big Bang Theory* provides the opportunity for the viewers to conduct their own research into the science information and concepts since, due to the entertainment nature of the show, "you probably would be introduced to some concepts but it doesn't really show you everything so it's like half-half. You really need to go and research [it yourself]" (F26NSNA). A reason for why the show cannot explain the science was mentioned by a participant who noted that the show runs for about "20 minutes and they might just brush up [on the science], like just talk about it [for] one or two minutes and that's it" (M25NSNA). In contrast, a documentary will spend "an hour explaining [the science]" (M25NSNA), thus "you can fit more into a documentary, which is focused" (F28SNA). Participants also expressed that documentaries would allow them "to feel informed and see a systematic development of an argument or an experiment" (F23NSNA) and would "also get you from A to B, they tell a story where they're building up the knowledge that you need to know to reach some sort of point" (F37SA).

As for other types of entertainment television shows, participants asserted that programs such as *MythBusters* (2003-present) and *Scrapheap Challenge* (1998-2010) were better at presenting science than *The Big Bang Theory*. These types of shows begin with a task and set out to test or build something based on scientific concepts and "explain the principles by which they're actually designing" (M48SNA), thus they include "more than the specific scientific facts that they look at" (M33SP). However, the participants also indicated that "the science is not very good [since] they don't construct repeatable experiments" (M48SNA) and, perhaps more importantly, "they skip over [the rigorous controls] because it will be too boring to watch, so they get just enough that it's difficult to argue with" (M29NSNA). Similarly, *The Big Bang Theory* also often 'skips over' the scientific rigour associated with science experiments.

> In science you have a hypothesis. You design an experiment to test the hypothesis. You follow some kind of procedure and in the end you have your result.

> And there are bits missing in *The Big Bang Theory*. You don't usually get the hypothesis or if you get that, you don't get the part to the end . . . There's one where [Howard] had designed the toilet for the space station and it had gone wrong . . . It wasn't really an experiment [but] he had designed a toilet, [and] you didn't know how he had done the design or what exactly had gone wrong, and how exactly they're going to fix it. (F37SA)

An explanation of why complicated science was often shown as incomplete was provided by a science postgraduate who expressed that scientific rigour may not be very entertaining, which was demonstrated by "a line from Leonard where someone asked him what he did that day and [he] says 'I thought [about stuff], and I wrote some [of it] on a whiteboard'" (M33SP). Rather, *The Big Bang Theory* usually focused on the consequences of the science thought processes or experiments since "consequences of doing things wrong is where the humour is" (F37SA). Another participant expanded on this idea by stating that scientific rigour doesn't include human errors, and that removing the human aspect would not make a good television show:

> I think [that's] one of the most important things about scientific process, is to take humans out of the equation if you can. And that doesn't make good TV I think. (M40SA)

Therefore, it would appear that television shows such as *MythBusters* and *Scrapheap Challenge* have the same problem as *The Big Bang Theory* where they are limited by their entertainment nature to present science. However, there is a slight difference where *MythBusters* and *Scrapheap Challenge* are designed to focus more on the science process, thus more time is spent explaining the science concepts. *MythBusters* and *Scrapheap Challenge* attempted to portray science in an educational way, such as taking "a scientific approach to demonstrate to people [that] science doesn't need to be boring" (M29NSNA), and as a result participants considered these programs to be more effective in stimulating interest and "much more so actually than *Big Bang Theory*. I think *MythBusters* is really great, probably great for making high school students want to do physics" (F37SA).

Another genre that was mentioned was game shows such as *Are You Smarter than a 5th Grader?* (2007-09, Australian version) and *Who Wants to Be a Millionaire?* (1999-

2010, Australian version), where the participants felt the science facts in these programs were real but even if they watched these shows "over and over again I still don't gain much from it" (F26SP). In this instance, game shows are similar to *The Big Bang Theory* in that they present science as snippets. In comparison to other entertainment sources, *The Big Bang Theory* would "need a lot more scientific content rather than the kind of shotgun splattering of scientific information that it has [now]" (M32NSNA) to become a 'learning' source, just as game shows would. The current form in which the science content has often been shown in snippets has caused the science to lose its usefulness as a learning source.

Secondly, the science in *The Big Bang Theory* is usually more advanced, or more obscure, than that in documentaries. With the addition of showing science in snippets, the level of difficulty only increases since "they're obscure enough snippets of information they're never going to be useful for me in any conceivable way . . . because it's at a quantum level or astrophysics and stuff like that" (M32NSNA).

> Like any individual example on something [in] *The Big Bang* might be fine but particularly the types of stuff that Sheldon supposedly works on which is so esoteric and out there, I kind of think it's so de-contextualised the way they present it that, in what sense is it useful to the viewer? So it's kind of the padding [and] it's the setting. (F23NSNA)

One example of the science concepts that Sheldon worked on was introduced in the episode *The Monopolar Expedition* (S02E23) regarding "the concept of magnetic monopole. I never knew there could be magnetic monopoles" (M26SP). Another example was in regard to an argument between Sheldon and Leslie in the episode *The Codpiece Topology* (S02E02) about "string theory and the other theory called quantum loop [gravity]. I have no idea what that is but I could say the name of the two theories" (F28SP). The participants expanded by identifying that the science was "sometimes too complicated for the audience to understand and the reaction would be locked on something [else]" (M18SU) and "some of the terms [they use], normal people don't really understand" (M24SU).

> The theme of *Big Bang Theory* is just for entertainment, they don't deal with science at all and if you're looking for science in *Big Bang Theory* I don't think

> you can find it. If you really look hard or if you know about string theory, that's a different story. (M26SP)

This participant's response raised the question of the audiences' level of science knowledge rather than the difficulty of the science in the show. If *The Big Bang Theory* was aimed at a different type of audience then the reaction to the science may be different. As one participant expressed, the science "might be [more distant] because they're theoretical physicists which is like, [an] elite sort of profession" (F26NSNA), suggesting that only audiences who have an in-depth knowledge of science, like physicists, will be able to understand the science in *The Big Bang Theory*. The difficulty of the science presented in the show may render the science information useless for many people and cause participants, especially those without a science background, to feel that "if you don't get it then you're not expected to get it" (F43NSNA).

> [In] *Big Bang*, they'll have the occasional jokes that they have to explain to Penny and that's in the most basic examples that everybody has seen before and we've all heard before because we have some science literacy. From then on it just gets into more and more obscure references and so you sort of keep laughing at it. Some of the jokes about string theory equations I'm sure they might actually be real and they might be really funny if you're an experimental physicist but . . . it's sort of an 'in' joke thing. I'll say I'm most of the way up the top, but there's definitely bits that I don't get. They don't explain [it], if you didn't already understand the more obscure references then I don't think you'll learn it from that. (M29NSNA)

> [For] *The Big Bang Theory*, I don't think you would ever really learn anything unless you already knew about it because it's so fast, and I think that when I watch an episode, I only really laugh at the jokes and appreciate the scientific references about which I already know. So maybe you can slightly augment or remind yourself of things that you know but I don't really think you can learn much from scratch from something that's sort of comedy focused because of the pace. (F28SP)

Therefore, when comparing the probability of 'learning' from an entertainment source such as *The Big Bang Theory*, participants indicated documentaries would be preferred since they "actually give you information on a subject" (M29NSNA), specifically "more detailed information" (M26SP), and also "retain some factual accuracy" (F21SU). But more importantly, documentaries are "more structured" (F26NSNA), the science "looks more serious" (M26NSNA), and "their purpose is to present science or their purpose is to explain science" (M27SNA). In contrast, *The Big Bang Theory* lacks focus on science since the show "spends a lot of time on plot development and characters" (F21NSU), and it's mainly "about the humour" (M59SNA) since it's "there to entertain you first, and needs to make you laugh" (F26NSNA). However, the entertaining nature of *The Big Bang Theory* helps with engaging the viewers, and thus increases the likelihood of people choosing to watch *The Big Bang Theory* over documentaries.

> [For] documentaries I find I always enjoy them when I actually watch them but I feel like they require brain power. So when I'm sort of trying to make a decision, if it's a choice between something light-weight and a documentary I'll think "oh, I need to not be feeling tired to watch documentary, I will need to do it justice" and so I never get around to it. (F23NSNA)

> I mean personally I would rather watch something written in terms of *Big Bang Theory*, but again, [you] have to recognise that the purpose is not, first and foremost, to convey complete information . . . but they can provide it in an interesting and entertaining way. (M50SNA)

Judging from these participants' responses, it would appear that *The Big Bang Theory* will attract more viewers than documentaries since it's 'light-weight', it's interesting and entertaining, and supposedly more likely to be chosen since it's "deliver[ed] with a bit of humour as well so it's not as dry. You're more likely to sit down to it after, say, a full-on day at work" (F28NSNA). In contrast, *The Big Bang Theory* is different to other entertainment television shows and "it's like you've never seen anything like this before. I mean [unlike] *Friends* and *How I Met Your Mother*, they're pretty similar" (F26NSNA). In the instance where the audiences are choosing between television shows where both are light-weight and entertaining, the participants would choose *The Big Bang Theory*.

> Quite often you get home from work you want to watch something that's not necessarily challenging but something that you can be engaged with. I find [the show's] got enough narrative dynamic that it's engaging but [you don't] just shut down and watch some crap unfold. It's actually interesting which means it's really re-watchable. (M26NSNA)

This suggests that even though participants considered *The Big Bang Theory* to be a bad source for 'learning' science, there's a higher chance the audiences would choose to watch the show over documentaries as well as other entertainment television shows because of its entertaining yet engaging nature. Previous interest in science is also a factor since participants "wouldn't watch [a] documentary unless it has interesting stuff in it" (M19SU), but interest in science is unlikely to affect the number of viewers for *The Big Bang Theory* since:

> I'm quite happy to watch *The Big Bang Theory*, but I would never ever, ever, ever watch like a physics type or astrophysics or whatever type documentary because it just doesn't interest me. (F22SU)

By including physics and astrophysics in the show, the audience will likely be exposed to the science content in the show more often. Therefore, *The Big Bang Theory* has the capability of reaching people who do not have an inclination towards science, and provide an opportunity to 'inspire' science interest.

It must be noted here that the word 'inspire' is a generalised term I used to describe how the audiences were 'stimulated' to find out more about the science in the show. The word 'stimulated' was first used in the focus group questions as a way to interrogate the participants' behaviour when they were exposed to the science content in *The Big Bang Theory*. More specifically, it was used to investigate how these exposures influenced their science information seeking behaviour (see section 3.4 for this analysis). For this current section, the word 'inspire' is used in the similar way, with particular focus on how the science content in *The Big Bang Theory* has influenced the audiences' interest or understanding of science before conducting their own research, as well as how they used this science information.

The science in the show could be used to inspire and engage audiences through different ways, ranging from a first point-of-contact where "if the general public doesn't have much of a science background then maybe it's a good start on what they need" (M40SA), to using clips from episodes as an introduction to a science concept in the classroom to 'inspire' the students' interest (e.g., Dubeck et al., 1990; Efthimiou & Llewellyn, 2006; D. Smith, 2009).

> I have some friends who are still science teachers and they actually have used *The Big Bang* to brighten up their classrooms for 12th grade kids . . . I'm going to use the Doppler Effect [as an example]. That wasn't one [they used] but if they were going to touch on that or look at sound waves or something like that, they would extract that clip. And they said that as a teaching tool it's really effective even though sometimes it may not be proper hard science, but as a way of engaging the students, especially in high school, it works! (F34NSNA)

Presenting short clips from *The Big Bang Theory* in classroom settings could also make the science concepts more relevant, helping the students have a clearer understanding of the science concept itself as well as how it relates to society (Brake & Thornton, 2003). The possibility of this was demonstrated through a conversation between two non-science non-academic participants where they asserted *The Big Bang Theory* has helped them with understanding science they've learnt in school.

> F34NSNA: I remember, well I can't remember the [exact] episode now, but it was something that I was like "oh my god, I suddenly think that I realise what my teacher was trying to talk to me about."
>
> F23NSNA: Yeah, I had a couple of moments like that, too. I can't quite think what [it was] but it's something like "wow, it makes sense!" And I don't know whether that's just it's like 10 years later or whether it's just putting it in a particular way, or with relevance I guess.

In addition, a participant asserted that audience members could refer back to *The Big Bang Theory* as part of a "normal conversation, like 'Doppler Effect, yes, we heard about it in *Big Bang Theory*.' But if I want to find out about it I'm not going [to] watch *Big Bang Theory*" (M26NSNA). This implies that the science in the show is memorable. The

Doppler Effect examples were just one of the many science concepts that demonstrated how the majority of participants, both scientists and non-scientists, held positive attitudes for *The Big Bang Theory*'s potential to communicate science.

In comparison to documentaries, an entertainment television source like *The Big Bang Theory* has multiple strengths that attract audiences. The participants who enjoy science or work in science often commented on the level of science difficulty when comparing *The Big Bang Theory* and documentaries, asserting that:

> *The Big Bang Theory* starts off being more intellectually interesting anyway. So if you're going to have a documentary, where *Big Bang* starts is probably the go, and it would be, well to me at least, it will be a lot more engaging and a lot more likely to actually watch the whole thing. (M43NSNA)

In comparison, the participants criticised documentaries because they are "targeted at a much lower intellectual level" (F43NSNA) where they "really dumb it down" (F25SP) in order to become "a window [to] get you in [to the science topic], rather than addressing or fully address a topic" (F23NSNA), so the participants often asserted "I often find that the science I would hope to learn, I [would] get disappointed" (M37NSNA).

> [Documentaries] cater to the lowest possible denominator that's watching it rather than assuming that perhaps due to the subject matter somebody with half a brain would be watching it ... because we all watch science documentaries at work. We come to work and talk about it and that's often the criticism that we'll end up with that it was just aimed a bit way too low a level, and they started to elaborate on this particular view but then stopped when it started to get interesting. (F52NSNA)

> I cannot watch a Nova special on space exploration. I can't watch the Discovery channel on the Martian life or Martian climate. I can't watch Science channel on Earth's global climate change. I just can't stand it, it's too basic for me. (F41SA)

Despite the fact that the participants felt documentaries were better for 'learning' since their sole purpose is to provide accurate and in depth science discussions, often

responses indicted the information in documentaries is too basic and caters to the lowest common denominator. However, participants also indicated that for *The Big Bang Theory*, they "would never expect to have any kind of mainstream entertainment show, especially sitcoms, to be educational ... The science is part of the setting" (M37NSNA). This was especially the case for science participants who expressed that "in terms of actually educating, if there's such [a] thing I haven't seen it so that's why I don't think you can ... I don't think it's science education at all" (M40SA) since they felt "[*The*] *Big Bang Theory* doesn't have that much science information in it" (F33SP).

What the participants noted though, was the show can be used as "a spark to gain more interest in an area [of science]" (M23SP) or "it will spark lines of investigation and questions" (F43NSNA), thus making it an "excellent science communication [tool] that way ... if you wanted to know more it would give you a good background from which to [go from]" (F28SNA). This is a benefit that *The Big Bang Theory* has that is different from documentaries, where the science often helped to stimulate interest, especially since "it just makes it seem a little bit more recognisable and familiar" (M33SP).

In general, participants indicated they would choose to watch *The Big Bang Theory* over documentaries since even though they may find the science in the show difficult to understand, they "just enjoy it, it's a relaxation" (M54NSNA), thus making it a "really good [source] for general public access to science" (M19SU). Therefore, *The Big Bang Theory* has advantages that are absent from documentaries, such as being more 'attractive' to the audiences, and although *The Big Bang Theory* cannot be used as a 'learning' source, it has the advantage of being an 'inspiring' source where, if the audiences wanted to, it could stimulate further research. It must be noted though, that there are other types of television shows which lie between entertainment television shows like *The Big Bang Theory* and science documentaries when it comes to the amount and quality of the science content. For example, the participants compared television shows such as *MythBusters* to *The Big Bang Theory* in the ways they presented science. Even though the participants indicated that *MythBusters* appear to be more useful when it comes to stimulating audiences' interest in science, particularly with high school students, it is unknown if this type of show will reach the same number of audiences, or even the

same group of audiences, as *The Big Bang Theory* and science documentaries. Therefore, further research into the groups of audiences who choose to watch different types of science based television shows can potentially yield fruitful results that will shed light on the most effective television genres to reach specific audience groups.

3.4 Information seeking behaviour

The participants also discussed whether they had been stimulated to find out more about the science information in *The Big Bang Theory*. When taking the academic background of the participants into consideration, it would appear that there were more non-science participants than science participants who indicated they were stimulated to find out more. However, when considering those people who did not find out more about the science after watching the show, there were roughly equal number from both academic backgrounds. In addition, there were a small number of non-science participants who couldn't remember whether they had found out more about the science information by themselves but had the feeling that they had. Therefore, these responses could be distinctively grouped into three categories: (1) *yes*, the participant was stimulated to find out more, (2) *no*, the participant wasn't stimulated, and (3) the participant *may* have found out more about the science but couldn't remember specific examples. I will explore each category separately to discuss the different types of explanations for the participants' responses.

Firstly, there were three types of explanations for the *yes* responses. The first type consisted of participants who indicated that they already knew about a particular aspect of science, and when it was mentioned on *The Big Bang Theory* they were stimulated to find out more. For example, one participant said that she wouldn't look up the science information unless she already had a vague understanding of it, because otherwise she wouldn't know how to spell some of the words used in the show, like Schrödinger's cat (F26NSNA).

> There [have] been a couple of times when I've been unsure of what they've been talking about, I've heard of it and I have sort of Googled it to try find a bit more. (M59SNA)

The second type of explanation consisted of participants who thought the science in *The Big Bang Theory* sounded interesting and it made them want to understand what the characters were talking about. For example, a science postgraduate asserted, "I understand what the joke would be about but I would have no clue about the physics part of it, so it makes me more interested to look it up and study" (M26SP). The third type of explanation was mainly from participants who were sceptical about the completeness and the scientific accuracy of the information in the show and their doubts stimulated them to find out more about the science, as demonstrated by an undergraduate participant who asserted:

> it's always sort of doubtful when I watch it. I'm like "do they sort of dumb it down for people and not have all the facts there" so if I'm confused about something I'll always try to look it up later. (F20NSU)

Most of the participants who gave a *yes* response expressed that the science sounded interesting and it made them want to find out what the characters were talking about, especially when the science was a key theme that the humour revolved around. Participants often indicated that they wanted to understand the science because it opens up a whole new level of humour to the jokes, allowing them to appreciate the science more. In addition, participants were likely to become less intimidated by science after watching *The Big Bang Theory*. This was demonstrated through two participants' comments where they had gone beyond searching on Google or Wikipedia:

> I recently subscribed to a YouTuber who does minute physics where he actually draws and talks about physics, science concepts ... *The Big Bang Theory* has definitely edged me towards the science, the interest in science, like I've always been interested but it's probably pushed me to learn more about them. (M25NSU)

> You know, one thing I have noticed since I've started watching this show, if there's lectures and if they interest me, especially for example solar flares, or even creationism versus scientific origins of the world, I would actually pause and give a look and think "do I have the time to attend it?" And I think that's something that I don't think I would have done prior to watching the show, so I think that's one behavioural change I've noticed in myself since watching ... I

> wouldn't walk in thinking 'oh my god, I'm not going to understand anything' because it's okay if I don't understand everything. (F34NSNA)

While the *yes* responses easily fell into three categories, the *no* responses were far more diverse. Many types of reasons were identified for why people did not look up the science in *The Big Bang Theory*, but three main categories could be identified which encompassed the majority of responses. The first category was of responses made by participants who were either already in a science field or had a working knowledge of the science presented in the show. For example, one participant said "it's the field that I work in already so a lot of the stuff they're talking about I'll know of at some point throughout my academic career" (F30SP). The second category consisted of participants who didn't have time to look up the science since, as they asserted, they sit in front of a computer all day at work so they didn't want to sit in front of a computer at home. A non-science participant explained that "most of the time I've watched it I wasn't near Internet access so there was a time lapse" (F29NSNA). The third category of responses was from participants who were not particularly interested in physics, but were more interested in other aspects of science such as environmental science. For example, one participant expressed "I'm not confident in my ability to understand it basically and I don't have enough of a drive to learn more about physics" (F28SP).

Despite the fact that these participants were not stimulated to find out more about the science information themselves, they provided examples of how the science in *The Big Bang Theory* has affected other people. For example, one participant asserted that while *The Big Bang Theory* did not stimulate him to look further into the science, it did stimulate the interest of his children: "No, but it has stimulated my kids to ask questions so it certainly, there's a certain amount of 'what's that' which comes out of it" (M48SNA). He then added that he was able to explain the concept of lunar ranging to his children with the help of the experiment presented on *The Big Bang Theory*. In contrast to the explanations for the *no* responses above, one participant's response suggested that the perceived scientific accuracy of the information on the show also determined whether the participant would look up the science:

> It's funny you mention that because I've never had the impulse to look up

> something I've found on *The Big Bang Theory*. I think *The Big Bang Theory* has done enough for me to establish its credibility, like it doesn't make outrageous claims ... I basically assume that if it's on *The Big Bang Theory* it's probably right. (M26NSNA)

This is the converse of the third category of the *yes* responses, where some participants were sceptical about the science presented so looked it up to check it. Both kinds of participant responses indicate that the audiences appreciate having accurate science information in *The Big Bang Theory*.

Many of the remaining responses were classified as *maybe* responses and had elements in common with *no* responses. Notably, the time lapse between watching the episodes and getting to the Internet was a major reason why the participants were unsure whether they had looked up some of the show's science or had just thought about doing it. Some participants said that although they did not actively look for the science information in the show, they had become more sensitive to it, and picked up more information when they saw it in the news or magazines:

> They went to [the] Large Hadron Collider ... so having seen that on the show, I might pick up a bit more if I heard something about it on the news ... but I wouldn't actually go out and then look up on it. (F33SP)

> I would be more receptive to new ideas and science [in the show]. I will store that [in my mind] and if I have spare time and feel like it, I might do some more research on the topic. (F35NSNA)

This resonates with the first kind of *yes* response, where participants who already had a vague understanding of the science would tend to pick up more information when watching *The Big Bang Theory* and do further research if they wanted to. Essentially, *The Big Bang Theory* has the potential to plant a seed of a science concept, which builds upon previous knowledge and upon which further knowledge can be built.

Even though there were many participants who expressed that they had been stimulated by *The Big Bang Theory* to find out more about science, they were among the

minority in the focus groups. Many of those who were not stimulated to look for more information already knew something about the science being discussed, or trusted that the information was true, and so felt no need to look into it further. For some participants the show planted a seed of interest, and/or made science seem less intimidating or alienating. Some of the participants' responses suggest that the science-based humour of *The Big Bang Theory* is important to stimulate information seeking behaviour, because finding out more about science increases the entertainment value of the show. Other responses suggest that an interest in scientific accuracy is another reason the participants were stimulated to find out more about the science, but there was no consistency among participants about whether they thought *The Big Bang Theory* was accurate or not.[1]

3.5 *The Big Bang Theory* and the nature of science

Even though the participants indicated that it was not possible to learn science from *The Big Bang Theory*, this did not apply to all aspects of science. An analysis of the transcripts indicated that many participants did learn about one particular aspect of science, and that is the nature of science (NOS). There were no focus group questions which directly asked about NOS, and yet most of the focus groups discussed at least one aspect of NOS, suggesting that audiences do notice these aspects even though no participant overtly related what they were talking about to NOS in any formalistic sense. Both science and non-science participants discussed the show's themes, scenes and episodes which demonstrated their engagement with three of the five aspects of NOS based on Bell and colleagues (2000): that science is empirically based, that science is subjective and theory-laden, and that science is socially and culturally embedded. This suggests that some non-scientifically trained audience members develop an understanding of NOS peripherally as they watch *The Big Bang Theory* through the seasons. As the data for this section were not planned as part of the focus group questions, it meant that this is not a systematic interrogation of how and whether participants observed elements of NOS in *The Big Bang Theory*. However, it has the benefit of being a spontaneous,

[1]Parts of this section were published in Li, R. and Orthia, L.A. (2013), 'Are people inspired by *The Big Bang Theory* to find out more about science? Results from focus group-based audience research', *Peer Reviewed Proceedings of the 4th Annual Conference Popular Culture Association of Australia and New Zealand (PopCAANZ), Brisbane, Australia*, 24-26 June, 2013, P. Mountfort (ed), Sydney: PopCAANZ, pp.300-310. Available from http://popcaanz.com/conference-proceedings-2013/

non-primed set of responses to the show.

To analyse the data for this section, the science participants' responses were separated from the non-science participants' responses. The responses from the scientists were used to determine the accuracy (or inaccuracy) of the *The Big Bang Theory* in their portrayal of scientists' experiences in the workplace and with colleagues. The responses from non-scientists, and sometimes from those new to the science community, were used to identify the most successful portrayals of NOS in *The Big Bang Theory* in terms of what such people learned or found most memorable. In the following, the participants' engagement with each of the three aspects of NOS will be discussed. For each, the scientists' comments will be summarised to verify the program's depiction of what they considered to be a realistic aspect of science. Then what some non-scientists seem to have learnt about this aspect of NOS from the show will be reported. Perhaps unsurprisingly for a character-driven television sitcom, the 'science is socially and culturally embedded' aspect was discussed most extensively in comparison to the other two aspects.

Science is empirically based

The idea that science is empirically based was the aspect of NOS that participants discussed least of the three. Seven focus groups raised topics relevant to it, but the discussions were not in depth with the NOS aspect, sometimes just being mentioned by one participant. A number of participants criticised the fact that the mass media rarely show the processes of conducting science, such as reaching an empirically-based conclusion from observation and experimentation, instead depicting science only in the form of end results. Some participant conversation suggested that *The Big Bang Theory* was different from the norm in this regard. Both scientist and non-scientist participants agreed that an important strength of the show was its ability to depict scientific processes, such as the lunar ranging experiment in the episode *The Lunar Excitation* (S03E23). *The Big Bang Theory* also demonstrated how scientific processes proceeded over time:

> Another important aspect of the show too isn't so much of the science fact that goes in the science itself [but] scientific method, scientific investigation, how that actually occurs in science, [and] the very fact that people will disagree on

> theories. See, you've got Sheldon constantly going 'Ah! This person is an idiot! How can they believe this! I'm going to prove that theory wrong' and that's an important part of science. In a lot of other shows where you actually put science in it's always science fact, [like] 'this is the fact' or something 'that's true.' It's not 'let's think about how science actually progresses.' (M25SP)

> I think what I like about *The Big Bang Theory* is that [for] most people when they think about science ... [or] hear about who wins the Nobel Prize [they're] like 'oh wow, they've discovered that.' I think what I like is they show all the work that goes behind getting to a discovery, like they show Sheldon continuously working on one problem and he'll get it after like six or seven episodes ... In real life you always hear about the discovery at the end and you don't realise how much work has gone into [it] ... and how much time looking at the equations and thinking of the ideas. So I like how this show kind of explores ... [how they] will think of an idea and it sort of goes through ... how they develop the idea and the failures that they have. (F20NSU)

Where more extensive discussion of this aspect of NOS did take place, it was primarily among non-scientist participants. As well as commenting on *The Big Bang Theory*'s depiction of scientific processes in general, some non-scientists also commented on its demonstration of empirically-derived results, most frequently through Sheldon's mathematical equations on whiteboards in his apartment and office. While mathematics itself is not an empirical endeavour, the participants indicated that they understood Sheldon to be using maths as an application to test and advance his research. For example, two participants discussed this in a non-science, non-academic focus group:

> F43NSNA: With Sheldon's maths in particular, it's something that I don't think many people will look at and have any clue with what he is doing ... but it sort of makes it something that's real, whereas [the concept of] maths is something that most people just don't get at all.

> F52NSNA: Yeah, but you can see that he is using maths as an application to work through a problem and get to a solution at the end. You don't necessarily have to understand the maths but you can understand why he's using the maths and how he's using the maths.

> F43NSNA: So it's selling the career as much as the science itself . . . I think that's probably one of the big benefits that [*The Big Bang Theory* has] got is that it's actually showing people what it means to be not just be a nerd or geek, but to actually be a scientist, a physicist, an engineer, [or] a mathematician.

Science is subjective and theory-laden

The notion that scientific ideas and theories are subject to debate within the scientific community was discussed by many participants, both scientists and non-scientists (in six groups), after they had noted its presence in *The Big Bang Theory*. This aspect of NOS was discussed more than 'science is empirically based,' but the examples from the show they mentioned to illustrate it were more limited.

A number of science academics reflected on the existence of such debates in real life. Some relayed their experiences of scientists having personal disagreements with others in the same field because they did not agree with each other scientifically. One participant commented on scientists' lack of interest in watching documentaries for which scientists with opposing theories were interviewed (F41SA). Another commented that the debates were quite open in the scientific community:

> You do have big groups of collaborators going "no, this theory" and the other one's going "this theory", and . . . they just don't get along . . . you see them at conferences together and it's just, it's hilarious, it's like little children sometimes. (F30SP)

The Big Bang Theory example most often mentioned by participants as reflecting this aspect of NOS was the debate between string theory and loop quantum gravity in the episode *The Codpiece Topology* (S02E02). In this episode, couple Leonard and Leslie discussed the possibility of having children, and the implications of Leonard's genetic disadvantages, such as asthma and lactose intolerance, that their children could potentially inherit. However, the relationship ends when 'arch-enemies' Sheldon and Leslie argue about the merits of string theory versus loop quantum gravity, and Leonard sides with Sheldon. Leslie explains that she could deal with their children having genetic disadvantages, but cannot abide the fact that Leonard does not agree on the same physics theory. A science

academic confirmed that these tensions between colleagues, or even family members, do occur, with an example of a heated debate within her field:

> There is the classic case in planetary science with [a] Martian meteorite . . . that had the supposed fossil inside of it, and that just ripped apart the community in some cases, and in one case a family. Two brothers do not speak to each other anymore because of it. (F41SA)

She went on to describe the deep personal investment scientists have in their ideas, confirming the realistic representation in the show:

> You get your baby theory . . . you're building evidence [and] the case for a specific theory, right? And the theory is not yet solved, otherwise why would we be gathering evidence for it, right? But then there are other people who think it is solved and then you get so annoyed . . . You get very attached to what you're spending your life doing. (F41SA)

The notion that scientific theories and results presented through the media were not supported by the entire science community was a new idea for many non-science participants. In particular, participants who were not familiar with science careers or higher degree research found the concept of debates among colleagues very interesting. Many participants were fascinated by the idea that scientists were so committed to their personal scientific theories that they could not be in a relationship with someone who did not believe the same thing. For one participant, who had just started a science-related Masters degree and was therefore new to the scientist community, the idea of Leonard and Leslie's relationship being affected by a difference of scientific belief was what exposed him to the notion of debates within science:

> The idea was that these [differences in scientific beliefs] are really important to people. There's emotion behind the science as well. People's ideas about the theories are really emotional in many ways and you can't date someone who believes in a different theory. I thought [that] was quite funny, and possibly happens. (M23SP)

A similar observation was made by a non-scientist regarding Sheldon and Leslie's debate about string theory and loop quantum gravity, and the emotional investment in their work:

> I really like the interaction between Sheldon and Leslie Winkle. Like the idea that you have these two people who just get on each other's nerves but then that comes from this kind of deep epistemological difference between the way they see quantum science happening ... It's like you can tell they don't like each other because there's just a personality clash but they perceive it as a difference between string theory and loop quantum gravity and I thought that was really cool, that idea that people get so invested in their work. (M26NSNA)

In addition, concepts in *The Big Bang Theory* that challenged the idea of science always being certain were eye-opening. The same participant commented on how the reclassification of Pluto demonstrated to him that science is subjective and theory-laden. This was in reference to the episode *The Apology Insufficiency* (S04E07) where the well-known astrophysicist Neil deGrasse Tyson made a brief cameo appearance, and explained to Sheldon that the demotion of Pluto from planetary status was a vote of the International Astronomical Union.

> It's part of that whole, "what do you know, and what's true, and when will paradigm shifts happen? And how that will affect your world-view towards them, and go, 'there aren't the number of planets in the solar system you thought there were."' That affects me not in the sense that I was particularly attached to ... living in the solar system with a particular number of planets, but if Pluto's planet-hood could be overturned, what else? (M26NSNA)

Science is socially and culturally embedded

The bulk of the data regarding NOS was related to the concept that science is socially and culturally embedded. This included discussion about social interactions between scientists as well as the nature of a science career. Hierarchies of qualifications or disciplines within the science community was the angle most discussed by participants within this aspect of NOS. Participants also discussed the show's portrayal of the

'scientist persona,' with scientists and non-scientists noticing different aspects of this, but agreeing that the characters' youthfulness was unrealistic. Discussion relevant to this NOS element occurred in eight focus groups, and when it did occur was generally extensive.

Scientist participants were particularly vocal about the depiction of scientific hierarchies in *The Big Bang Theory*. One of the examples participants mentioned was Sheldon considering people who hold PhDs to be superior to those who hold Masters degrees, and thus the importance of differentiating between those called 'Dr' and those called 'Mr' (or presumably, but not mentioned, 'Ms'). One such example was given by a computer scientist employed by a government science research agency, where he noticed the use of titles on office door labels through the different departments:

> In computer science nobody uses a title. It's just not done. And it's really interesting going to the other side of [the science research agency] because when you've walked from ICT into Antennas . . . all of a sudden they've used 'Dr' or 'Mr' on the door labels. You walk back out again and everyone is 'Rod Anderson' or something . . . and it's something [that] I actually thought is really interesting, is that [*The Big Bang Theory*] obviously picked up on the same thing. (M48SA)

However, the hierarchy most discussed by participants was Sheldon's ranking of the different sciences, specifically his disparaging attitudes towards engineering and geology. Scientists in the focus groups gave many real life examples reflecting this hierarchy, confirming it resonated with their experiences:

> Theorists generally . . . carry themselves a little bit higher than the observationalists, who carry themselves higher than engineers, who are higher than the technicians. So they feel like they are [more superior], and they've carried that through to the show very well. (F37SA)

> If you ever dealt with theorists versus practitioners, you would know that there is substantial rivalry. Even [at my previous workplace], and I'm sure you've come across it. (M59SNA)

One comment was offered by an engineering postgraduate who supported Howard's argument in *The Big Bang Theory* that engineers don't need PhDs:

> They used to have discussions about Howard not having a PhD. That's basically a true thing. Engineers don't need to care about PhDs because when I was becoming an engineer, I knew people [from the industry who] I have interacted [with at] seminars, they used to say if [you] have a PhD and 200 publications and not a decent project, you're not an engineer. (M27SP)

Scientists in the study also discussed at length the stereotypical representations of scientists' personalities in *The Big Bang Theory*. A physics post-doctoral candidate reflected on his experience with the thought processes and behaviours of physicists in comparison to non-scientists, implying a truthfulness to the depiction of physicists in *The Big Bang Theory*:

> I hang around physicists a lot and they do act a bit strange in a sense that they're very empirical and evidence-driven so they pick a lot of what most would consider 'arguments.' But they are more interested in getting the truth, so someone will say something [then] someone else will say, 'no you're wrong, because x, y, z.' I think [for] most people [when] you go up [and say] 'you're wrong' they take it personally, [but] most people I know will just be like, 'okay, why?' So that kind of behaviour in that sort of way is different. (M40SA)

Another aspect of personality that scientist participants commented on was the idea that Sheldon's behaviour reflected that of a person with Asperger's syndrome, which they felt had resonances with real life scientists. One science postgraduate gave an example of a person she knew in astrophysics who has Asperger's syndrome and behaved like Sheldon:

> This person had Asperger's and the person was very, very smart in the sense that she knew how human interaction worked. And the way she got through life was she would look at someone's face and reason to herself, 'okay, they're smiling therefore that means they're happy, but they're also slightly frowning at me so maybe they think I said something wrong.' And you could just tell they were reasoning their way in social situations. Every now and then it would break down. They completely miss the point. (F29SP)

The discussion followed on to which fields of science people with Asperger's were more likely to go into. According to the same participant's experience, they were more likely to go into theoretical physics because they are 'drawn to do a subject . . . they're good at.'

While the show's characters rang true in some of these respects, discussions among both scientists and non-scientists suggested *The Big Bang Theory* is inaccurate in its portrayal of scientists in one respect: the characters' youth relative to their professional positions and status. An employee at a government research agency reflected on this where she asserted "even working with a bunch of scientists every day . . . most seem older than me, whereas the ones in *The Big Bang Theory* seem younger" (F44SNA).

Non-scientists in the focus groups brought up many similar issues to the scientists re the social and cultural embeddedness of science, but from a different perspective. Many of them reported starting off with varying assumptions of what scientists were like and what a science career consisted of, but being challenged in their assumptions by *The Big Bang Theory*. When the participants had not had personal contact with the inner workings of university life, especially not beyond undergraduate level, they tended to be unaware of the hierarchies and status symbols within science and academia. The participant who had just started a Masters degree in science explained that the PhD/Masters hierarchy was a new concept to him:

> One thing that I sort of think about was how [the characters] always tease Howard because he only has a Masters, and he is only an engineer and that kind of stuff. [I'm] sort of thinking more about the differences between science, scientists and the status symbols and having a doctorate. (M23SP)

Participants also mentioned Sheldon's hierarchical differentiation between the sciences:

> I think what they do fits . . . what is presented to us . . . as the hierarchy within science, that Sheldon and cohort are like the elite. They're the ultimate smart kind . . . and then it filters on all the way down to the engineers. (F23NSNA)

An undergraduate science student conjectured that this hierarchical distinction was due to differing levels of mathematical difficulty and also the level of impact that different

areas of research have:

> . . . I think perhaps also the methodology, like the ranking of different sciences based on their degree of mathematics, or the difference between a research that is ground-breaking or just to reinforce or replicate previous research. Those sort of perhaps more method-based concepts rather than actual scientific content I wasn't familiar with and certainly before starting university I had really little understanding of university attitudes and systems. So I guess there's a certain element to that seeing as they work at a university but again, [what is shown on *The Big Bang Theory* is] only limited. (F19SU)

Non-scientists also discussed the stereotypical representations of the scientist persona, specifically the scientists' attitudes towards their research. Many non-science participants commented on the fluency with which the characters talk to one another, especially when science jargon is included, and that this was the image of a scientist:

> It's just that I think the science that they talk about defines them as the character for me because we know Howard is the engineer, and Leonard and Sheldon are . . . [in] physics. The fact that they talk about it is more defined to what their background is and for me it just shapes their character. (F21NSU)

> I feel like the science is part of their characters and it's . . . the fact that they talk about it so technically and so quickly and in such a sophisticated way . . . [and] they don't even think about it . . . that's how you know 'oh yeah, that actually is their job, that's what they do all day everyday' and that's why they're so different from the rest of us. (F26NSNA)

One participant suggested these characters were different because they work in higher research at university, regardless of whether it was in a science or non-science discipline:

> I think the academic nature of their work . . . [like] I was really keen in higher research for a while [and] I started a Masters of Arts . . . You sort of get into that head space where you're talking about your work all the time with people understanding, or someone like Penny who's an outsider who doesn't know anything about it [and] it's really confusing for them . . . It's just this kind of

> culture where everyone does higher research and is extremely intelligent in one area, and as a result their social life sort of falls by the wayside and they're not quite so good at relating to people. (F26NSNA)

The Big Bang Theory has been successful in communicating one aspect of scientific careers to non-scientists: what scientists do day-to-day. An example was provided by an astrophysics postgraduate about his mother, who had previously thought that when her son was 'at work' it meant that he was sitting in a lecture theatre taking classes. However, she now has a better understanding of science as a profession after watching *The Big Bang Theory*. Another example was given by a non-science participant who indicated that her children, who are studying art at university, now know what scientists do during the day:

> My children [are] much more in tune now with 'oh, that's what research scientists do.' They go into the university, they do their research, they write papers, they all read each other's papers, they comment on each others' papers and that's what they're doing. (F52NSNA)

The unrealistic nature of the scientist characters' youth was also a topic of interest for the non-science participants. One particular participant felt that it wasn't credible for Howard to be a young engineer under the age of 30 and to already have quite an advanced career. She further explained this by saying it seemed Howard had only recently graduated from his Masters degree and was already being invited to go to the International Space Station. She then compared Howard to Sheldon and Leonard, noting that it was understandable in Sheldon's case because he was a child prodigy so it didn't seem too odd that he was so advanced. However, in Leonard's case, as an experimental physicist, he seemed to be doing very well for an early career researcher. She justified her observations by relaying her experiences meeting health care researchers:

> For work I meet a lot of health care researchers and I'm always surprised when I meet one that turns out to be under the ages of 40 or 35, because when they've got a 'Dr' or 'Prof' after the name I've always sort of expected them to be a lot older. (F26NSNA)

A participant in the same focus group argued that when comparing a science PhD to an arts PhD, it seemed more plausible that scientists would have a more advanced career:

> For someone that's young and has a doctorate I would say 'oh, they're probably a scientist' because when people are really gifted in science ... they tend to develop really quickly. Like if you are gifted in history you still need all those years and anthropology you need a lot more fieldwork. Psychology as well, there's other things that prevent you from being really young and reaching that level. (M25NSNA)

The participants' responses demonstrate that, broadly speaking, *The Big Bang Theory* does communicate elements of NOS to its audiences, including those new to or outside science. The scientists' comments revealed that the portrayals of scientists and science in *The Big Bang Theory* resonated with their own experiences, with the exception of the characters' youth. The non-scientists' comments gave insight into their prior assumptions about some aspects of NOS, and also showed some changes to their understandings after watching *The Big Bang Theory*. The focus group data suggest that people do observe aspects of NOS in *The Big Bang Theory*, and thus inadvertently learn something about the nature of science from watching it.[2]

3.6 Discussion

The participant responses about whether their attitudes toward science changed after watching *The Big Bang Theory* were significantly different to each other. Some responses demonstrated that personal experiences and pre-existing attitudes had a stronger impact irrespective of whether the participant was enthusiastic about science before or not, thus these participants were less likely to change their attitudes. This was mainly the case for science participants, where they proposed that the reason why people tend to have difficulty changing their attitudes toward science was because of the age of the audiences, and that if the same focus group questions were asked to younger audiences then the responses might be different. Indeed, the lack of personal experience with science outside the classroom may cause younger audiences to feel negative towards the science they've encountered, but the use of entertainment television shows and other forms of fiction in

[2]This section is based on the conference paper presented at the *International PCA/ACA Conference* in Warsaw, Poland, July 2013. Parts of the section was published in Li, R., & Orthia, L.A. (2016). Communicating the nature of science through *The Big Bang Theory*: Evidence from a focus group study. *International Journal of Science Education, Part B*, 6(2), 115-136. doi: 10.1080/21548455.2015.1020906

classrooms has been shown to improve this attitude by motivating students' interest in science (Dubeck et al., 1990; Efthimiou & Llewellyn, 2006; D. Smith, 2009). This was probably the same reason some participants felt they had changed their attitudes toward science after watching *The Big Bang Theory*, since they may have had less encounters with science. As a result, these participants felt science was interesting and enjoyable rather than dry and remote after watching the show. Perhaps the reason why the participants felt science was more accessible was because, as mentioned above, fiction puts science in a social context via characters, settings, plots, emotions, decisions and arguments (Rose, 2003; Berne & Schummer, 2005; Segall, 2007), thus making the science more relatable because participants could identify with these events. Nonetheless, participants felt the show had a bigger impact on their perception of how science could be presented rather than what science is like as a discipline.

The participants indicated that *The Big Bang Theory* was an inspirational source rather than a learning source since it could inspire the viewers to do further research if they wanted to, but it was not possible to learn the science in the show itself. There were two reasons for this. First, the science discussions in the show tend to be much shorter than educational sources. For example, participants compared *The Big Bang Theory* to documentaries as a way to demonstrate how the show only portrayed snippets of science, and how it was not enough to educate about science topics like nuclear fusion or exoplanet detection even though it may stimulate the audiences' science interest. Participants expressed that the reason why *The Big Bang Theory* communicates science in this manner is because it is a sitcom and each episode only runs for roughly 20 minutes, meaning that the actual science content may only be a few minutes long. Indeed, this is the nature of television shows where the majority of the time will go towards character development (Haran, Chimba, Reid, & Kitzinger, 2008).

In contrast, the participants expressed that documentaries are built around a particular science topic and systematically develop an argument. In comparison to sitcoms, participants also expressed that television shows like *MythBusters* are better at presenting science than *The Big Bang Theory* since they develop each episode around one or more science concepts. An explanation of the different types of science presentation styles

could be associated with the genre the program is in. For example, a participant noted that the level of scientific rigour will determine what kinds of science content will be in a particular genre, and since scientific rigour is hard to make entertaining, it is less likely to be in entertainment television shows like sitcoms where the main aim is to produce humour. Therefore, the participants concluded by asserting that the way *The Big Bang Theory* portrays science as snippets undermines its usefulness as a learning source.

The idea that the snippets of science in *The Big Bang Theory* can inspire science interest is in itself an interesting concept, especially comparing to how teachers use snippets from television shows and movies in classrooms to stimulate students' interest. However, the critical difference between these two types of snippets of science information is the presentation style. While *The Big Bang Theory* includes snippets by what the characters are working on, they do not explain how the science behind it works. On the other hand, teacher modify these snippets for classroom use, thus making it an educational tool. It would appear then, that the issue of these snippets of science information being unsuitable for educational purposes is not because they are presented as snippets, but rather it is the context in which these are presented that determines their capability of being educational.

The second reason why *The Big Bang Theory* is not suitable as a learning source was because the science content and dialogue were much more advanced than educational sources. This meant if the audiences did not have prior knowledge about topics like quantum physics, it would be impossible to understand the science the characters were talking about. As a result, the participants felt the lack of prior knowledge limited the usefulness of the science content. Again, the participants compared the show to documentaries, and indicated that documentaries will most likely retain factual accuracy and present more detailed information. This is consistent with the work of Haran and colleagues (2008), where the authors indicated documentary "holds a privileged position within society, a position maintained by documentary's claim that it can present the most accurate and truthful portrayal of the world" (Haran et al., 2008, p.68). These two reasons aligned with Weitekamp's (2015) argument that "the potential of television situation comedies for real contributions in the public understanding of science, are in

some ways, inherently limited. By definition, the genre uses settings to shape comedy, not to educate the public" (p.84). However, the participants also acknowledged that they are more likely to pay attention to *The Big Bang Theory* because of the format of a sitcom being a light-weight interesting entertainment television show, which is consistent with the findings of Hawkins and colleagues (2005). In addition, by incorporating science information into the content of the show, *The Big Bang Theory* has the capability to expose the audiences, who are not interested in documentaries, to various science topics.

In addition to many of the participants' comments noted above about the difference between *The Big Bang Theory* and documentaries, the participants appreciated the level of difficulty of the science content in *The Big Bang Theory* and in turn criticised documentaries for 'dumbing down' their science to cater to the 'lowest common denominator'. As a result, the participants asserted that the level of science difficulty in *The Big Bang Theory* would stimulate their science interest more than documentaries. However, one may argue that the two genres use science information differently, where documentaries are used to explore the history of the particular science issue, and fiction is used to relate that science issue to society (Bates, 2005), thus the level of science difficulty in the two different genres can't be compared. Nonetheless, the participants concluded that both *The Big Bang Theory* and documentaries have their individual benefits in communicating science, and that *The Big Bang Theory* is a better tool for inspiring public interest in science.

It would appear that in terms of motivating audiences to look for additional science information, *The Big Bang Theory* does have the potential to stimulate interest in science, among scientists and non-scientists alike. Some participants were not stimulated to seek more information either because they already knew something about the science being discussed, or trusted that the information was true, and so felt no need to look into it further. For others, the program planted a seed of interest, and/or made science seem less intimidating or alienating, both of which may enable future science engagement to develop. This is consistent with many of the previous studies on public responses to science-themed fiction, which mostly demonstrate that people process the science they see or read in fiction in complex and diverse ways that vary with innumerable contextual factors (a constructivist model of 'learning'), rather than merely 'learning' it in a linear

fashion (Orthia et al., 2012).

Some of the participants' responses suggest that the science-based humour of the program is an important driver of information-seeking behaviour, because finding out more about science increases the entertainment value of the show. This is an important finding since it can inform other television shows of a way to enhance the audiences' interest in science and how to stimulate science information-seeking behaviour. In addition, other responses suggest that an interest in scientific accuracy is another driver that can encourage information-seeking behaviour, and can also promote viewership, but there was no consistency among participants about whether they thought *The Big Bang Theory* was scientifically accurate or not. It may be that people with an inherent interest in scientific accuracy are drawn to watching *The Big Bang Theory*, rather than the show itself encouraging this interest, though certainly some participants watched the show despite not having an inherent interest in its scientific subject matter.

In regard to the portrayal of NOS in the show, it would appear that the participants identified three elements of NOS. While a concerted analysis of NOS in *The Big Bang Theory* makes these seem obvious (for examples, see Li & Orthia, 2016), that does not necessarily mean viewers interpret them or remember them in the same way as a researcher who is actively looking for these scenes. Nonetheless, NOS featured frequently in the participants' responses, in particular the aspect, 'science is socially and culturally embedded'. A reason this aspect is most frequently raised may be because, as Dhingra (2003) argued, "The characters on television are frequently the reason students can either relate to the story being told or not, the reason they view the program or not" (p.237). Dhingra advised that "Analysis of the nature of science on television needs to attend to viewer perceptions of who the scientist characters are, and be related to embedded messages about the nature of science, because it is the characters who actually tell the stories on television" (p.237).

Therefore, the interactions between the characters, with a major focus on the institutional aspects of science, were the most frequently discussed ideas because *The Big Bang Theory* is an entertainment television show. The second most frequently mentioned NOS

element was 'science is subjective and theory-laden'. Again, this was mostly discussed in relation to the characters' interactions, but more specifically on how the characters would disagree with each other when it comes to a science theory. The least discussed element of NOS was 'science is empirically based', where the discussion revolved around the methodological aspects of science. This was not frequently discussed since this NOS element did not require an interaction between characters. Rather, the participants mainly referenced Sheldon when they commented on this NOS aspect since his work with maths provided an image of empirical work. Nonetheless, The presence of NOS discussions suggest that *The Big Bang Theory* has the capability to communicate some aspects of NOS peripherally as an embedded message. Since the characters' interactions and conflicts seem to be overall the most memorable aspect, television producers could potentially use this result if they want to create fictional shows that will inspire interest and educate viewers about NOS.

The analysis of the participants' responses demonstrated that *The Big Bang Theory* does have the capacity to inspire interest in science and to enable people to learn things about NOS, despite their belief that people can't learn anything about science by simply watching the show. In addition, this research complements the literature on the uses of fiction for science education, since it demonstrates some of the ways *The Big Bang Theory* has changed its viewers' perceptions of science (for the better) in an informal viewing environment. This is a positive outcome for science engagement since this demonstrates science in fiction does not corrode the viewers' scientific literacy skills, which is a major concern for scientists and policy-makers (Hughes et al., 2008). It also demonstrates that the science on the show doesn't impact people's perceptions of science, or their level of scientific literacy, in a linear fashion (such as following the deficit model) since the participants engaged with the science in a critical manner. This is consistent with what Kitzinger and Hughes (2008) found in their study.

Chapter 4

Presentation of scientists

In the following two chapters I will discuss the participants' responses regarding the scientist characters in *The Big Bang Theory*. The male scientist characters the participants discussed included Sheldon, Leonard, Raj and Howard, and the female scientists included Amy and Bernadette, as well as Leslie. The difference between these two chapters is the focus of the discussions – the current chapter discusses the portrayal of the characters as scientists in general and the next chapter specifically discusses the portrayal of the female scientists.

A reason why these chapters are divided relates to issues surrounding gender equality. Gender equality is deemed an important issue on a global scale and has been addressed by international organisations such as the United Nations. Various policies and protocols have been produced as a result of societal demands to ensure men and women receive equal rights (e.g. *Convention on the Elimination of All Forms of Discrimination against Women*, 1979; *Optional Protocol Convention on the Elimination of All Forms of Discrimination against Women*, 1999). However, these gender-related problems still exist, and women in science are experiencing it first hand. Their experiences include, but are not limited to, gender stereotyping, gender discrimination in the workplace, and having a lack of role models or mentors (S. Bell, 2009). It must noted though, that although it is important to address and tackle gender equality as a global and local crisis, we must recognise that these issues are not limited to the real world. Rather, gender equality also exists in the fictional world, such as on television. Therefore, the next chapter is used to explore the image of the fictional female scientists and report the participants' discussions about the gender equality issues surrounding the characters' portrayals.

There are also a number of practical reasons for dividing the discussion about the scientist characters into two chapters. Firstly, the focus group questions were separated to discuss scientists in general and then female scientists specifically. The motivation behind the specific female scientist-related questions was partly because the female scientists were introduced later in the show, thus I anticipated that the participants may not have had as much to say about them in comparison to the male scientists. The specific female scientist related questions were then used to elicit how the participants felt about the presentation of female scientists more deeply and as a result, prompted a separate chapter for this exploration. The responses associated with female scientists from the general questions will be used as an introduction for the specific female scientist related questions in the next chapter. Secondly, the portrayals of the scientists in *The Big Bang Theory* were compared to the stereotypical images of scientists. Since, according to the literature, the stereotypical images of male and female scientists are vastly different to each other, it was necessary to explore these images separately.

In this chapter, I will discuss how each of the main male characters' portrayals were different to each other and how they evolved through seasons 1-4 (with inclusions of responses about season 5 where appropriate). A few minor characters will also be discussed since the participants mentioned these characters on multiple occasions, with the majority of comments referring to the guest scientist characters David Underhill and Elizabeth Plimpton. Both the main and minor scientist characters provided different images of scientists, and have the potential to influence the participants' ideas of what scientists are like. Therefore, I will explore how the characters were seen by the focus group participants and attempt to answer the following question:

> How has *The Big Bang Theory* shaped peoples' ideas about who scientists are and what they do?

4.1 Cultivation theory and common scientist stereotypes

The image of scientists in television shows and movies has been an important area of research since science advocates commonly believe that these images of scientists could strongly affect the way the public perceives scientists in real life. This is associated with

what George Gerbner and his colleagues called cultivation analysis, also known as cultivation theory, which "determin[es] the conceptions of social reality that television tends to foster in different groups of viewers" (Gerbner, Gross, Morgan, & Signorielli, 1981, p.41). Gerbner and colleagues indicated that the general aim of cultivation analysis is to:

> determine whether those who spend more time with television are more likely to perceive social reality in ways that reflect the potential lessons of the television world [...] than are those who watch less television but are otherwise comparable (in terms of important demographic characteristics) to the heavy viewers (Gerbner, Gross, Morgan, Signorielli, & Shanahan, 2002, p.47).

Cultivation analysis has been applied to studying both science and scientists. Gerbner and colleagues (1981) used prime-time dramatic television shows with scientific content between 1969 and 1979 to investigate the public's attitude towards and confidence in science. Their findings indicated that most of the science portrayed was through negative images (such as violence, the exotic and dangerous 'future', natural disasters, illness and drugs). In addition, questions that arise from science issues on television are often not discussed and explained fully. As a result, misconceptions emerge, and this may lead to fear, causing the audience to be unfavourable towards science (Hamm, 1991). Gerbner and colleagues also identified that heavy television viewers were more distrusting of science comparing to light viewers regardless of age or income. However, Morgan and Shanahan (2010) noted in their review paper that:

> Television viewing correlated negatively with science knowledge, and greater knowledge was associated with having fewer reservations about science. The relationship between amount of viewing and reservations about science was thus partially mediated by science knowledge (p.347).

Gerbner and colleagues (1981) made similar observations that "Controlling for education reduces cultivation to small and non-significant proportions" (p.43). However, they also noted that there are still some sub-groups of people who are affected by extended television viewing even though they may be highly educated (i.e., college educated). Similarly, Dudo and colleagues (2011), in a recent study along similar lines, demonstrated, "Television viewing is negatively associated with knowledge of science,

which in turn is associated with more positive attitudes toward science" (p.769), but among highly educated viewers, those who are also heavy viewers are less positive about science. Despite the fact that these comments focus on science, the essence could be extrapolated for scientists since knowledge of scientists may have a meaningful impact on how people cultivate beliefs about scientists they see on television. It must be noted though, that in comparison to science being portrayed on television, scientists do not appear as frequently (Dudo et al., 2011), and they are "relatively rare and specialized dramatic character[s]" (Gerbner et al., 1981, p.42). As a result, Gerbner and colleagues grouped together science and scientists under the umbrella term 'science community'. However, the phrase 'science community' is possibly not representative of how audiences may cultivate beliefs about scientists based on extended television viewings. Therefore, there is a need for research studies specifically dedicated to understanding the cultivation effects television viewing has on people's beliefs about scientists. This is particularly important for this current study which attempts to understand how the audiences of *The Big Bang Theory* were affected by the portrayal of the scientist characters.

Some researchers have conducted studies based on cultivation theory to investigate how scientists have been portrayed and the image that the viewers may have cultivated after continuously watching television shows, but the audiences in these studies were mainly focused on children (e.g., Long, Boiarsky, & Thayer, 2001; Potts & Martinez, 1994). Gerbner's (1987) is one of the few (and the first) studies that investigated how adult viewers cultivate beliefs based on scientist characters on television. He found that audiences who watch entertainment television shows thought badly of scientists because they agreed with questions like "scientists are odd and peculiar people" and scientists "spend little time with their families" (p.114). These results suggested that US network prime-time dramatic programs during his study period 1973-1983, had painted the image of a scientist as an eccentric individual who dresses differently, has a lack of knowledge of the social world and prefers solitude. The viewers who watched more television (i.e. heavy-viewers) were more likely than those who watched less television (i.e. light-viewers) to agree with these negative images of scientists.

However, Gerbner's study did not explore its participants' reasons for their choices, rather the results were based on a Likert scale type data where the participants were to choose whether they agreed or disagreed with the statements, meaning the results only identified a correlation, not a causal relationship. Also, Gerbner's explanation of the way audiences foster negative beliefs about scientists stems from the fact that television scientists are being portrayed negatively. Therefore, axiomatically, one can argue that positive depictions of scientists on television can lead to audiences cultivating positive beliefs about scientists, if cultivation theory holds. Dudo and colleagues' (2011) study made similar observations to this idea, but with a focus on audiences' attitudes toward science. Their study used prime-time network television programs to determine how scientists are portrayed and found that even though there is only a small number of scientist characters in these network television programs, the vast majority (80.6%) were portrayed as 'good' people (i.e., hero-type protagonists). Dudo and colleagues argued that the reason their results has a:

> lack of a direct negative relationship between television use and science attitudes may be partially explained by our content findings: scientists, when they appear on television, are usually portrayed as "good." Perhaps this overall goodness outweighs the relative absence of science from the demography of television (p.796).

Again, science and scientists have been combined together to understand how audiences attitudes toward science have changed, rather than specifically focusing on how the audiences attitudes toward scientists have changed. What is interesting though, is that even though the majority of the scientists portrayed on television in the 21st century may be 'good' scientists, some of the 'negative' stereotypical characteristics, such as being eccentric individuals who prefer solitude, can still be incorporated in these characters. This raises the question, if scientists are still being portrayed using these 'negative' characteristics (e.g., eccentric or lonely) but as 'good' people (i.e., hero-type protagonists) on television, how does this affect the audiences? The characters on *The Big Bang Theory* could potentially shed light on this question. However, firstly, it is important to determine more specifically what a 'good' scientist character is, and what are the 'negative' characteristics that are associated with scientists. Therefore, the following

sections will explore studies which focus on the depiction of scientists in fiction.

Many studies have investigated how scientists have been portrayed in fiction, such as television shows, movies, and magazines. Hirsch (1958) analysed the image of scientists in American science fiction magazines from 1926 to 1950 and found that scientists have been divided into heroes and villains since the early 20th century. Despite the number of scientists featured as major characters in these stories, the overall numbers of scientists decreased between 1926 to 1950 with the number of heroes decreasing at a much faster rate than villains (Hirsch, 1958). However, when Hirsch analysed the number of villain characters in these magazine stories, he found that in comparison to other occupations (i.e. businessmen, politicians and criminals), scientists were more frequently featured as villains, with the exception of the wartime period between 1938 and 1945. This suggests that despite the number of scientist villains steadily decreasing, they were still considered to be more evil than other occupations. Haynes's (1994) analysis of the different scientists' portrayals in Western literature from the Middle Ages through to the 20th century supported this idea that scientists were usually depicted as villains since the majority of the scientist stereotypes she identified were negative portrayals.

Weingart and colleagues (2003) analysed 222 movies spanning eight decades to determine the types of scientists that have been portrayed in film. The authors specify what they define as a good scientist and an ambivalent scientist. Good, or benevolent, scientists tend to be "naive when dealing with powerful interests" (p.283), and ambivalent scientists tend to be:

> those who are easily manipulated; they are idealistic but become progressively corrupted; they are ambitious but lose sight of the consequences of their work; and, most importantly, they grow willing to violate ethical principles for the sake of gaining new knowledge (Weingart et al., 2003, p.283).

Based on this list of definitions that describe an ambivalent scientist, it is clear that the vast majority depict a bad scientist villain. It is important to make a distinction here that an ambivalent scientist is not necessarily a scientist villain, since they can be seen as a person who can be both good and bad. Therefore, scientists can no longer

be simply separated into 'good' or 'bad', but rather into three categories – 'good', 'ambivalent', 'bad'. It is also important to note that even though the authors recognised that a limitation of their sample of movies was that it is "not representative in the strict statistical sense, nor could it be, since the entire number of films showing scientists or science is unknown" (Weingart et al., 2003, p.282), they did not provide a list of the movies they analysed. Not only does this lack of a list of movies make it difficult to repeat their study, it is unknown how many of these scientist characters are good scientists and how many are ambivalent.

Weingart and colleagues noted that there is a disciplinary difference between the good scientists and the ambivalent scientists, with more good scientists in "Anthropology, astronomy, zoology, geology, and the humanities" (p.283), and more ambivalent scientists in "medical research, physics, chemistry, and psychology" (p.283). Therefore, it must be noted that the way scientists have been portrayed has continually evolved not only through different genres (e.g. science fiction, horror, and comedy) and different sources (e.g. movies, television shows, magazines), but also depend on the different science disciplines. Due to the different scientist stereotypes that have been depicted through these different genres and sources in the past decades and centuries, it is important to summarise here the most common scientist stereotypes to understand which stereotypes are positive and which are negative.

In a 2003 journal paper summarising her 1994 book, Haynes (2003) briefly discussed the common Western culture scientist stereotypes and concluded there were seven main types: (1) the evil alchemist, (2) the noble scientist, (3) the foolish scientist, (4) the inhuman researcher, (5) scientist as adventurer, (6) the mad, bad, dangerous scientist, and (7) the helpless scientist. In addition, Van Gorp, Rommes, and Emons (2014) analysed fictional and non-fictional television programs in the Netherlands and identified the most common scientist 'prototypes': (1) the genius, (2) the nerd, (3) the puzzler, (4) the adventurer, (5) the mad scientist, (6) the wizard, and (7) the misunderstood genius. The difference between a stereotype and a prototype is that the latter takes into account "all the stereotypes of a person in these professions, including aspects that are irrelevant to their professional roles, such as sex, ethnicity, appearance and attractiveness" (Van Gorp et al., 2014, p.647).

However, the majority of the scientist prototypes identified by Van Gorp and colleagues could be associated with those stereotypes listed by Haynes without taking account of the aspects 'irrelevant' to the professional roles, and thus I will include these prototypes in the following list of scientist stereotypes based on Haynes's (2003) paper. In addition, I will categorise these stereotypes as good, ambivalent, and bad scientists.

1. The evil alchemist: This type of scientist is often portrayed as someone who is secretive and isolated (both physically and socially), shown in laboratories with 'high-tech' gadgets and machines, and willing to push the boundaries of knowledge and create illegal and dangerous things and situations. This is a depiction of a bad scientist.

2. The noble scientist: This type of scientist is a selfless individual who focuses on using science to bring good to society. The idea of the noble scientist is based on team work and creating an open scientific community of sharing knowledge internationally. This can be associated with what Van Gorp and colleagues (2014) call *the wizard*. Although this prototype does not completely mirror Haynes's noble scientist, the wizard is a team player who supports others. The wizard is different in that they feel the science result is more important than the process of science, and that they are the "personification of a perception that science is the best or even only way to solve problems, as the ultimate answer to all questions that society faces" (Van Gorp et al., 2014, p.654). This is a depiction of a good scientist.

3. The foolish scientist: This type of scientist is generally more interested in new discoveries than the truth. They tend to be portrayed as obsessive and irresponsible, and often include the absent-minded professor who has the stereotypical trait of being oblivious to anything apart from the scientific research at hand. This can be related to what Van Gorp and colleagues (2014) describe as *the genius*, where the "characteristic often takes the form of absent-mindedness or confusion regarding everyday affairs, which symbolises their detachment from the world in which ordinary people live" (Van Gorp et al., 2014, p.652) despite being able to produce great inventions. This is a depiction of an ambivalent scientist.

4. The inhuman researcher: This type of scientist is a person "who has sacrificed his or her emotions and human relationships in an obsessive pursuit of scientific material-

ism" (Haynes, 2003, p.249). They often ignore and detach themselves from personal relationships and may take part in inhumane and unethical scientific research. This is a depiction of a bad scientist.

5. Scientist as adventurer: This type of scientist "conquer[s] the natural world and transcend[s] human limitations" (Haynes, 2003, p.250). Scientists as adventurers are heroes who overcome natural obstacles, and sometimes triumph over evil villains. Van Gorp and colleagues classified *the adventurer* as the "personification of the physically active scientist" (p.653). They are typically solving a science riddle that is appealing to the audience, which is "mysterious, spectacular, valuable, and therefore also valued" (p.653). Also, they usually "take on the role of hero in fiction stories ... [and are] willing to risk [their] life in the name of science" (Van Gorp et al., 2014, p.653). This is a depiction of a good scientist.

6. The mad, bad, dangerous scientist: This type of scientist is an exaggeration of the evil alchemist. Instead of being destructive on a small scale, they can cause destruction on the national, or even global scale, usually for a large sum of ransom money or to end the existence of a flawed world. In Van Gorp and colleagues' (2014) paper, they call this *the mad scientist*. This is a depiction of a bad scientist.

7. The helpless scientist: This type of scientist is a helpless victim who cannot control their own discovery or creation. They are shown as ignorant of the negative social implications of their research and "at worst, quick to suppress any such realization, lest their grants be cut" (Haynes, 2003, p.253). There are some similarities here to Van Gorp and colleagues' (2014) prototype of *the misunderstood genius* where the scientist "destabilise[s] the existing world order ... [and] gets into trouble when power elites consciously want to bring him into disrepute or others want to cash in on his inventions" (Van Gorp et al., 2014, p.654). The misunderstood genius is different to the helpless scientist because their discovery or invention will be recognised by peers eventually, rather than being established as having a negative impact on society. This is a depiction of a ambivalent scientist.

Two of the prototypes from Van Gorp and colleagues' work are vastly different to the stereotypes mentioned by Haynes (2003), making it difficult to incorporate these into

the above list. These prototypes are: *the puzzler* and *the nerd*. *The puzzlers* are obsessive about what they are interested in, more specifically having "endless patience to solve enigmas, the structure and precision applied and the satisfaction [they find] in working on the smallest detail" (Van Gorp et al., 2014, p.652). They tend to focus on the process of science and are shown to work systematically through their 'riddles' (Van Gorp et al., 2014). It is a depiction of an ambivalence scientist. *The nerd* prototype is similar to the puzzler since they are both obsessive about what they are interested in. However, they are different because:

> In fiction, lack of social skills is a defining component of the nerd, as is their intelligence and competence in their chosen subject. Because they deviate from the norms for social behaviour in many respects, they can still come across as "stupid" to others. However, it sometimes seems that the reaction of others does not bother them. Unlike the genius, however, the nerd also has opponents and he mostly works with computer technology, which is seen as less spectacular and sexy (Van Gorp et al., 2014, p.652).

The nerd prototype is a depiction of an ambivalent scientist. It is interesting though, that even though there were movies in the late 20th century which included the nerd prototype, such as *Revenge of the Nerds* (1984) and its sequels which had computer science college students as the protagonists, these were not mentioned in Haynes's (2003) paper. A reason for this may be that she categorised the nerd stereotype with 'The foolish scientist' given their overlapping traits of being obsessive and socially inept. Thus, while Van Gorp and colleagues have separated these two types of stereotypes, Haynes may have categorised them together. The similarity between the foolish scientist and the nerd could be seen through their common depictions in comedies, since the scientist is often seen "as an intellectual who is precariously stationed on the margins of acceptable cultural parameters, often socially inadequate and not practically intelligent" (Terzian & Grunzke, 2007, p.416).

It is interesting to note that Weingart and colleagues (2003) found "the strongest genre among films about science is the horror movie. By contrast, there are hardly any comedies about science. Evidently our society does not find much to laugh about in

science" (p.286). This suggests there hasn't been many opportunities to explore the foolish scientist and the nerd scientist as protagonists in comedies, thus it may have been difficult to clearly differentiate the difference between these two scientist stereotypes. Nonetheless, Haynes does mention the stereotypical traits associated with the nerd scientist as part of her description of the foolish scientist. These type of portrayal are particularly important for *The Big Bang Theory* for two reasons. The first reason is that the scientist characters exhibit stereotypical traits associated with nerds (which is most obvious when they interact with Penny). The second reason is that *The Big Bang Theory* is a comedy, making the nerd stereotype, as well as the foolish scientist (of what Van Gorp and colleagues call *the genius*), the most relevant stereotypes for this study. In the following, studies focusing on comedies are reviewed in order to better understand the depiction of the nerd/the foolish scientist.

Terzian and Grunzke (2007) analysed six Hollywood comedy films released between 1961 and 1965 where the main protagonists were scientist. They found that these scientists were often connected to higher education institutions, and despite the fact that they are "projected as respected figures for their expertise and roles as protectors of the republic, [they were] frequently lampooned as impractical and socially awkward misfits who betray the nuclear family" (Terzian & Grunzke, 2007, p.409). An example of a comedy film with a scientist character as a protagonist was discussed by R. Jones (1998), who analysed the British postwar era film *The Man in the White Suit* (1951). He found that the "scientists' separateness from 'normal' society is often signalled by differences in clothing and appearance ... [and] the outsider position is accompanied by a lack of understanding of the workings of society" (R. Jones, 1998, p.138-139). These descriptions reflected the nerd/the foolish scientist stereotypes in the 21st century, thus it would appear that the image of these scientists have survived since as early as the 1950s. Recently, Bednarek (2012) analysed one of the characters on *The Big Bang Theory*, Sheldon, in an attempt to demonstrate that he followed the nerd prototype. She expressed:

> Stereotypes or schemas are part of the relevant common ground that scriptwriters aim for. This includes schemas about social identities. In *The Big Bang Theory*, the most relevant social identity at stake seems to be that of the nerd

or geek (Bednarek, 2012, p.203).

Bednarek took a linguist's approach and used two methods to look at the characterisation of Sheldon, and concluded that he conformed to the image of a stereotypical nerd. In the first method, she identified the linguistic 'tags' in Sheldon's speech, such as the constant use of academic related language, like 'a number of' and 'a series of'. In the second method, she discussed Sheldon's behaviour by using an example from the episode *The Luminous Fish Effect* (S01E04) to demonstrate his lack of social norm understanding and other typical nerd-identified stereotypical traits. Based on her findings, Bednarek concluded that Sheldon followed the stereotypical nerd traits since his speech patterns are consistent with higher education academic language (Terzian & Grunzke, 2007), and he has a clear lack of social norm understanding (R. Jones, 1998; Terzian & Grunzke, 2007; Van Gorp et al., 2014). It would appear that the focus of the nerd prototype is generally described through their social standing (e.g., social incompetence) rather than their scientific work. This separates the nerd prototype with the foolish scientist stereotype, since the latter tends to be more focused on the scientific work rather than the social standing. In this case, since *The Big Bang Theory* mainly focuses on the social interactions, these characters are more closely related to the nerd stereotype.

What is still important to note though, is that the nerd stereotype depicts ambivalent scientists, rather than straightforward good or bad scientists. Therefore, in order to determine whether the scientists in *The Big Bang Theory* can help cultivate a positive image of scientists, another method must be used to determine whether the characters are positive or negative depictions of scientists. In this case, I will be using the stereotypical scientist's demographic characteristics.

Other than the stereotypical scientist behaviours described above, the appearance and the general demographic details of fictional scientists can also assist in providing a positive or negative image of scientists. For example, as noted above, Gerbner (1987) expressed that audiences thought badly of scientists because they agreed with statements such as "scientists are odd and peculiar people" who "spend little time with their families" (p.114). Axiomatically, this would also mean that if scientists were portrayed as normal

individuals as part of society, or people who spend quality time with other people, these depictions can potentially cultivate beliefs that scientists are good people (as opposed to a good scientist). Since the nerd prototype is mainly associated with the scientists' social standing, the depiction of a good person would be defined as a competently skilled scientist who is part of society (as opposed to deviating away from society). In addition, demographic details such age and ethnicity are also important to consider since they provide the opportunity to break the common stereotypical image of scientists being one specific type of person. Even though this demographic diversity may not directly affect the image of scientists being sociable people, it can potentially address this chapter's sub-question by creating a better understanding of who scientists are, and subsequently be a good outcome for science in general.

Many studies have investigated the stereotypical demographic characteristics associated with fictional and non-fictional scientists. Weingart and colleagues (2003) found that scientists in Hollywood films were typically Caucasian (96%), American (49%), male (82%), and middle aged (40% - roughly between 35 and 49 years old). Only 24% of the films portrayed scientists as youthful (between 20 to 34 years old). The majority of the films showed that scientists looked normal, rather than caricatures (Weingart et al., 2003). Furthermore, a third of the scientists were portrayed as single and more than a third did not disclose their relationship status. Very little of the private lives of scientists were depicted (Weingart et al., 2003). Again, it is difficult to identify which movies these scientist figures came from since Weingart and colleagues (2003) did not provide a list of their selected movies, thus it is difficult to determine whether the scientists the authors analysed were affected by selection biases.

Flores (2002) had similar findings when he analysed the depiction of physicians in 131 movies. He found that 91% of the physicians were white, 85% were male and 41% were in their 30s. It is interesting to note that even though there is a difference between medical physicians and research scientists, the statistics were roughly the same, especially when Flores (2002) excluded movies where the physicians only held a Ph.D. but not an M.D. It is unclear whether the similarity in the statistics between Weingart and colleagues' study and Flores' study is due to medical physicians regularly being grouped together with

research scientists, or due to other reasons. However, it is clear that research scientists also have these demographic traits.

Van Gorp and colleagues (2014) reported on the presentation of scientists and engineers in fiction and non-fiction Dutch media and showed that these scientists also demonstrated the general demographic trends Weingart and colleagues (2003) proposed. Van Gorp and colleagues (2014) noted that out of a total number of 381 science experts in Dutch *non-fiction* television programs, the majority of the scientists and technicians were male (78.7%) and white/Caucasian (96.3%). They also found that in non-fiction television programs, the age range of the experts was getting younger, with the number of scientists depicted as 19-35 years old increasing from 20% to 40% (Van Gorp et al., 2014). In contrast, the general appearance of the scientists presented on *fiction* television shows was somewhat different:

> the artists and actors who need to visualise a scientist draw on a repertoire of external features, such as masculinity, fuzzy hair, a bushy beard, a bald head, thick glasses and an eccentric or old-fashioned style of clothing. Iconic images of scientists like Einstein and Darwin are likely to have served as inspiration for this recognisable appearance. This depiction facilitates fiction producers in making the scientist easily recognisable for the audience (Van Gorp et al., 2014, p.656).

Long and colleagues (2001) also found the same problem in their study of more Caucasian scientists in comparison to minority scientists. They analysed children's educational television shows to determine the distribution of scientists' demographic traits, and also how knowledgeable they are, as a way to determine the scientist's professional statuses. Their results suggested that of scientists who appeared in the shows, there was no significant difference in the number of male and female scientists, and they were equally knowledgeable (Long et al., 2001). However, when comparing the ethnic distribution of the scientists, Long and colleagues noted there were more Caucasian scientists than 'minority' scientists (with a ratio of 3:1). It is not very clear what they classified as 'minority' though, since they listed African descent, Hispanics, Asians, and 'undetermined' as individual ethnicity categories without stating which of these fell into

their overarching 'minority' category.

This only became more confusing when one of my focus group participants, who is an American and works as an academic in astrophysics, asserted that *The Big Bang Theory* still maintained stereotypical traits that were only apparent to those who are from the US.

> I think they're still really honing in on the stereotypical scientist. They haven't shown any minorities ... In the United States, minority is typically associated with African Americans or Hispanics, that's just what it is, so they haven't done any of that. (F41SA)

The contradicting information with Long and colleague's (2001) categorisation of 'minority' and my participant's definition of what 'minority' is to an American causes confusion over what really counts as 'minority'. Nonetheless, Long and colleagues (2001) concluded that Caucasian scientists and 'minority' scientists were portrayed as equally knowledgeable.

It would appear that generally scientists portrayed on television tend to be older, white men. Their private lives and relationships are usually undisclosed, and their characters may be defined as either normal or eccentric. In addition to the typical behaviour described in the nerd prototype, that scientists are socially inept and are particularly competent in their chosen subject (Van Gorp et al., 2014), these traits can be used to determine whether the characters in *The Big Bang Theory* have been portrayed positively, or whether they have created a better understanding of who scientists are. It is important to remember though, that pre-existing images of scientists that the audiences hold will determine how they feel towards the characters on *The Big Bang Theory*, and whether it has helped cultivate a positive image of scientists or shaped people's ideas of scientists in general. Other than the possibility that the audiences will have personal experiences with scientists, their pre-existing images could also have been cultivated by scientists on television and movies in the past. Therefore, it is essential to understand how scientist stereotypes have evolved and developed.

Haynes (2003) found that the social and political world in which the movies were produced appeared to have strongly affected the development of the scientist stereotypes. An example is the stereotype of 'the boffin' described by R. Jones (1997). Jones analysed British films from 1945-1970, after World War Two. Boffins are different to the stereotypes listed above since they "work for the government, usually on weapons production ... [and] seems to derive from the actual social conditions prevailing in wartime Britain" (R. Jones, 1997, p.34). He also noted that of the three British films he analysed, *The Small Back Room* (1949), *The Dam Busters* (1954) and *Very Important Person* (1961), the image of the boffin became gradually more stereotypical through the years, "suggest[ing] that as the war became a less immediate presence in people's memories, the real situation of the scientists in wartime also faded from recall, leaving a rough outline in the stereotype" (R. Jones, 1997, p.45). Therefore, drawing a parallel with the creation of the boffin stereotype in the postwar era and the changes the stereotype went through, it is possible that the social and political world of the early 21st century could also affect the development of new scientist stereotypes, or change the pre-existing scientist stereotypes. In her 2014 paper, Haynes discussed changes to the scientist stereotypes, arguing that depictions of the mad, bad and dangerous scientist were decreasing:

> In the first decade of this century, even sporadically in the 1990s, this entrenched stereotype of the mad, bad scientist has been progressively eroded. A significant number of novels and films have now appeared in which scientist characters are no longer merely semiotic indicators of fearful threats, but modelled on ordinary people whose science intersects with their other human concerns - family, friendships, love, loss, grief and leisure (Haynes, 2014, p.5).

Haynes suggested the mad, bad and dangerous scientist image has become less common because real scientists are now often seen on television, for example as presenters on science documentaries. By constantly seeing scientists on television, the public becomes familiar with scientists, and rather than being shown as threatening or secretive, scientists become people who are "infectiously curious about our world, communicating what we want to know in language we understand" (Haynes, 2014, p.5). Also, being able to access scientific research through the Internet in the form of reviews and scientific papers, the public has the opportunity to educate themselves about science, suggesting "we no longer feel inferior

in scientific matters but, rather, empowered to form our own opinions, to make decisions, even to protest against research of which we may disapprove" (Haynes, 2014, p.6). Haynes also noted that there are now numerous novels and films in which the central protagonist is a scientist, which help portray a wider range of scientists and the various issues they may encounter. Haynes argued that in the 21st century, the evil and mad villain can be associated with other roles, such as terrorists, thus:

> the psychology of the unbalanced, evil mind is the real and abiding source of fear, but this is no longer attributed to scientists. The 'popularity' of the mad scientist as both fictional character and movie star has declined because we no longer need him (Haynes, 2014, p.12).

Not only can the social and political world specific to different eras affect the depiction of scientists in those particular eras, the development of new scientific understanding can also affect the science incorporated in the movies. Jörg (2003) compared the three film versions of *The Island of Dr. Moreau* (1932, 1977, 1996) and noted the science in the films evolved in parallel to the development of genetics, such that:

> each variation of Dr. Moreau absorbs the increase in knowledge of the twentieth century, especially in the field of the life sciences, and echoes what people felt about science during the period of release: eugenics in the 1930s; sociobiology in the 1970s; and genetic engineering in the 1990s (p.303).

Due to the constant development of newer scientist stereotypes and the phasing out of older scientist stereotypes, it is difficult to determine what sort of image of scientists the public has cultivated. It becomes even more difficult when the public do not cultivate information from the media exclusively, rather people will incorporate their own understandings and experiences with these images to form personalised images of scientists, as well as science in general. Orthia and colleagues (2012) demonstrated that audiences respond to the same text, in this case the episode 'Lisa the Skeptic' from *The Simpsons*, differently due to their personal experiences and views towards various aspects of society. Through a qualitative study using focus groups, Orthia and colleagues concluded their participants saw the message within the episode and the interaction between science

and religion in different ways in accordance with their personal views of science and religion, as well as their "awareness of the genre and familiarity with television production conventions" (Orthia et al., 2012, p.161). Therefore, the different ways their participants processed and reproduced the content of the episode

> suggests that there are factors, difficult to define, that have a strong bearing on the way people process the science they encounter. This is consistent with a constructivist account of how people build their knowledge of science and shows that deficit model assumptions are misguided (Orthia et al., 2012, p.170).

Accordingly, one of the areas of interest in this study was to investigate how the participants' pre-existing images of scientists were consistent with or different from the main male scientists in *The Big Bang Theory*, and whether the show's portrayals affected their pre-existing images. I discuss the participants' opinions of the main characters to identify the aspects where *The Big Bang Theory* followed or defied their expectations of scientist stereotypes, as well as how the participants saw the minor characters, who only appeared on the show a few times, since they had the potential to be portrayed in a different light to the main characters. This is to observe whether the audiences of *The Big Bang Theory* saw these characters as positive or negative depictions of scientists. By doing this, it may be possible to determine whether *The Big Bang Theory* represents a new paradigm in images of scientists, moving away from stereotypes identified by scholars so far. I then discuss whether the participants' pre-existing images of scientists changed after they watched *The Big Bang Theory* as a way to determine if this study gives support to cultivation theory's hypothesis, which states that extended viewing of television shows cultivates beliefs about scientists.

4.2 Character portrayals and stereotyping

Participants' opinions about whether the main characters were stereotypical ranged from 'absolutely not' to 'yes, extremely', and everything in between. In order to classify the different groups of responses along this continuum of stereotypical portrayals, I present the individual responses to pinpoint specific ideas. To begin, I discuss responses that suggested the characters are extremely stereotyped and the participants' justifications of

why it was necessary for the writers of the show to create these types of characters. Then I examine how some participants saw the characters as having only some certain traits of scientist stereotypes. Lastly, I discuss the responses where participants indicated that they thought the main characters of the show strongly differed from scientist stereotypes, and I also discuss the portrayal of the minor scientist characters. The purpose of this section is to determine whether the participants felt the depiction of scientists in *The Big Bang Theory* was positive or negative, and how these positive and negative images relate to different degrees on the stereotypical portrayal continuum. This is important since if audiences cultivated beliefs based on the scientist characters in *The Big Bang Theory*, it may affect their overall perception of who scientists are.

4.2.1 Characters as extremely stereotyped

Various comments highlighted the participants' views that the characters are "exaggerations of the stereotypes" (F29SP) and "they're all right at the very edge" (F52NSNA) of the continuum, and that "everyone is turned up to 11, even Leonard because [of] his tendency to back out of things is much more than I would be expect normal person to have" (M48NSNA). They are "unusual caricatures" (M40SA) because the writers are "magnifying the aspect of their personality" (F28SNA). Participants noted that they "haven't met any scientists like that at all" (F21SP) but the characters are "fitting people's stereotype, [with the way] they act and speak strangely" (M25NSNA) and being "a bit eccentric in some aspects than the other [people]" (M26SP).

> There is that one comment when they're fighting their robots and Howard was depressed because he got turned down by a girl and [Barry Kripke] said "well, we're all awkward and turned down by girls, that's why we fight robots." So that was sort of a stereotypical thing there ... There was that [time] when they were competing for the office and they couldn't play sports ... that was a very stereotypical thing. (M26SP)

According to the participants, the writers "magnified the aspects of the characters to make it funny" (F28SNA), the characters "represent more of the extreme cases to entertain the viewers" (M24SU), and "it reinforces the stereotypes of scientists, I think that's why it's funny" (F26NSNA). This was often used to justify why the characters are portrayed

this way, since participants asserted "if they didn't take the stereotypes and pushed them to extremes it wouldn't be funny anymore" (F23SP) and that "they are meant to be comic characters and to do that they have exaggerated certain aspects of them" (M48SA), such as taking "a type [of person] or a trait or whatever and take it to crazy lengths" (F23NSNA).

> I like it because it's a spoof of physicists. And maybe it's because I'm not a physicist and physics is something that I've never really taken to but I think I like it for the same sort of reasons that I might like watching the *IT Crowd* ... because they are taking the piss of certain really obscure professions and I think they do it in quite a funny way. The *IT Crowd* is very funny and *Big Bang Theory* for me, it's funny for similar reasons because they are taken to extreme. But physicists do kind of fall into those categories and I think the four characters, they just illustrate what I see in physicists and I find that funny. (F28SP)

However, the disadvantage to this is "it makes them amusing characters but not necessarily representative" (M33SP).

> I would argue that pretty much any comedy relies on stereotypes and preconceived notions of people's personalities associated with particular aspects, whether it be occupation or lifestyle or whatever it might be in order to create humorous situations. (F19SU)

> I think the characters have to be [stereotyped] in TV to a certain extent – because it's a symbolic kind of medium you have to use a symbol to represent a whole. So you can't show absolutely everything in a character because you just don't have the time, so you have to use kind of a shorthand, which means using stereotypes. But I don't think that it's done in a negative way, I think it's just done because that's the way that medium works. (F38SNA)

Occasionally, the exaggerated stereotypes were considered a negative depiction of scientists. For example, a science academic used the characters' appearances to describe how *The Big Bang Theory* followed the usual stereotypes that often appear on television, including those which are not considered to be scientist stereotypes.

> What is still stereotypical about the show is that they have one good looking scientist on the show who turned out to be a jerk because he cheated on his wife with Penny ... Bernadette is gorgeous I think, but they gave her that neezly voice ... The women on the show are not particularly good looking and smart, and the men are not particularly good looking and smart, so there are still some stereotypes I think they are emphasising. (F41SA)

Some non-science participants also felt the same way, and indicated that these portrayals demonstrated how eccentric the scientists in *The Big Bang Theory* are.

> I think they are all quirky, like all very quirky. Because in real life, of course there's no normal person in real life but we still behave on social norms ... whereas it's so blatantly clear all of them are so quirky, and we see every single one of them has a weird problem. (F21NSU)

> I think lots of shows get accused of making something too glamorous, but this is the other way round. They take everything out of it and make it sort of really concentrated and geeky. And I'm like "well, not all scientists are like, stay the whole time in their labs or like writing on their board all the time." Like not everyone does that. (F20NSU)

> I think the character of Sheldon, sometimes it steps over to the uncanny valley. I find it hard to believe anyone who really was like that could function at all in society because I don't think people would enable someone who was that annoying, enable him in quite that way. (F52NSNA)

As a result, many science participants still recognised that the show is "just playing on stereotypes, because that's not the way I view scientists but it's probably the way other people view scientists" (F21SP), and that it may have been used as a shorthand to represent scientists "through Penny's perception, or the non-scientific interpretation of the stereotypes and the assumptions that people make" (F19SU). This prompted another science participant to assert "I want this show to be more realistic, not this kind of extreme" stereotyping since "I wouldn't like if the program actually aided the stereotypes" (M26SP). However, presenting scientists through this shorthand depiction can potentially

cause problems. A science participant who had experience teaching children about the field of science expressed that the portrayals in *The Big Bang Theory* didn't help with promoting a 'normal' image.

> When we talk about [the work we do at the national research organisation], we try to get kids to realise that science is just normal and they don't always wear lab coats. So [*The Big Bang Theory*] is kind of saying something a little bit different, but hopefully most people can kind of understand that [they're just] stereotyped. (F33SP)

Even though the portrayal of the characters in *The Big Bang Theory* were considered stereotyped, not all participants considered these negative depictions of scientists.

> I feel that they're treated with respect, like the characters are treated with respect and with empathy and genuine appreciation, and indulgence and warm heartedness towards them. Rather than as an object of derision or mockery or something to laugh at, so I think they're treated well. (F38SNA)

Some participants appreciated this positive depiction of scientists since "it shows them as flawed characters, but in a way that's kind of a good thing. It's almost endearing" (F28NSNA). Another non-science participant also appreciated these portrayals, but rather than being an endearing portrayal, this participant felt it was an empowering portrayal:

> I find it empowering, as someone who is geek identifying or nerd identifying. And you often see geeks stereotyped in particular ways on TV, and I think that the way that there are four characters each with their own foibles kind of constructs a more three-dimensional notion of what it means to be a geek or a nerd. And so while each of the [characters] are a stereotype in and of themselves, put together you kind of get this three-dimension[al] picture of actually what it's like to be nerd and how they are real people as well. I really identify with just the scenes of the four of them throwing ideas around. [It] kind of makes me feel like that's me represented in TV. (M26NSNA)

Some science participants also felt that the scientists on *The Big Bang Theory* were positive depictions of scientists, and that the characters were "extremes of recognisable

behaviour types" (M48SA) and "they're caricatures of real people" (F28SP). Therefore, the characters' portrayals are "very accurate stereotypes" (M26SP) and the personalities "are within normal range" (M19SU).

> I think part of the reason it's good is that there is something actually realistic about each of the characters. It's not too far from reality in physics, and a lot of people know a scientist and they can probably put them in a category of one of those characters. (F37SA)

In particular, the participants associated the unique portrayal of the character Sheldon with having a mental disorder, specifically Asperger's syndrome. Many participants mentioned this in the focus groups, and despite the producers denying that Sheldon has Asperger's syndrome (Collins, 2009), the participants recognised that "Sheldon has probably [got] some kind of disorder" (M25NSNA), whereas others thought that Asperger's syndrome is not limited to scientists since "a friend of mine ... he's almost [the] spitting image of Sheldon in just about every way except that he's not a scientist" (F38SNA). However, the fact that Sheldon portrays someone with Asperger's syndrome-like traits was considered a positive image since he is representing real people:

> I think I do like the way that the four main characters are portrayed because to me it rings very true. I'm sure I've met people who really are like that. I mean people like Sheldon do exist, like he has Asperger's and I've met people with Asperger's. And okay, maybe they're not as extreme but it's a stereotype [and] he is representing people who do exist. (F28SP)

> Out of the scientist mates that I've got, some of them have Asperger's and things like that which can lend themselves to excelling in science, sometimes at the cost of social interactions and stuff. But then I also know linguists and mathematicians and people outside of your technical sciences. (M32NSNA)

It would appear that there is roughly equal division between people who felt the exaggerated portrayals of the scientist characters were positive and those who felt it was negative. However, the reasons people felt these portrayals were either positive or negative were different. Non-science participants mainly expressed that these images are exaggerations of unrecognisable stereotypes. Science participants indicated that these stereotypes

are a shorthand for describing how people like Penny saw scientists. On the other hand, there were participants who felt that even though the characters are exaggerated stereotypes, it is still a positive depiction of scientists. A few of the non-science participants indicated that these portrayals are endearing, and sometime empowering. As for the science participants, they expressed these are positive images because the stereotypes are based on recognisable scientist behaviours. This was especially the case for Sheldon and Asperger's syndrome. What was interesting to note was that both science and scientists indicated they recognise traits associated with Asperger's syndrome, and that Sheldon is representing real people, irrespective of whether these people are scientists or not.

4.2.2 Characters retained some stereotypical behaviours and traits

Despite the fact that many participants considered the characters to be extremely stereotyped, often they identified a difference between an exaggerated scientist stereotype, and a character with exaggerated traits that could also be associated with normal people. This moves across the continuum from extremely stereotyped to the characters retaining a handful of traits that could be associated with the stereotypical scientist.

> I think that they are exaggerated characters but I don't know that they're necessarily exaggerated scientists. Like I think Raj is an exaggerated guy who is really afraid of women or something like that, and well, Sheldon just has Asperger's or something. And Howard is in a very exaggerated way insecure. But I don't know if that's in my mind a scientist or just like regular people problems. (F26NSNA)

> It's more about what sort of stereotype characteristics would a scientist [have]. Because there is a mix of them, I think you've got to consider them all together as a package of qualities and characteristics that make up a scientist, so it just shows that any one of them is not a pure picture of a real scientist. Some of them might be like Sheldon, and some of them might be like the others. But more than anything, them all together, they're just ordinary people. It's just their jobs sort of thing. (M54NSNA)

One positive image was the characters' fashion sense. Both science and non-science (and mainly female) participants discussed the characters' fashion sense, and how their

"dress sense is not the same dress sense [as stereotypical scientists] but it's still not what you would call mainstream dress sense" (F31NSNA). Although the characters are not considered as "dressing fancy" (F35NSNA) everyday, "they all have distinct styles ... Sheldon's T-shirts are all very nerdy, or very scientific" (F34NSNA). Therefore, the positive depiction of scientists is that "these are young people with their own fads and fashions and idiosyncrasies" (F53SP). This was particularly interesting since a few participants compared this to the common portrayal of scientists wearing lab coats by asserting that "you don't see a white lab coat in the show which is good, not that science needs a lab coat" (M54NSNA), perhaps with the exception where "Amy wears a lab coat but it's expected in a bio lab" (F28SNA).

The stereotypical scientist traits were also discussed, but it was mainly about how these traits contributed to a negative image of scientists. One concept that a few of the non-scientist participants mentioned was the concept of elitism, describing how the scientist characters saw themselves as superior to other characters, including, at times, other scientists themselves. The representation of elitism in *The Big Bang Theory* stretches further than the science community into social interactions with people in the non-science realm.

> I do observe that the show is portraying scientists as a bit elitist, [and] not for the common person. I don't like that very much as a concept. I think they work on making science relevant to everyone rather than elitist. The best example of that was when they were just showing how dumb the boyfriend was that Penny brought home, it's like "blow up the moon!" And they were looking at each other, and Sheldon agreed that was pretty stupid ... They do refer to scientists but I think they look down on commercial scientists. It's a bit elitist still, [I] tend to think. (M54NSNA)

However, another non-science participant argued that *The Big Bang Theory* is a show about interactions, and thus has the capability to link different groups of audiences to society, including those who belong to exclusive or elitist groups, making these elitist traits a positive depiction of scientists.

> It somehow brings in people who belong to this incredibly what seems to [be]

> either exclusive or elitist, or sometimes both, environment and bringing them back into the world of humanity. And I kind of think maybe it's brought me [as a philosophy graduate] closer to the rest of the world. (F23NSNA)

Similarly, *The Big Bang Theory* also has the potential to do the same for linking the nerd and geek culture to society since the characters portray "more of an interaction between normal people and the nerdy people" (M19SU). One participant felt that this was the purpose of Leonard, where he is "sort of in a way a bridge from the group of geeks to the more mainstream I think. He's the one who's probably closest to being normal" (M53NSNA). What is important to note here, is that even though some participants appeared to naturally refer to these scientist characters as 'nerds' or 'geeks', other participants argued that "the show makes all the scientists look kind of nerdy, and that's not really true" (F22NSU). Both science and non-science participants argued, based on personal experiences, that scientists are not all geeky or nerdy, and not all geeks and nerds are scientists.

> It is kind of geeky and how they make it that they're all into comic books and all those sort of things and like Star Wars bed sheets and all those sort of things. It portrays them really stereotypically geeky, which is different to the way I've viewed them [scientists]. (F21SU)

> I certainly know people that are a lot like them and some are in science and some aren't. So I just kind of see them as geeky characters who happen to be scientists rather than scientists are geeky. (M28SNA)

> To a certain extent they could have possibly been lawyers or historians. They didn't necessarily need to be scientists to have that whole sort of social awkwardness and geeky-ness about them. (F26NSNA)

Therefore, even though portraying the characters interacting with society could potentially link geek and nerd culture to society (a positive image), it also suggests to some audiences that all scientists are geeks and nerds (a negative image). In addition, these comments suggest that the nerd stereotype could be considered separable from the other scientist stereotypes, because it could equally apply to characters from other

professions. This is indeed a possibility, however, researchers have often extrapolated stereotypical traits from other scientist stereotypes to describe other professions as well. Examples include Van Gorp and colleagues' (2014) description of *the puzzler* as the "detective [like Sherlock Holmes] among the scientists" (p.653), and Haynes' (2014) described that the mad scientists role as the "unbalanced, evil mind" has been replaced by terrorists as the "new face of terror" (p.12).

It may be noted that apart from the scientist stereotype and the geek stereotype, the characters also displayed traits of various other stereotypes that can be related to scientists, such as a cultural stereotype. One particular example was in regard to Raj's cultural background, where he brings "multiculturalism with him [into] that little group" (F35NSNA). A science participant asserted Raj was a good fit into the group because, based on cultural stereotypes, "Indians are really big on science and physics ... Indians [are] quite a large academic type" (F22SU). Another example of the cultural stereotype was Howard with his Jewish background.

> Also [with] Raj, it could be a cultural thing as well, like he can't talk to women, because aside from that he's pretty normal. I mean he does his nerdy stuff. And even Howard just being Jewish as well. There are cultural things in the show that might not necessarily relate to the science bit of it. They might change who they are so I guess what the show has shown is that it's not only scientists are this way, but when you have a scientist with a different cultural belief or something, maybe that's the way they'll interact with the rest. (M25NSNA)

Even though the cultural stereotype may be a positive depiction of scientists by expanding on the stereotypical image of scientists mainly being white or Caucasian, a non-science participant felt that this portrayal of Raj's Indian heritage could possibly "be culturally insensitive a little bit" (F28NSNA), and this also applied to Howard and his Jewish stereotype.

> You've got the very Jewish one and the very Indian one and it's a bit simple, [like] the stereotyping of those people into particular ethnic groups. If it wasn't a comedy it could be offensive, but I think it's not they're negative about their particular cultural backgrounds. It's just that it's so obvious. (F44SNA)

Again, there were mixed responses in regard to whether the portrayals of the scientists in *The Big Bang Theory* were positive depictions or negative depictions, except for the fashion sense where the participants appreciated the most of the characters did not wear lab coats. The mixed responses from the participants highlighted the 'pros' and 'cons' of portraying scientists in different ways. For example, two individual non-science participants had different views towards the way the characters have been portrayed as elitist, with one participant indicating it is bad to portray scientists looking down on non-science people or commercial scientists, and the other indicating that it is good to portray elitist scientists interacting with society. These contradictory responses also applied to the geek/nerd stereotypes, as well as cultural stereotypes.

4.2.3 Characters breaking stereotypes

At the end of the continuum were responses that indicated the characters are a "different portrayal of scientists to the usual mad scientist sort of cliché. Usually when scientists [are] on television, it's creating monsters" (M53NSNA), and "it's nice to have a variety" (M48SA). The characters helped portray other aspects of scientist behaviour that were often surprising for the focus group participants. The aspects ranged from scientists having a sense of humour, to having personal lives, and building relationships. Many participants found the idea of scientists having personal lives a refreshing concept. This may have been because showing the characters involved in everyday life "makes them not look crazy, but fun" (M30SP). This idea resonated with both science and non-science participants.

> [It] decodes what a scientist is ... so just looking at what they do after they finish work, [and] the likeability. So I guess most people would have this inherent belief that "oh, scientists are always doing work, always thinking about what they have to do the next day" but it shows that they also have a life as well so that's interesting. (M25NSNA)

> It changed them a little bit because I guess mostly the stereotypes that I've seen are showing the stereotype of the scientist that works in a laboratory or in their day-to-day work. And this is showing the stereotype of the scientist outside their comfort zone of their lab. So it's showing the stereotype of the scientist interacting with the rest of the world and that's different, that's not

> something I've seen before. (F38SNA)

A benefit of portraying scientists in an everyday situation is that it increases the curiosity factor about a physicist's life.

> For some part yes, I want to talk with real [physicists]. I feel like from this point of view, before I didn't care, I mean I become friends [with them] if we have same interest or something like that, but I just want to talk [because of] my curiosities now. Because I've seen this [show] and now I have [this] kind of interest [in] how they are in real life. (F30SP)

Also, it would seem that participants were surprised that scientists "can be funny [and] approachable" (F26NSNA) and "I find them all likeable to some extent and able to be related to" (F44SNA). Also, there is "a lot of humour, especially with Sheldon. I was kind of surprised by how socially awkward he was" (F21SU) but "Sheldon can be likeable" (F37SA).

> I think maybe that a lot of it is mocking themselves and each other, [which] allows the public to come in and not feel like they have to take scientists so seriously or they're less likeable people. (F53SP)

The majority of the comments were about how scientists were portrayed as being able to interact with people and form friendships, which strongly contradicted the stereotypical image of scientists as solitary individuals, characteristic of the evil alchemist and the inhuman scientist (Haynes, 2003). It may also be because *The Big Bang Theory* is a show about scientists, and it would have affected the entertainment nature of the show if the characters were portrayed as lonely individuals since the show is based on interactions between the characters. The participants felt that from these portrayals, scientists "can be easy to talk to because Penny talks to them" (F26NSNA) and "they have the desire to have [a] normal life and have more friends or someone to talk to" (F26NSNA). Examples were provided by the participants like "when Amy Farrah Fowler decides that Penny is her best friend, they accept that and they sort of become friends" (M23SP) and it's interesting "to see Sheldon interacting with a member of the opposite sex and seeing how that works" (F21SU). It is surprising that many of these responses were made by science participants

and discussed different types of relationships, such as friendship, romantic relationships, and family.

> You often think of the scientist as singular. To have a group of scientists interacting and having a great time together, I enjoy the fact that they can just be together which is something you don't often see in science actually. I mean, yes, in teams but not socially like that and supporting each other and glorying [in it], and also the tolerance. (F53SP)

> They're not ashamed of who they are but they still want something more like everybody. You want relationships with people, [like] loving relationships and families and things like that. It's about that struggle that everybody goes through, it doesn't matter who you are ... I know plenty of people who are very religious who are scientists so [religion and science] can co-exist, but it can cause a lot of volatile situations that don't need to be when people get on their high horse one way or another and they just want to butt heads ... I think it also shows too that people who are fundamentally different, like your socially active young woman and your nerdy scientist guy can actually interact and have a meaningful relationship that can grow and that works. Even though from a stereotypical point of view, they are fundamentally different and really shouldn't even acknowledge each other's existence. And I think that's really important that different people can be friends with each other and have a working relationship. (F30SP)

> Like their [relationship with their] families, so you have Sheldon coming from an uneducated kind of family who doesn't get him and in fact has got him tested to see if he is insane. And then some[one] like Leonard whose parents are brilliant and who are kind of divorced from humanity. I myself have parents who are actually a lot closer to Sheldon's so when he has his issues with his family, that relates very closely to my experience. (M25SP)

However, one science participant felt "they're a bit more obsessed by women than most of the scientists that I know, a lot of the scientists I know" (F38SNA). Other participants

also asserted that the male characters' attempts to have romantic relationships was a surprise to them.

> None of the guys I've met are super extreme, [or] like crazy about their work and always talking technically. And never known any of them get laid ever, like they never have girlfriends. So that was one of the things about the show that kind of surprised me. They actually date fairly regularly for guys who don't know how to talk to women. (F26NSNA)

> I was just so surprised that [Howard] was so expressive and kept hitting on women. I mean I understand the psychology behind it like why he keeps hitting on women because if he doesn't then he's never going to get laid because he's not attractive. I just expected him to be quieter and, [it's] not the stereotype I expected. (F22SU)

Presenting scientists which break the stereotypes "humanises the stereotypes rather than reinforces them" (F23NSNA) and shows "scientists are people, too" (M25SP) but that they are also "flawed" (M48SA). Participants asserted that "I think it is actually showing a picture to the public that scientists are human beings" (M40SA), especially when "normal people don't associate themselves with [them]" (M27SP). They further justified that this was the purpose of "Leonard, [who] has common sense. Some scientists can have absolutely no common sense whatsoever, but it shows he has fun at the same time" (F19SU) since "Leonard is normal but does science" (F19SU). Many participants also felt the characters were humanised rather than unique individuals, which contributed to their enjoyment of the show.

> I think it was good to maybe humanise scientists, showing them organising social outings and all that sort of stuff. Whereas you've got the stereotypes where they're just inside all day and doing their research or whatever. (F29NSNA)

> I think it's not afraid to show the nerdy side of scientists and science, and I love that because they glory in it. They're the 'in' crowd and the stereotypes, especially Sheldon, it's tempting to think that there are elements that exist in scientists that these characters represent . . . but I just delight in it. The characters themselves, the stereotypes they represent and the wit, they're pretty up

> front about who they are and the fact that they have particular interests . . . It changes for me the stereotype of the scientist and now I have other stereotypes to enjoy. It's a much more enjoyable, more human stereotype. (F53SP)

> I think the characters are also portrayed as cool in their own way, like they don't get women and they're a bit hopeless and stuff but they're funny. They're all funny, and that's something that we all appreciate. (F28SP)

By attempting to humanise the scientist characters in the show, it has the benefit of addressing a variation of the typical scientist stereotype which may not be immediately apparent and encourage more tolerance towards them.

> Even if the outing is seen as being nerdy and stuff like that, the fact that it is still going out and doing things like playing laser tag and stuff. I mean I do that every Monday night . . . but it's still largely very social which I think that the mainstream non-nerdy culture doesn't realise. (M32NSNA)

> I can maybe see some astronomers as more human now I guess, because you get the parts of their personality that would probably irritate me. Some people that I used to work with in particular I started seeing them as more human. And I guess that it was more open-minded because I even like Sheldon, I mean I actually think the show would not be the same without Sheldon and I really like him even though he would be so irritating to be around. (F37SA)

The youth aspect of the characters appeared to be one of the factors that contradicted the scientist stereotypes since "they're much younger" (F31NSNA) and they're "your own age, rather than the old stereotype" (F53SP). The main characters in *The Big Bang Theory* also introduced ideas about scientists which are not portrayed in the scientist stereotype, like money – where "they're less worried about external revenue earnings than most of the scientists I know" (F38SNA). However, the characters in the show "don't have a problem, they have enough money to do things to buy their comic books and things" (M54NSNA), and they are portrayed as "rich in the show and I didn't think scientists are that rich, because they always eat takeaway food and they have every [gaming] console ever made" (F21NSU).

> I think in one of the recent episodes they went to the comic book shop and just bought the sword from *Game of Thrones* . . . [He just] pulled out $200 from his pocket and I was like "what? how did you have the money in your pockets?" So it's a bit crazy. (F20NSU)

It would appear that all of the responses that discussed the characters breaking scientist stereotypes are positive depictions of scientists. In particular, the characters break the stereotypes mainly through interactions with other people, but also through being depicted doing different activities during their personal lives, and that scientists can have a sense of humour or can be funny. By portraying scientists in these ways, it helps to develop a more humanised scientist stereotype, even if they still follow some traits described by the nerd prototype (Van Gorp et al., 2014). However, there were two aspects which the participants were ambivalent about – money and obsessed with women. Although these are not negative portrayals, the participants did not indicate these are positive portrayals either. These two aspects demonstrated that portrayals which help break the scientist stereotypes are not necessarily all positive depictions.

An explanation of why the characters' portrayals ranged from extremely stereotyped to breaking the stereotype was that *The Big Bang Theory* develops the main characters season after season. As many participants indicated, their personalities "grow and develop" (F28NSNA), and "that as the characters develop it shows that they are able to be more than the stereotypes" (M54NSNA) by becoming more socially adapted, as well as more socially aware of their surroundings. Two participants identified different reasons why the characters develop season after season. One accredited the show's writers as attempting to expand and break the stereotypes, and the other demonstrated the influences that different individuals will have on each other.

> I thought the depiction showed they had to conform a bit more [to] what a general audience would expect but thought it was a little bit extreme. But then that has changed over the course of the show. Like they were extremely awkward and inept in the first couple [of seasons] and then it has quite a bit of growth for the characters . . . It's presenting a familiar sort of package they have people to deal with first and a driver for the humour. And then once people got

> used to that and laugh with them and start identifying these stereotypes, they could broaden the characters and then introduce [a] broader range of people in [the] same sort of fields. And so they can demonstrate to people who didn't know scientists that, yes there is this broader range of people out there and you don't have to pigeon-hole people in this sort of thing. (M29NSNA)

> There are elements that they can change. Some will stick to their stereotypes but they're also changeable, they're changing people ... On one end you have Sheldon and Amy Farrah Fowler who's become more sociable and bit more wanting to be around people. And you see Penny as well wanting to be smarter after dating Leonard and she starts dating the other guy, the one who's the absolute idiot and breaks up with him and she's like "You ruined me! I can't handle the dumb guys any more." And it sort of shows that she changes as well and they work together to change, and it's really important for me. I've noticed that it's about 'here are these stereotypes' but just because someone fits to that sort of stereotype doesn't mean that you can't relate with them and work with them and be friends with them, and some of those things change, and people change as well. (M23SP)

4.2.4 Portrayal of minor scientist characters

The minor scientists in *The Big Bang Theory* were also discussed during the focus groups and their portrayals were compared to those of the main characters. Occasionally, the minor characters were believed to hold less stereotypical traits than the main characters. An explanation of why this was the case was proposed by some participants.

> You can also look at the other scientists that are portrayed in the show and they seem remarkably normal people in comparison. So in some way you could argue by isolating the nucleus of the group and just showing how weird they are, actually most scientists are perfectly normal. It's just a few of them are really weird. (M43NSNA)

> You are only getting a glimpse of those other [minor characters] so the other way you could look at it is, the only reason we're seeing the difficulties [in

> the main characters is] because we're going so deep into the day-to-day nitty gritty ... You're only seeing it from one perspective. You could look at that [minor characters] group and say "well I wonder if they are equally as bent and twisted" if you focused on them as opposed to focused on these [main] people. (F43NSNA)

> I think they're trying to show that scientists can be different as well with that. Remember the one of the really famous scientists who's really good looking? So he had the looks and he's smart, so I guess Leonard feels really jealous that he had both. I mean you would always think that you can either have one or the other like the type like Penny, or you're like the other guys. But when someone has both then that really might hit you, but it happens in reality as well. (M25NSNA)

The two minor 'recurring' scientists which the participants used as contrasts were Barry Kripke and Leslie Winkle. Barry Kripke (John Ross Bowie) has been a recurring character since season 2, working as a plasma physicist at Caltech with a distinct speech impediment. He is portrayed as Sheldon's nemesis throughout the series and a competitor in the physics department. Leslie Winkle (Sara Gilbert) was an experimental physicist who shared a physics lab with Leonard. She was portrayed as a strong, independent woman who often had arguments with Sheldon, but was also sexually active with Leonard and Howard. Leslie was a series regular in the first few seasons of the show, but has since left. The discussions around Leslie Winkle were divided into two areas: Leslie as a minor character and Leslie as a female scientist. The participant responses which discussed Leslie's representations as a minor character will be discussed in this current section, whereas the comments that investigated her portrayal as a female scientist will be presented in the following chapter on female scientists.

In addition, multiple guest stars who appeared on the show as 'one-off' scientists were also considered for this discussion as they portrayed scientists in a very different light. The two minor characters that were most discussed were David Underhill and Elizabeth Plimpton. David Underhill (Michael Trucco) was introduced in the episode *The Bath Item Gift Hypothesis* (S02E11) as an experimental physicist who was visiting

Caltech and asked Leonard to help him with his research. He was portrayed as a handsome, charming, cool and successful physicist who rode a motorbike. He also began dating Penny in this episode. However, it was revealed at the end of the episode that David Underhill was married and Penny subsequently ended the relationship. Elizabeth Plimpton (Judy Greer) was introduced in the episode *The Plimpton Stimulation* (S03E21) as a cosmologist from Princeton University who stayed with Sheldon and Leonard while on a visit to Caltech. She was portrayed as sexually active throughout the episode and attempted to sleep with Leonard, Howard and Raj. Other minor characters who were also mentioned, but to a lesser extent, included Professor Crawley in *The Jiminy Conjecture* (S03E02) and Dennis Kim in *The Jerusalem Duality* (S01E12). Professor Crawley was an entomologist who appeared in a short scene where he was furious because he lost his entomology lab to the physics department due to funding cuts. Dennis Kim was a North Korean boy genius who was invited to work at Caltech in the field of physics. He was portrayed as smarter than Sheldon despite the fact that Sheldon was also a boy genius.

These scientists were just a few of the minor characters who appeared on *The Big Bang Theory*. However, from the number of minor characters that were specified by the participants, the producers had ample opportunities to create scientists which were different from the main characters and also from the scientist stereotypes. This was considered to be a good inclusion since "it adds things to the show, [like] adds perspective. [We] can see more personalities of different scientists" (M20NSU) and that "it shows that scientists are people with a lot of variety. They can be anyone" (M28SP). By having scientists who "aren't stereotypes, on balance it's positive" (M40SA) and they "do give a good sort of range" (M29NSNA). However, occasionally the participants would still identify these minor characters as having a few exaggerated stereotypical scientist traits where they would "feel like everybody on that show has their quirks" (F26NSNA) and that "they are still stereotypes and they are still caricatures but to a far lesser degree than the main characters" (M32NSNA). Examples were provided where three non-science participants expressed that Leslie "has a weird personality as well. I think scientists have their special personalities" (F26NSNA), and "some of them are incredibly stereotyped too ... [like] the bug guy [Professor Crawley]" (F28NSNA), and also that "they do follow the stereotypes though, I mean like the Korean teenage genius, to a certain extent is a

stereotype as well" (F26NSNA).

As a result, many participants considered that "it's mainly through the guest or the minor characters where they perhaps break the stereotypes" (F19SU), or at least "to an extent that they're brought in as a contrast" (M43NSNA) since "they were different from the stereotype, [it] kind of emphasised how stereotyped the main characters I guess, in comparison" (F21SU). This idea was noted by Haran and colleagues (2008), who asserted that ensemble casting would lessen the burden of representing all scientists through one individual character, and this is especially true in a series format like television shows where the storylines would evolve over time and help develop the individual characters' personalities. For example, participants felt the character of David Underhill "was a bit of a deviation away" (F21SP) from the scientist stereotypes since he, and also Elizabeth Plimpton, "were really promiscuous people actually. So they're anti-stereotype almost" (M26SP). More specifically, participants felt these portrayals were better associated with non-scientist stereotypes.

> [The characterisation of Elizabeth Plimpton] is unusual because it combines the ditsy blonde with the scientist. And I think that's not [a stereotype] you'll see very much I don't think. There's no reason why it couldn't be the case given the range of characters they show, it would sort of make sense but it is an unusual one. (F26NSNA)

> Well I suppose [David Underhill's] not a science stereotype. It's almost like pick-it-up and put-it-in the dodgy guy stereotype . . . He's almost in the sleazy stock trader high-end [stereotype], so [it's] out of place for a scientist but using all of those stereotype constructs, so it's not a normal scientist. (F31NSNA)

In addition, Leslie Winkle and Barry Kripke were also discussed and were often compared to each other. For example, one science participant felt that "Leslie Winkle is a more realistic character . . . but no, I don't think Kripke is" (M27SP), but another science participant asserted "Leslie, she's also a bully, but she only seems to bully Sheldon, which I think can be an exception because he's really strange. But Kripke bullies everyone" (F19SU).

However, the nature of *The Big Bang Theory* being a short 25 minute television show has also caused a few participants to indicate that the minor characters are still not completely separated from scientist stereotypes.

> Any of the scientists who just do a little spot, they don't get a chance to really show anything about science or the process of science or the culture of science apart from "here is a scientist in a lab with a whole bunch of weird specimens around them" or "here is a scientist in a lab coat" or "here is a scientist in a conference getting the Nobel Prize" or something like that. So they're probably, if anything, even though ironically some of them are real scientists, they're probably more stereotyped than the main characters just because they don't have an opportunity to do anything other than be a scientist. (F38SNA)

This idea where scientists appearing for a short period of time tends to be more stereotypical was mentioned by Haran and colleagues (2008), who used the example of characters in films. They noted that since films are generally 90 to 100 minutes long, there is a finite amount of time for character development, thus "a feature film ... deals in iconic shorthand to sketch in stereotypes and counter-stereotypes" (Haran et al., 2008, p.15). However, this is only relevant when the character is a protagonist since having ensemble cast would limit the amount of time spent on individual character developments. This means movie characters other than the protagonists were more prone to have character developments only for the purpose of a plot device.

> The fact that they are scientists is more of a plot device and really isn't relevant. That's sort of why they're there, like the classic one is the *James Bond* movie where Denise Richards was a nuclear physicist and everyone was like "yeah, really?" And so that's why she's there but I don't see her doing any physics. (M29NSNA)

Therefore, if the show was to introduce a scientist character as a guest star or minor character, "it would look silly if they would bring something to counter the stereotypes because part of the humour of the show is stereotypes" (M26SP). Nonetheless, the minor scientist characters that appeared on *The Big Bang Theory* contrasted the existing stereotypes portrayed through the main characters, thus rendering these minor scientist

characters positive depictions of scientists since they could potentially assist in breaking scientist stereotypes. However, it must be noted that not all of the participant responses were positive. For example, a few participants felt Leslie and Barry were bullies, suggesting that there are traits other than them being scientists that will create a negative depiction of scientist.

4.3 *The Big Bang Theory* in shaping images of scientists

Participants had different opinions on how *The Big Bang Theory* had shaped their images of scientists, but it would appear that overall, the show had a larger impact on the participants' images of scientists than it did on their ideas about science.

> It's more scientists, not science to me. Science is just real life things, it's everyday things. It can be funny. Anything can be funny. But it's the scientists that surprised me, that I didn't realise scientists can be like this, maybe because I just don't know [many] scientists like that. (M26NSNA)

The participants had different responses when asked whether the portrayal of the scientists had either changed or reinforced their pre-existing images of scientists. In some cases, participants indicated that the characters "did to a degree change it but also reinforced in other ways. Like showed they can be all different ages, that the up and coming ones are really, really quite young" (F19SU). The specific responses that detailed aspects that had changed were diverse but mainly discussed how their pre-existing images differed from those of the scientist stereotypes. Sometimes the participants would also express that they were not sure how the portrayals affected them, but "it didn't fit my assumption of my image of a scientist. I don't know whether it actually changed my impression of what the stereotypical scientist is, so [it's] a mixture" (F19SU). The appearance of scientists has been one of the major changes that the participants pointed out to be different to the stereotypical images. For example, one participant noted that "one's really tall and one's brown" (F19SU), and another participant asserted:

> I didn't expect them to be this young at least. Maybe it's because all the scientists I know are famous and when they are famous they are usually old because they need to do a lot of research ... [My perception] changed a lot

> since my stereotype was, as I said before, old people who are sort of into that and into that only, so it changed a lot. (M19SU)

Another was a scientist's social behaviour and personality that did not follow the stereotypes, such as "I didn't know scientists could play games and read comics so to a certain extent, yes [it did change my perception]" (M24SU). This was considered to be a good portrayal since it helped the participants "to know about the scientists and how they might act in the real life, and make it very comical. And it connects scientists and non-scientists" (F30SP). Another science participant expanded on this idea of what a scientist's real life would be like, more specifically how scientists would interact with other people.

> I guess that it may have changed my idea of scientists a bit because they did seem a bit younger and more concerned with how the world worked outside of their own little narrow disciplines ... We see scientists in the workplace producing science but it is interesting to think of how their lives function in different circumstances. And I quite enjoy all of the stuff about everyday psychology, learning how to manage your world when you think a bit differently to other people. So I guess I've put more thought into how scientists interact with the world when they see it in one way but other people see it in a different way, so probably has changed my view a bit of how they function. (F44SNA)

In contrast, often the scientist stereotypes were reinforced by the scientists in *The Big Bang Theory*, and participants would feel "there is no probably, it [definitely] reinforced them" (F43NSNA), but "not in a bad way" (F23NSNA). The way the portrayals may have reinforced the image of scientists varied due to the participant's background. For example, participants who worked with scientists who are similar to these characters expressed that the characters helped reinforce some stereotypical traits, like for a science participant in biology who felt "maybe about physicists ... I still think they're kind of like, lasers and computers and numbers and stuff and this just reinforces it" (F33SP).

> Maybe a little bit of reinforcing it, not really changing it though. I think it's because I've worked with a lot of people that fit those stereotypes already so

> it's like "I used to work with someone like that", [or] "yeah, I know someone like that." (F31NSNA)

As *The Big Bang Theory* was considered to be "a show about stereotypes" (F22SU), participants also indicated the show reinforced by "reaffirming that there are people like that out there" (M25NSU), but also "critiqued the stereotypes of science by expanding on them" (M26NSNA).

> I think because you know how we've said before that there are a lot of stereotypes in that show, but at the same time it also breaks the one traditional stereotype with all scientists in the one box. It's made it very clear that no, it's not the case. But they are all themselves in a stereotypical box, different boxes. (F34NSNA)

> Reinforced in other ways like their social [aspects]. I think Sheldon, more than anything, enforced it. Maybe they haven't got the best social skills. Like Raj not talking to women, Howard being the complete opposite of Raj, but then having the middle ground with Leonard who can talk to girls but shy, but all guys are like that. So, I think in a way it did a bit of both – like it changed it but it enforced it. (F19SU)

In contrast, there were also participants who believed that the show did not change or reinforce the images of scientists for them, for example a participant asserted "I didn't have a stereotype before, it's just they're normal people doing science" (M20NSU). Like this one, the majority of the responses indicated that there were no changes to the participant's pre-existing images of scientists.

> My perception of scientists hasn't changed because they're people as well. You'll have the quirky ones, you have the normal ones and you have the ones that you wouldn't touch with a barge pole. So for me personally it's not changed, they're people like everybody else. (F34NSNA)

There were many reasons why the participants did not change their pre-existing images. One was because the characters in *The Big Bang Theory* also "stick to the stereotypes" (F22SU) that the participants held. For example, a participant asserted

that the characters were consistent with how she saw scientists, as "pretty nerdy, they speak in languages we don't understand. I think the characters do fall in that stereotype" (F26NSNA). Therefore, the interactions between the characters resonated with these participants, since "it's not kind of romanticising the fundamental irritations and difficulties of getting on with people like that, but it makes them very appealing I think" (F23NSNA).

Some non-science participants did not hold scientist stereotypes beforehand and were aware *The Big Bang Theory* was deliberately stereotyping the characters rather than portraying realistic scientists. For example, one participant indicated that "I didn't really have a stereotype of scientists because I just find science is interesting" (F21NSU). Another participant raised the question of whether "anyone [would] really watch the show and be like 'scientists must be like that?' [Since] it would be bizarre, pretty naïve" (F21NSU). This latter reason why participants did not change their views was elaborated in two other participants' responses, where they recognised *The Big Bang Theory* is a fictional entertainment show, thus unlikely to portray anything realistic.

> It didn't do anything for me I think. I do try not to stereotype and generalise. I don't think I had much of a particular stereotype of scientists before watching the show ... That's what I take issue with and I don't think it does that for me because I take it purely as fiction. I take it as fiction and very light fiction at that, so it's not likely to really change my viewpoints in any concrete way. (F26NSNA)

> I haven't [changed my views] but only because it's a TV show. It's not like portraying anything realistically and because I'm thinking that all the time I haven't changed my perception. (M19NSU)

It is interesting to note here that all of these participants who indicated that *The Big Bang Theory* is just a television show, and therefore does not portray real-life scientists accurately, were non-scientists. This is a contrast to the science participants who expressed that the scientist characters in the show are accurate depictions of real scientists as noted earlier in this chapter. Alternatively, other stereotypes may have a stronger impact on how the participants judge the scientists. This resonated with another non-science participant

who indicated that the first impression and assumptions made about that person are more likely to be based on other traits rather than whether someone is a scientist.

> I guess I don't see people as scientists or not scientists. I see them as people first of all in a way. I think I will be more likely to make assumptions of people based on whether or not they're old or young or what race they are or what nationality they are before I'm likely to make assumptions based on whether or not they are scientists. (F26NSNA)

A common explanation for why participants were not affected by the characters' portrayals was because their personal experiences with scientists had a stronger influence on their pre-conceptions. For example, participants expressed that they did not change their perceptions because they "still work with [scientists], still know what they're like, still know how they act" (F28SNA) so "watching a TV show is not going to change what you think about your colleagues that you work with" (F29SP), especially "because I'm around scientists and I am a scientist, it didn't really like do much" (M18SU). This was also the case for participants who have friends and family members that work as scientists.

> My dad's an engineer and we've got lots of friends and family friends who are in the science field, so I always think of them as scientists, and they've always been considered scientists. Even though I watch the show it [hasn't] really changed what I think of scientists. (F20NSU)

However, science participants further commented on how these portrayals may affect them personally as scientists and how they're "not offended by it" (F37SA).

> It shows that scientists are human and have interests and can have lives. I don't think people actually watch that and think all scientists are like Sheldon, so no I'm not offended. (M40SA)

The reason why the participants were not offended was that they did not identify with these stereotypical characters, thus the participants "feel fine, it just makes me laugh and I laugh with it" (M28SNA) since "I think we're supposed to identify with Leonard being a normal guy doing some reasonably abnormal stuff like physics, so not offended" (M33SP). As for those who were not in a science research career, the show has assisted

them to become more tolerant of scientists and "you'd probably be more friendly with your scientist friend" (F23NSNA).

Many participants also shared their thoughts about how *The Big Bang Theory* could have affected the general population's views on scientists. The stereotyping of the scientists was expected to have "reinforced a lot of the public's view of scientists, perhaps like the social awkwardness and what scientists do with their leisure time and how they think" (F52NSNA). Science postgraduates expressed their concern over the consequences of the show portraying scientists through these stereotypes, especially "if people who are not familiar with scientists, who [do] not have friends with scientists, they will have a wrong idea of what they will be. So I think that annoyed me" (M26SP). This consequence was already evident through one participant's response:

> I don't want to be friends with those people, maybe [the] women physicists but not guys like that. I'm kind of scared to talk to them ... [and] I don't like the way they describe [the scientists] and [since it] probably will affect us. I was worried if some people might be bullied by some other people after watching the show, because "oh you're a [physicist], you are blah, blah, blah. You can be [a] geek, [and] kind of isolated" or something like that. (F30SP)

The majority of the participants were not concerned about the negative impact of the show on the science community, and considered it a way to change the public's attitude. This was demonstrated by a science participant's response in regard to his friends' attitudes toward the show:

> I mean a lot of my sort of friends who aren't scientists all like *The Big Bang Theory*. [They] all really enjoy it. So whatever they get out of it is positive as opposed to negative. If it was negative I'm sure they wouldn't watch it, so it probably enhances the appreciation of science and scientists. (M59SNA)

It would appear that the benefits of the show have the potential to outweigh the negative impact for multiple reasons, ranging from having likeable characters to building tolerance and being "more acceptable [of] some of the scientists [who] are not socially very adept" (M27SP), or rather, "that's made it more socially acceptable to be socially

awkward" (F25SP). This reflects what science participants expressed to be the situation for people working in a science environment. Science participants asserted that "scientists often work in academic environments which are more tolerant to diversities. You can get away with being more or less conformist, so in that respect being more acceptable" (M40SA). An example of this was provided by a science participant who reflected on her experience in her previous job:

> I have found in [the national research organisation] where I used to work for 17 years as a scientist, there is a tolerance amongst scientists and people who are a bit different because of their intellect [and] of what they can do. So a lot of their social inadequacies are tolerated by management, as well as peers. In [*The Big Bang Theory*] they go beyond tolerance to having a great time, [and] I like that. (F53SP)

The participants indicated that "a lot of people happily admit they watch the show and you don't have to be into science to watch the show. People actually perceive that as a cool show to watch" (F26SP) and "so that's why even though they are sort of stereotypes it doesn't worry me so much because [the characters are] likeable and entertaining stereotypes and they do grow as characters" (M29NSNA). Therefore, participants summarised that "I think the public's attitude is changing and *The Big Bang Theory* is a very positive portrayal of it" (M33SP), and *The Big Bang Theory* "has a much more positive effect on public awareness of science than it has any negative effect on stereotypes or anything like that" (M28SNA). This means the show may influence the audiences in positive ways, such as making them more tolerant toward scientists and able to view scientists in a positive light:

> People might not mind these socialisation types of approach of people working with scientists. They may realise "okay, this is part of the way they are. It's not unique with the person we are interacting with, it's the way with most of these guys." So they might tolerate or might [be more accepting]. (M27SP)

> It may have changed my attitude towards scientists. Even though I've always thought that scientists do fascinating stuff and are interesting people and get to do an awful lot of fun stuff. I guess I feel warm and fuzzy towards the

> idea that they're now part of mainstream entertainment, [the] mainstream sort of comedy culture and that makes me feel extra proud of being involved in science somehow. Not in a huge way but I guess I probably identify with the characters on *The Big Bang Theory* more than I would identify with for example, the scientists on *CSI*. Or the scientists who are the evil want-to-blow-up-the-world kind of people, or any of the other scientists that I've really seen on TV. So to me it was really fun to see science portrayed in a light-hearted, fun, entertaining and warm-hearted kind of way. And so that's probably how the show's changed my attitudes. (F38SNA)

4.4 Discussion

The participants' responses indicated that the depictions of the scientists in *The Big Bang Theory* were interpreted differently, but also clearly demonstrated that, overall, they felt these portrayals were more positive than negative. This was particularly evident in their discussions about how the main characters broke the scientist stereotype. For example, participants indicated that depicting the social interactions and the characters' lives outside science was a new concept. This is consistent with the literature, which states that where the majority of the time scientists' personal lives are not portrayed or are not the focus of the story, but rather scientists are often shown in the lab or day-to-day work (Weingart et al., 2003). The frequency with which this type of portrayal appears in television and movies was demonstrated through the number of stereotypes that show scientist as isolated, socially incompetent, and obsessive individuals (Haynes, 2003; Van Gorp et al., 2014). As a result, the participants did not expect the characters in *The Big Bang Theory* to be funny, approachable, and likeable, or be in romantic relationships and have groups of friends.

An explanation as to why the characters in *The Big Bang Theory* were portrayed as interactive people may be due to the nature of the show being a sitcom, which is inherently based on characters' interaction with each other. As Haran and colleagues noted, television shows allow for more "exploration of science as a career, the nature of team work and diverse motivations in pursuit of their professional as well as personal

objectives" (Haran et al., 2008, p.26) in comparison to movies.

Even though some participants felt that having stereotypical portrayals was good in various ways, there were other responses that conflicted with these viewpoints. An example was how the participants were surprised by the characters' fashion sense. They expressed that even though the characters' fashion sense is not considered 'mainstream' or fashionable, at least they did not follow the typical scientist attire of the white lab coat. The significance in the difference of their fashion sense to the mainstream fashion sense highlighted how scientists are separate from normal society (R. Jones, 1998), which is consistent with how the characters in *The Big Bang Theory* have been portrayed, supporting the fact that the characters still maintain certain stereotypical aspects.

Nonetheless, the overall depictions of scientists could potentially assist the viewers in cultivating a positive belief about scientists if they watch *The Big Bang Theory* frequently, which is the core premise of Gerbner's cultivation theory (Gerbner et al., 1981; Gerbner, 1987; Gerbner et al., 2002; Morgan & Shanahan, 2010). As for whether the portrayal of characters in *The Big Bang Theory* presents a new paradigm in images of scientists, it would appear that the characters still followed stereotypical scientist traits, specifically those of the nerd. The show humanised the image of scientists by portraying them as individuals who may embody stereotypical, but recognisable, traits, and who are part of society. In addition, the continuing development of the characters is also an explanation for why the participants' responses can be categorised as identifying three different degrees of stereotyping. The characters in television shows are developed through the seasons, and since the characters show personality growth, their changing depictions may subsequently break some stereotypical traits. This is a benefit that television shows like *The Big Bang Theory* have, that the character development allows these scientists to slowly break away from the stereotypes, and provides more opportunities to portray them in different (and unexpected) ways. These arguments suggest that different genres will portray scientists differently, which is consistent with Weingart and colleagues' (2003) findings.

It would appear that the scientist characters in *The Big Bang Theory* had varying

effects on the participants' pre-existing images of scientists, with a few participants indicating that the social aspects made an impact on how they saw scientists. One reason for this may be because they have cultivated their new beliefs and impressions based on the depiction of scientists in social situations interacting with different people. For example, the depiction of the characters as part of a friendship group and interacting with other people demonstrated that it can be easy for non-scientists to talk to scientists and that they also want to make friends. However, it must be noted that not all portrayals of the characters' social lives helped in breaking the stereotypical image of scientists. In particular, a few participants were ambivalent about the scientists' youth and their obsession with women. Even though they did not specifically indicate these are negative images of scientists, but nor did they think they are positive images. The results actually suggest they may cause the audiences to cultivate the wrong image of scientists by creating unrealistic definitions of who scientists are.

Some participants felt that the portrayal of the characters reinforced their pre-existing images since they could identify 'realistic' stereotypical scientist traits within their friends, family members and colleagues. Therefore, rather than changing the participants' attitudes toward scientists, interventions such as personal experiences with scientists (i.e., knowledge of who scientists are) can moderate cultivation effects. This is consistent with what Morgan and Shanahan (2010) stated in relation to science knowledge mediating negative beliefs about science after watching television shows that portray science negatively.

In contrast to those who felt the show changed or reinforced their pre-existing image of scientists, the vast majority of the participants indicated that their views had not been changed by the characters in the show. One explanation was because their experiences with real scientists had a more influential impact. Another was the fact that the participants were constantly aware that *The Big Bang Theory* is a television show. These two explanations are consistent with what Orthia and colleagues (2012) found in their study, where their participants were mindful of the television show's genre and the conventions associated with television production, and consequently this affected how they responded to the text.

The results of this chapter suggest that the images of scientists portrayed in *The Big Bang Theory* have influenced some participants' pre-existing images of who scientists are. This finding both supported and opposed cultivation theory to different extents. The reason why the data supported cultivation theory is because not all of the participants cultivated their beliefs about scientists based on what they saw on the show. Rather, the majority of the participants did not change their perceptions of and attitudes toward scientists, mainly due to the fact that external forces drove them to believe otherwise, such as personal experiences with scientists and the conventions associated with television production. This closely followed the observations of Gerbner and colleagues (1981) and Dudo and colleagues (2011), who noted that knowledge of science is negatively associated with television viewing, and that it reduces cultivation to small and non-significant proportions. In this case, the participants who had a better understanding of who scientists are were less likely to cultivate the images that are presented to them through *The Big Bang Theory*, as shown through their responses.

On the other hand, the results opposed cultivation theory because it demonstrated that one television show could impact the audiences' perceptions and opinions of scientists. Since cultivation theory is based on the total amount of television viewing rather than the viewing of one specific television show, the participants' responses demonstrated that it is not necessary for the overwhelming majority of television shows to portray "good" scientists in order for the audiences to change their perception of scientists. It would appear that the viewers' interactions with the image of scientists they see on television do not follow cultivation theory in a predictable way. Rather, cultivation theory appears to be a simplistic way of explaining how a sub-section of people interpret and receive these images.

Nonetheless, the responses demonstrated that the changing image of scientists portrayed on televisions allow some viewers to create a positive perception and belief about scientists in real life. As Haynes (2014) has argued, the stereotypes of scientists have changed through time, such that the mad scientist is now a less common depiction of scientists in the 21st century, being replaced by (real) scientists who are depicted as curious about the world yet willing to communicate to the wider public in a language they

understand. The scientist characters in *The Big Bang Theory* play a role in contributing to a better image of scientists, since they can provide a familiar, and approachable, image of scientists. This is particularly important for science as a discipline, where scientists and science communicators are often concerned about the public's pre-existing image of scientists, and the participant responses demonstrate that *The Big Bang Theory* is a useful tool to counteract these negative pre-existing image of scientists.

Chapter 5

Presentation of female scientists

This chapter will discuss the female scientist characters in *The Big Bang Theory*. As noted before, three female scientist characters were included as major characters in the first four seasons of the show. They are: Bernadette Rostenkowski-Wolowitz, Amy Farrah Fowler, and Leslie Winkle. Leslie appeared in the first two seasons as Leonard's colleague in experimental physics. Bernadette was introduced in season three as a waitress working to put herself through her Ph.D. in microbiology. Lastly, Amy entered the show in the season three finale, and was later introduced in season four as a neurobiologist/neuroscientist. The depictions of these three women are very different, and individually very interesting case studies which explore different portrayals and stereotypes. Additional guest stars appeared on the show as female scientists and were portrayed differently to these main cast members and these were also discussed during the focus groups. The array of female scientist portrayals provide a rare opportunity to compare and contrast within one television show. Therefore for this chapter, I will attempt to answer the following question using my focus group participant data:

> What do people think and feel about the presentation of female scientists in *The Big Bang Theory*?

5.1 Portrayal of female scientists in fiction

Many studies have demonstrated girls' relative lack of interest and desire to enter science fields. Research based in Western countries has shown that women face many difficulties in science, ranging from the perception that science is an inappropriate career path for women (Steinke, 1998, 1999), being portrayed as stereotyped and lower on the 'career ladder' in comparison to their male counterparts (Weingart et al., 2003; Cheryan, Siy, Vichayapai, Drury, & Kim, 2011), and the possibility of being discriminated against such

as having their research judged or questioned (Steinke, 2005), or not given the job they applied for (Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012). These reasons can cause students to begin segregating themselves between the 'female-friendly' and 'male-friendly' school subjects, including different science disciplines, and this segregation usually develops more prominently as the child goes through secondary education. Baram-Tsabari and Yarden (2011) reported on a quantitative study of the progressive change of science segregation in school students from kindergarten to 12th grade (K-12) in Israel and the United States. The data for this study were self-generated by the students. More specifically, the students submitted science questions that they were curious about and wanted to find out about to an Ask-A-Scientist type website. These reflected the students' own interest in science. The data indicated a significant change in the students' interest in the different science disciplines with respect to the different school grades. It was reported that the:

> Female's and male's interest in science developed along different paths ... and resulted in a stereotypically gendered interest pattern in the tenth to 12th grade group. This gap was not always apparent: in the youngest kindergarten to third grade group ... there was no statistically significant difference among the science fields that the two genders asked about ... The gap widened gradually and rapidly ... The difference between boys' and girls' interests was found to increase over 20-fold as they grew older (Baram-Tsabari & Yarden, 2011, p.535-38).

Baram-Tsabari and Yarden (2011) also elaborated on the individual science disciplines in their study. For the purpose of this thesis, I will focus on the conclusions they made regarding biology and physics since these are the two sciences that dominate in *The Big Bang Theory*. Baram-Tsabari and Yarden noted the number of questions of a biological nature were roughly equal for both genders from kindergarten to sixth grade. A slight change was detected at the junior high level in seventh to ninth grade students. Boys' interest in biology dropped, with only a slight increase once they went into senior high school (10th to 12th grade). As for girls, their interest in biology remained constant then increased dramatically once they hit senior high school. The number of physics questions posed at the early stages of schooling were similar in number for boys and girls, which

mirrored biology. However, a contrast was identified in senior high school. While the number of physics questions asked by boys increased, the number of physics questions asked by girls decreased.

Baram-Tsabari and Yarden's (2011) study is only one of many which have looked at this difference. What is different though, is that the majority of the other studies only focused on a small age range rather than the K-12 that Baram-Tsabari and Yarden analysed. An example is a study by Baram-Tsabari, Sethi, Bry, and Yarden (2006) who focused on 4th-12th grade students. The method used in this study was very similar to those by Baram-Tsabari and Yarden (2011), but only used one source of self-generated questions rather than collecting from multiple sources. Baram-Tsabari and colleagues indicated that "the girls in our sample found physics to be significantly less interesting than the boys, whereas biology was of greater interest to girls than boys" (Baram-Tsabari et al., 2006, p.1062), which is consistent with other studies (e.g., M. G. Jones, Howe, & Rua, 2000; Baker & Leary, 1995; Baram-Tsabari & Yarden, 2005).

Another example is a study by Cakmakci and colleagues (2012), who used the same method of analysing submitted science questions to Ask-A-Scientist websites but with Turkish primary school students (7-14 years old, which is equivalent to Australia's year 2 to year 9). In their study, Cakmakci and colleagues added the dimension of questions gathered in school where the students were asked to write a question they wanted to learn from a scientist, thus forming a collection of questions from both formal and informal settings. They reported similar findings to previous research where "girls [tended to ask] more questions related to biology and earth sciences than boys. On the other hand boys asked more questions related to technology than girls" (Cakmakci et al., 2012, p.477). What was different was that "no gender-related differences in the field of interest were found in the case of physics, [rather] there were slightly more girls' questions (10.8%) than boys' questions (9.4%) related to physics" (Cakmakci et al., 2012, p.477). Cakmakci and colleagues (2012) also found that when comparing science interest against the student's age, their science interest in chemistry, earth science, physics and technology increased, whereas interest in astrophysics and biology decreased.

One reason for the segregation of boys and girls into the different sciences could be attributed to role models. Having role models such as female scientists could potentially benefit girls by constructing a gender-inclusive image of scientists, thus breaking the illusion of science being a masculine career path. To do this, girls need to be exposed to both male and female scientists from a young age to cement this idea and carry it through their schooling. This idea is linked to the gender schema theory. Steinke (1998) described this theory as the way girls build knowledge from role models in a society that "emphasises differences based on gender" (p.144). The theory discusses the internalisation of gender-based roles in societal practices, how girls identify the compatibility of different careers with their internalised gender-based knowledge, and follow these definitions through life. In the case where real-life role models are absent:

> images of women scientists in the media may serve as important sources of information about science. Children who have little access to the world of science may construct an understanding of the role of women in science based largely on these images (Steinke, 1999, p.112).

However, Baker and Leary (1995) noted in their study which investigated what influences girls to choose to study science, that:

> The media, while affecting the girls' attitudes toward science and scientists, provided few role models of women in science. The images of scientists presented by media were both positive and negative. This mixture then required the girls to sort through the messages (p.18).

As a result, these different portrayals of female scientists on television or films may communicate confusing images of science, such as creating:

> a masculine image of science [which is often] conveyed through media images that focus on the underrepresentation of women in high-status positions within the scientific community, the gender discrimination that exists within the scientific community, and the conflicts between women scientists' professional and personal lives (Steinke, 1999, p.113).

Middle school girls' wishful identification (or 'wanting to be like scientist characters that they see on television') can also be affected. In their study, Long and colleagues investigated the portrayal of male and female scientists on television, and found that:

> the fact that male scientist characters had a larger screen presence, were more likely to be portrayed as violent (which research shows is a wishful identification attribute for boys), and were more likely to be portrayed as independent (a stereotypically male behaviour) suggests that these television programs provided fewer opportunities for girls' wishful identification with and social learning from scientist characters than they did for boys (Long et al., 2010, p.375).

Steinke (1998) also noted three avenues where girls are likely to conceive a 'masculine image of science': school, home, and the media. The use of media for interventions in schools has shown to be ineffective in breaking down this gender stereotyping (Steinke et al., 2007). Steinke reasoned that the gender schema works more effectively in young children (more specifically pre-school children) as it is difficult to alter pre-existing stereotypes (Steinke, 1998). Therefore the media can have a much more significant impact on teaching children in their earlier years about gender stereotyping in science before they start their schooling.

However, this does not mean that adolescents cannot change their views since the media still has the capacity to portray and cultivate images of scientists for them. To highlight how media can cultivate students' view of scientists, Steinke and colleagues (2007) conducted a study which used the draw-a-scientist-test (DAST). This study revealed that a media literacy intervention does not necessarily affect middle school students' gender stereotyping. Middle school students were divided into three groups: discussion-only, discussion-plus-video, and control. The results showed that throughout the three groups, there were no significant differences in the students' tendency to draw a female scientist rather than a male scientist despite the discussion-only and discussion-plus-video groups being exposed to counter-stereotypes. However, one of the prominent findings highlighted that the majority of students indicated television and film as their number one go-to source when they wanted to remember images of scientists for the DAST test, and this was true for both boys and girls. This was not limited to

the discussion-only and discussion-plus-video groups, rather "many participants in the control group who did not participate in media literacy training also listed television and films as the primary source of information for their drawings of scientists" (Steinke et al., 2007, p.58).

In another study, Steinke and colleagues (2012) investigated adolescents' wishful identification with the scientists they see on television, or their desire to be more like them with respect to the character attributes they possessed. Despite the possibility of the middle school students already having pre-conceived images of scientists from a young age, this study showed these students still had wishful identification with different attributes of scientists such as being intelligent, caring, dominant, respected and working alone. Steinke and colleagues (2012) found that "adolescent boys and girls reported gender differences in wishful identification for some of the selected character attributes depending on whether they viewed male or female scientist characters [in the selected television show clips]" (Steinke et al., 2012, p.187). Generally, adolescent boys had more wishful identification with male scientists than female scientists, and specifically identified with male scientists when they were portrayed as dominant. Similarly, girls identified with female scientists when they were portrayed as dominant. In addition:

> boys' wishful identification with male and female scientist characters portrayed as intelligent was relatively lower than with scientist characters portrayed with most of the other attributes ... while girls' wishful identification was greater with male scientist characters portrayed as intelligent than with male scientist characters portrayed with any of the other attributes, it was greater for female scientist characters portrayed as being dominant or shown as working alone than for female characters portrayed with any other character attributes, including intelligent (Steinke et al., 2012, p.188).

These studies indicate that media has a significant leverage on how children and students view scientists and accumulate these images as well as produce wishful identifications through television and films. In addition, despite interventions such as media literacy in classrooms, the gender stereotype of scientists appears to be difficult to break. Therefore, another avenue must be taken to foster a more favourable image of female

scientists, such as increasing the number of female scientists appearing on television and film, and creating more positive portrayals.

Content analysis studies have shown the number of female scientists on television and film is lacking (Steinke & Long, 1996; Steinke, 2005; Long et al., 2010). Steinke (2005) found that of 74 science-based films she studied from the period 1991-2001, only 25 featured female scientists and engineers among the main characters. In Weingart and colleagues' (2003) study, they found that in the 222 movies they analysed, only 18% of the scientists were women. Steinke and Long (1996) noted that in the instances where women and girls appeared on U.S. children's educational television shows, they were usually in secondary roles such as pupils, assistants and science reporters, and less frequently as scientists. In contrast, men were more likely to appear on these television shows than women, and were more likely to be scientists (Steinke & Long, 1996). Long and colleagues' (2010) study on 14 U.S. television programs with a scientist as the main character that were popular among middle school students demonstrated a clear consistent stereotype. The majority of the findings supported previous studies in that the scientists tended to be an "unmarried Caucasian man who did not have children, held a high-status science position, and was likely to be portrayed as being intelligent" (Long et al., 2010, p.372), although the few female scientists portrayed also had all these attributes. This suggests that there is an equality to the portrayal of men and women in regard to their identities as scientists even though the frequency of appearance greatly differed.

The types of stereotypical images of women in science need to be identified, as individual scientists can portray different images other than having high status or intelligence. Various studies have investigated the image of female scientists on television and film (Flicker, 2003; R. Jones, 2005; Steinke, 2005; Long et al., 2010). These studies spanned decades of movies and various genres of television shows, and the conclusions they came to were roughly the same. When comparing these portrayals of women in science to those of men, it is evident that most are vastly different to the classic stereotype, such as the 'mad scientist', which is usually associated with male scientists (Flicker, 2003; R. Jones, 2005; Steinke, 2005). For example, Steinke (2005) compared the depictions of the female scientists to those of the stereotypical images of male scientists. One of her findings was

that female scientists were mostly portrayed as attractive rather than with the messy hair and out-dated fashion sense associated with male scientists:

> In the depictions of female scientist and engineer primary characters [are] shown as attractive, the women generally were physically fit, wore stylish clothes or attire that would be considered appropriate for their professions, and wore their hair in contemporary and fashionable styles (Steinke, 2005, p.39).

The female scientists and engineers were mainly portrayed as career professionals in contrast to the frequent depiction of male scientists as mad, clumsy or nerdy:

> The female scientist and engineer primary characters in films that portrayed them as professionals were depicted as knowledgeable, articulate, outspoken, driven, confident, competent, creative, and independent. Most of the female scientist and engineer primary characters presented themselves as hard-working professionals, exhibited a strong passion for their work, and showed relentless determination even when faced with adversity (Steinke, 2005, p.42).

The female scientists and engineers were mostly portrayed in distinguished positions:

> many of these portrayals showed female scientists and engineers working as principal investigators and project directors, while others showed female scientists and engineers as equal contributors on various scientific research projects, typically working with male colleagues as equals or as equal members of a research team (Steinke, 2005, p.44).

This contradicted other findings where women were usually depicted as "lower on the career ladder" (Weingart et al., 2003, p.283). The contradicting depictions between men and women in science warrants a typological analysis of how women in science on television and movies are portrayed. Some of the emergent 'types' overlap one another in these studies, and can be mapped onto the six stereotypes presented by Flicker (2003):

1. The old maid: This type of female scientist is "only interested in her work, as though she were married to it" (Flicker, 2003, p.133), however a typical development of the

narrative will show her derailed from her science focus and endeavours because of a love interest. Although this type of female scientist is competent in her profession, she communicates the idea that "femininity *and* intelligence are mutually exclusive characteristics" (Flicker, 2003, p.133; original emphasis). This is similar to R. Jones's (2005) observation that female scientists tend to have 'no family ties'. Even though the female scientists demonstrate nurturing traits associated with other people (either with their colleagues, partners or relatives), they do not have families themselves. This type of portrayal emphasises the discouraging notion that family life and a science career cannot coexist.

2. The male woman: According to Flicker (2003), this type of female scientist is generally shown being part of a team of male scientists and has developed an assertive personality. She is often shown as having "a rough, harsh voice, dresses practically and from time to time succumbs to an unhealthy lifestyle (bad sleeping habits, smokes, drinks, takes pills. . .)" (Flicker, 2003, p.133) which may mirror that of male scientists. She is shown as less competent than her male colleagues though and also asexual. However, Flicker asserted this type of female scientist has the emotional approach necessary to develop the final solution to the problems in the film. This type of female scientist is similar to what R. Jones (2005) calls 'alone but ordinary', where they are typically portrayed as a normal woman but the only female researcher in an all-male research team. In contrast to Flicker's female scientist who wears masculine attire, R. Jones's female scientists are depicted as ordinary women rather than with the stereotypical male scientist traits.

3. The naïve expert: This type of female scientist is typically attractive and younger than expected when compared to her professional status, but "for the dramaturgy . . . she is a crucial character" (Flicker, 2003, p.312). She is often depicted as a successful scientist (especially for her young age) but her naïveness and emotions tend to cause trouble, and only men can help solve the situation or save the day. This type of female scientist is often shown as "the 'good' type of woman - morally impeccable - who believes in goodness and is accordingly naïve in her actions" (Flicker, 2003, p.312).

4. The evil plotter: This type of female scientist is the opposite to 'the naïve expert' as

she is often portrayed as part of the evil forces or the villains. She is typically a very attractive young woman with an ego. As a result, this type of female scientist "is corrupt and uses her sexual attraction to trick her opponent" (Flicker, 2003, p.313).

5. The daughter or assistant: This type of female scientist is portrayed as lesser to the man that she accompanies, and is usually considered only there for her social competence, emotional assistance, or even sexual assistance. This type of female scientist "is marked by dependence on a male character" (Flicker, 2003, p.314). This is roughly equal to the 'qualified but subordinate' category identified by R. Jones (2005), where female scientists are typically part of a research team headed by a male scientist. They often perform tasks lower than their scientific ability, such as taking notes from a male colleague. Also, they are often referred to not as 'Dr' or an academic title but rather they are referred to as 'Miss', suggesting the focus is on them being a woman rather than a scientist.

6. The lonely heroine: This type of female scientist is a more recent development according to Flicker (2003), and portrays women as competent and successful, and often more so than men. In comparison to 'the male woman', this type of female scientist is not asexual, is attractive and also likeable. She is comfortable with working in a male dominated environment. However, she is portrayed as having a lack of "professional recognition by those in power and the right lobbying, which her male counterparts deny her, in order to be a match for those male-bonded structures, or to counteract them, this competent woman scientist still needs a male mentor" (Flicker, 2003, p.315). Even though these female scientists are seen as high status in their research field, "these women often found themselves having to explain their credentials and professional experience, defend the value of their research projects or research ideas, and justify their decisions about their research" (Steinke, 2005, p.47).

Another characteristic noted by R. Jones (2005) is the 'romantic plot' which spans the majority of the films he analysed. Steinke (2005) found similar widespread romantic plots in her movies, and "in fact, twenty of the twenty-three films featured female scientist and engineer primary characters involved in romantic relationships" (p.49). This type of portrayal can be incorporated into many of the above groups simply by placing the female

scientist in a romantic relationship with a male co-star, therefore it can be thought of as an overarching stereotypical 'attribute' of a female scientist.

Jones further noted that of the eight films he analysed, the female scientists were typically "ordinary working women and their situations accurately reflected the conditions for women working in science at the time" (R. Jones, 2005, p.84). He expanded on this by providing an analysis of post-World War Two Britain, concluding that the portrayals of female scientists (as 'alone but ordinary', 'qualified but subordinate', with 'no family ties', and included for the 'romantic plots') reflected that particular era with women more likely to stay home and look after the family once they got married. Jones noted that movies produced in that era were made this way because of the experiences of women finding love while they worked in the science industry and that "the film-makers were searching for realism, but [also] because they were hoping to broaden the appeal of the films by including a 'love interest'"(R. Jones, 2005, p.84). Or in other words, the inclusion of romantic plots has the purpose of "widen[ing] the appeal of their films to both men and women" (R. Jones, 2005, p.86). What Jones also observed was the lack of improvement on this image, and that the idea of female scientists as love interests has been passed down the generations since post-war films (R. Jones, 2005). Consequently, even though the role of female scientists changed through the decades, the women scientists were more often portrayed not as professional scientists, but rather in the general sexualised stereotype of the love interest.

The passing down of these stereotypes has created many barriers and difficulties for women in science due to traditional, social and cultural assumptions, and:

> this overt and subtle stereotyping of female scientists and engineers found in many of the depictions of female scientists and engineers in these films threatens to undermine girls' identification with these images and their future interest in SET [Science, Engineering and Technology] careers (Steinke, 2005, p.55).

One of the many problems is the depiction of the marital status of the scientists. Even though the numbers of fictional scientists who were married or had families were limited

in television shows and movies, Long and colleagues (2010) found that:

> television programs are portraying greater gender equity in the areas of marriage and family, [however] these results should be interpreted with caution because of the smaller number of references to scientist characters' marital and parental status (Long et al., 2010, p.373).

The small number of scientists being depicted as married or with a family emphasise the vast number of scientists who are single. Irrespective of the scientist being male or female, this lack emphasises and "reinforces the stereotype of scientists as individuals who devote themselves to their professional work at the expense of their personal lives" (Long et al., 2010, p.373). Steinke's (2005) content analysis highlighted the low likelihood of female scientists becoming mothers. Only four of the 23 movies she analysed depicted female scientists as mothers, and "most of the female scientists and engineers in the selected films were single, and if they were married or later married, most did not have children" (Steinke, 2005, p.51). As a result the characterisation of women does not reflect the breadth of reality. This is particularly the case in modern society where women are more likely to continue with their careers after marriage and starting a family (Steinke, 1997), thus the image of a female scientist having to choose between their career or family creates an unsettling discouraging notion that can cause a negative impact on the science industry.

In contrast, *The Big Bang Theory* breaks many of these stereotypes and misconceptions. The show includes romantic relationships between the characters, and especially in the later seasons shows that scientists can have a successful professional career while still enjoying their personal lives. The three female scientists, Amy, Bernadette and Leslie, embody different traits from the six stereotypical categories of female scientists, such as being socially competent and having assertive personalities, but also have some aspects not listed in those six groups, for example they are shown to be respected by men. For example, Bernadette has traits from the 'daughter or assistant' category because of her social competency, but she does not reflect the idea that female scientists are less competent than men. Rather, she is respected by the male scientists since, for example, they refer to her as 'Dr' rather than 'Miss'.

What is important to note though, is that different people will classify the female scientists differently. For example, McIntosh (2014) likened Bernadette to the 'naïve expert' since she often commented on the "mishaps and mistakes that occur within the lab and that sometimes cross ethical lines" (p.198). These two different interpretations demonstrate how different individuals will perceive the same character in different ways, and address the fact that the character may embody a combination of these stereotypes. Therefore, it is worthwhile to analyse perceptions of these characters so we may understand what makes them the same or different to the common stereotypes, and what aspects of these characters are considered good or bad by audiences.

Three specific focus group questions were dedicated to examining audiences' responses to the portrayal of female scientists in *The Big Bang Theory* and they were designed to encourage the focus group participants to (1) explore how they interpreted these female scientists, (2) how the characters differed from or agreed with their image of female scientists, and (3) what they would ideally like to see in a female scientist on television and film. In addition, participant responses also alluded to whether they cared about the gendered aspect of these portrayals in regards to the show in general.

5.2 Portrayal of female scientists in *The Big Bang Theory*

The portrayal of the female scientists in *The Big Bang Theory* was seen to vary considerably from character to character. One participant expressed that "it's really the males [that] are more stereotypical, I think the women are one of two extremes and nobody really in the middle" (F37SA). Although Leslie was considered to be a minor character as she only appeared in the first few seasons, she provided a good opportunity for participants to compare and contrast against the other main female characters. In general, the female scientists in *The Big Bang Theory* were considered to be less stereotypical than the male characters and more rounded, such as being more socially adept. This was especially true for the character of Bernadette as she was considered "the only one that's [different to the other characters]" (F22SU). Bernadette was considered to resemble a 'normal' character, "like the way she dresses and the way she presents herself" (F29SP) and that she's a "much more socially adept and regular functioning human being as opposed to some

of the others" (M29NSNA). She was also compared to the way Amy has been portrayed since "Amy kind of [represents] Sheldon's [type of] people and Bernadette is [more] part of the normal scientists" (M32NSNA).

> I think that's where Bernadette comes in. . . . Bernadette is a scientist, she's a microbiologist and . . . she's just so normal, like she doesn't have that caricature personality I think the boys do. She goes to work, she doesn't have the social phobias or the social anxieties and stuff and she's just kind of "yeah, I rock up, I hang out with my friends, I do this kind of stuff without being over the top like the boys kind of are." (M32NSNA)

> She's kind of interesting in that she fits in very well with the other scientists but she can also relate on Penny's level as well. She'll have the conversation about the pretty shoes or the nail polish as well as the ones [about] molecular structure of something. (F34NSNA)

Further comments were made about these portrayals, and many of them were of a positive nature, such as the female scientists being portrayed as intelligent, capable and "tough" (F37SA). This provided a contrast by having "actual smart women and some dumb guys as well, it's a little bit less sexist" (M18SU).

> I do think there is a perception of scientists being older white men in lab coats with beards, and having young people doing it was refreshing and later in the series having two women, or three women, [including] Leslie Winkle, coming in being scientists was also I think really refreshing . . . I kind of like the way that Amy Farrah Fowler breaks the stereotype of women as well. I think in the start of the show you have four male scientists, the men are smart [and] the woman is not. And bringing in women scientists I think is really important to sort of help break that and to have a woman who is not the dumb stereotypical blonde that you get in lot of TV shows, I think is great. (M23SP)

> I like how the other women scientists are kind of on equal footing when they introduced the new ones . . . I just like how they are actually just as funny as the guys and just as smart and they don't look down on them and they see

> them as a challenge to them. And I just found that really refreshing to see, [that] it's not completely male dominated. (F26SP)

Leslie was particularly mentioned since she was portrayed as working in a male dominated field.

> Well, she is [a bitch] but you can kind of see why, do you know what I mean? you only need to see two episodes with her in the canteen putting up with this absolute shit, and well you can see what she is. (F23NSNA)

> Although I do think that [Leslie] Winkle, she's so amoral, she's so in-your-face and [stuck] up, she's just fearless. I like the way that breaks the stereotype of women in a way, and let alone women scientists, so I think she's a delightful stereotype break. (F53SP)

It is interesting to note that female participants (two of whom are scientists) enjoyed Leslie's portrayal of having a strong personality, where in contrast it was two male participants and one non-science female participant who liked Bernadette's portrayal as sociable. This emphasised the difference between what the participants saw as important in the female scientists' portrayals. A possible explanation for this distribution may be because the portrayal of Leslie and her interaction with the male scientists, with specific focus on Sheldon, speaks to the experiences faced by the female science participants, thus causing them to be more empathetic towards her. On the other hand, for those who do not have the same experiences, such as the male participants and the female non-science participants, it may be difficult to relate to the situations Leslie face while working in a male-dominated science field. In this case, they may only have the capability to compare the portrayal of the female characters against their understanding of women in science as seen through the entertainment media. It must be noted that this argument is only a speculation based on some of the participants' responses, but this idea warrants an in-depth investigation through future studies.

The participants who liked Bernadette may have compared her to the other characters in the show, especially to Amy and Penny who are on opposite ends of the social-ability spectrum. As for Leslie, the participants who liked her portrayal may have

had experience in the field thus was able to identify with working in a male-dominated field. However, this does not mean that all participant will relate to Leslie since one scientist participant felt that "I don't really actually know anybody like her at all. I actually have trouble relating to any of the women in the show and I wish I could. I relate to the men much more" (F37SA). Nonetheless, it is clear that the female scientist participants in the focus groups were more sensitive to how women are portrayed when they are working in the maths-intensive sciences, whereas men mainly focused on the female characters' portrayals in general. The non-science female participants commented on both of these issues, suggesting that they notice both aspects of how socially adept female scientists are but also how they are treated in a male-dominated science field.

However, not all the participants considered the female scientists as being portrayed in a positive light. A discussion within a focus group indicated that the female scientists were not as well developed as the male scientists, and seemingly, not as interested and curious about the world around them.

> F38SNA: I feel like the girls aren't portrayed quite as well as the guys. And I don't know whether my view is tainted because I'm a girl and a geek and a scientist, and so I've got a different perspective on how I think people like me should be portrayed on TV ... They're sort of more of a foil for a gag more often rather than being genuinely interesting characters.
>
> F44SNA: ... all of them are not quite so cool and exciting as the male characters.
>
> F38SNA: They don't seem as interested in science.
>
> F44SNA: And it may just be because they're fairly new characters and so they haven't had time to develop fuller personalities.
>
> F38SNA: They don't seem as genuinely interested in the science and the world around them. They don't sort of make passing reference to the science like the guys do. When they make reference to science somehow it's forced because you have to remember these [girls] are actually scientists but most of the time they could just be girlfriends of Penny's. So the scientist aspect of them, as in the characteristics of curiosity and love of ideas and curious about the world

> around them and wonder about the world around them doesn't come across very much I don't think.

This can be seen through Bernadette as a few participants pointed out that she seemed to be portrayed as a lesser character in comparison to both Penny and the other female scientists.

> But I think a lot of it also is that Penny is just a stronger character and the others sort of look to her for guidance when put in various situations. Because otherwise Bernadette should be, you know, she's smarter, she's much more professionally successful, she's going to be much wealthier [and] she sort of comments on that a few times. (M29NSNA)

> The point I was going to make was that she seems to also self downplay her science background and we seem to see her a lot more as the waitress in The Cheesecake Factory. She doesn't seem to talk much about her science in the way that other characters do. (M53NSNA)

> I don't like Bernadette because she's also portrayed as [ditsy], like she's someone else who's just kind of some sexual floozy just like Leslie. Like, how is she credible? I don't know if they are trying to make a statement about the fact that the physicist can have blonde hair and big boobs because that's kind of what she represents to me. (F28SP)

Leslie's portrayal was another case where participants were not particularly fond of her due to her attitude towards the male characters.

> I think she's very narcissistic. She's all about herself, she used Leonard as an experiment in sex, [and] she was rude to Sheldon's achievement ... Actually she has this normal person look and kind of normal person behaviour and she plays music as well and yet she drives that machine and had this frozen banana thing out of it, that's pretty cool but her character wasn't nice. (F35NSNA)

> So I think that thing you've mentioned before of the ferocity with which scientists will attack each other's ideas. They've kind of taken that maybe a little

> bit out of context, so the way that Leslie Winkle is always calling Sheldon 'doctor dumb arse' and they're being personally offensive to each other. To an outsider, that just saying your idea is wrong, like it seems really rude whereas in fact it's more just part of the general kind of interplay of teasing out ideas. But again maybe that's why the general public would think scientists are socially awkward because they won't prefix your idea was wrong with "oh, see I was thinking that maybe if you look at it from another way", or the nice things that you usually say. (M33SP)

On the other hand, participants felt that some stereotypical traits associated with 'nerd' scientists were also incorporated into the female characters, such as unfashionable appearance and being socially inept (in the case of Amy) (Van Gorp et al., 2014). This included the 'look' of a scientist, like "Bernadette has got those standard signs of the glasses and the hair up and so on" (M29NSNA), as well as the personality traits where participants felt that they "haven't seen lots of really geeky female scientists out there so it's a bit of something different" (F21SU) and expressed "that's why in the show I like Amy Farrah Fowler and Bernadette because they are geeky women and I think that's a really important thing to acknowledge" (M23SP). In contrast to the male scientists, who enjoy playing games and watching science fiction movies, the female scientists were less interested in these. The difference in stereotypical portrayals between female scientists and male scientists reinforces the findings of Steinke (2005), R. Jones (2005) and Flicker (2003).

> I think the main characters are all . . . sort of creating that stereotype of scientists [having] that nerd tendency to a certain extent and I think those two female characters sort of break that so I think it's really interesting . . . Amy is more [like] Sheldon but when I say nerdy I meant those nerd cultures like Marvel comics, Star Trek, anime, card games and you know those entertainment cultures that are specifically for geeks and nerds. Amy sort of despises them. I think Amy and Sheldon actually had a fight because Amy actually discarded Star Trek as "cheap science fiction". (M19SU)

However, the definition of 'nerdy' was interpreted differently by different participants as shown through one participant's understanding.

> I would just say it's more just someone who has a tendency towards being interested in more intellectual aspects of life in general and conversation and pastimes whether they be particularly of those cultures or not. (F19SU)

Therefore, the female scientists in *The Big Bang Theory* were portrayed as intellectually nerdy, which may help to break female scientist stereotypes like 'the naïve expert', 'the evil plotter' and 'the daughter or assistant' (Flicker, 2003). However, a science undergraduate compared Amy (a scientist) to Penny (a non-scientist), suggesting the inclusion of intelligent female characters helped break away from the portrayal of women being uneducated in the show.

> It's just completely different and it sort of breaks down stereotypical barriers of it, like women being as nerdy as Sheldon in Amy's case so actually doing real science and not being the dumb illiterate hick from Nebraska. (M18SU)

Many participants felt that women on television in general are portrayed as love interests, and *The Big Bang Theory* has maintained this trend even though the characters may be believable as scientists since "from time to time they still talk about science, and [use] a lot of [scientific] terms as well in the conversation" (F26NSNA). The participants may have been affected by the way the female scientists were first introduced into the show since they "have only been introduced for the romantic sense . . . They've never been introduced for the science sense or anything else, any woman character has always been on the romantic sense" (M26SP). Bernadette first appeared on *The Big Bang Theory* in the episode *The Creepy Candy Coating* (S03E05) when she went on a double-date with Leonard, Penny and Howard. In this episode, Leonard was asked to set Howard up on a date with one of Penny's friends, and Bernadette was chosen as she was working with Penny at The Cheesecake Factory at the time. Throughout seasons 1-4 (and the first half of season 5), Bernadette was rarely portrayed conducting or interacting with science, as pointed out by a participant who recalled "from a science point of view you don't really see Bernadette doing much science though. She's mainly there for relationship interplay with Howard" (M40SA).

As for Amy, she was introduced at the end of the episode *The Lunar Excitation* (S03E23) when Raj and Howard signed Sheldon up onto an online dating site in an at-

tempt to find him a female friend. After Raj and Howard's insistence that Sheldon meet with Amy, Sheldon reluctantly accepted in an attempt to prove that online dating is 'complete hokum'. Leslie was introduced in the episode *The Fuzzy Boots Corollary* (S01E03) as Leonard's colleague who he tried to ask out on a date. She rejected his offer after they engaged in an experiment to test whether there was any feelings between them so that a relationship may be built. Later, Leslie had a more prominent appearance in the episode *The Hamburger Postulate* (S01E05) in which she invited Leonard into her string quartet and subsequently succeeded in seducing him. In both of these episodes, Leslie was included for the romantic rather than the scientific sense. As a result of these 'first appearances', participants indicated that the female characters were shown as secondary characters who were there as the male scientists' partners. McIntosh (2014) made similar observations, and argued that for Amy and Bernadette, but presumably also for Leslie, their "scientific careers set them up as suitable partners for their accomplished boyfriends, but these careers become fodder for the developments of their relationships" (p.199). Some participants saw this as a missed opportunity as "it's a shame that they didn't make them more rounded, more interesting characters who can actually compete with the guys at their own game if that makes sense, rather than just being the sidekick" (F38SNA).

> This isn't a criticism of *The Big Bang Theory*, it's just an observation of the role of women in any show, like they're always love interests. There's a love interest there somewhere, that's just a stereotype that all creative people who write any sitcom or soap opera like *The Bill* turned into. I liked *The Bill* once upon a time, they don't make it any more but just in the last few years of that [I] just got tired of when they introduced a new police constable that she'd be a love interest. That's what she's there for and I think that applies to *The Big Bang Theory*. It's not a criticism of *The Big Bang Theory*, it's just it fit the mould. (M54NSNA)

> I think of Amy and Bernadette less as scientists and more as like the girlfriends, because they're not introduced first as a scientist. Like Amy is the girl that Sheldon is going on a date with and that's crazy because how could Sheldon be going on a date? And Bernadette is the girl that Penny sets Howard up with, and that's crazy because how could she actually like Howard? I mean

> the fact that she is a scientist and, you know, her career is very important, that comes out but I think that's not as important as her relationship with Howard [in] the show. Not saying anything about women's careers but to the show it's more important that . . . she makes more money than he does, that's a big thing in an episode. (F26NSNA)

The minor female scientists also followed this trend, such as in the case of Elizabeth Plimpton who "was definitely there as a sex interest and the fact that she was a scientist was just a way of getting her into the that episode" (M33SP). Another participant also commented on the portrayal of Elizabeth Plimpton in *The Plimpton Simulation* (S03E21) and considered it a lost opportunity to create a better female scientist character.

> I kind of think what annoyed me about that episode with that woman, the one that's meant to be in Sheldon's area, is that they made her out to be [ditsy], you know what I mean? and I thought 'here is an instance where they can really make something out of having a woman in this highly theoretical bizarre field that's dominated by men like Sheldon and they just totally ruined it'. They're happy to have these female scientist characters but on some level they're subsidiary. There's Amy who's so needy that at some level we feel like she's training the monkey as an image of herself and that's kind of scary. And there's Bernadette who's just so obsessed about her yeast. They need a bit more depth. (F23NSNA)

Participants held mixed views as to whether the female scientists had been sexualised in the show, with some participants saying yes and others saying no.

> I have to say I like that they haven't sexualised the female characters. Like I keep coming back to *Two and a Half Men* but I mean the women there were just tokens . . . and they were all legs and boobs. And I really like that they haven't done that with [*The Big Bang Theory*] because it does seem to happen a lot and they haven't dumbed the women down. (F28SNA)

> The thing that kind of irks me about that a little bit while it was great to see more female characters and stuff coming in was they sexualised every single

> one of them ... like they try to doll [Amy] up and, when the episode where she touched the dude in the bar to solve her problem and stuff, the fact that they're catering to a market which, fair enough, geeks are horny bastards, every dude is and there are very few women I've met that aren't either, but the fact that they went down that path. With Penny, fair enough, that's the objective ... that's the character. Bernadette, having someone that Howard could have dated, fair enough, but Amy that kind of really irked me, I really wanted her to stay asexual, and just like Sheldon. (M32NSNA)

A few participants noted the female scientists were portrayed as quite sexually active and this caused discomfort for one particular female scientist participant.

> As a portrayal of women scientists or whatever, I don't like the characteristic because I think that might give a misunderstanding of such a position to [a] lay audience ... [like sleeping around] or like the way [Leslie] talks, I think maybe the real women [physicists], probably they, I mean this is just a comedy but they don't feel good ... if I was them probably I don't want to be portrayed like that ... I care about [the] negative [social] impact on these people. That's what I care [about]. (F30SP)

Even though the female characters were mainly included as a love interest and sexually active, a few participants found this encouraging because it explored various aspects of a scientist's personal and professional life as well as making them seem "a bit more human" (F37SA) which can be seen when comparing Amy to Sheldon. This provides an opportunity to examine the rarely mentioned idea of scientists being in relationships and eventually getting married (Long et al., 2010). This is explored in more detail in the next section.

5.3 Inclusion of female scientists

In general terms, the focus group participants felt "very good about" (F33SP) the addition of female scientists in *The Big Bang Theory* and felt that "it's nicer that they're not all guys" (F28NSNA).

> I think season four is particularly interesting, where I don't know if they've got feedback from the audience that it was a very male specific show, and they've

> actually tried to kind of have the same thing with the female characters as well, the introduction of major female characters and it's been really good addition. (M26NSNA)

> I would say they're good in the contribution of show. I think it tends to show people that it's okay being interested in the sciences, it's perfectly acceptable and you'll have all your fun sitcom shenanigans, do well, have exciting things happen, meet sexy and attractive people and it sorts of expands more by moving into female characters.(M29NSNA)

However, not all participants were entirely happy with the way they were introduced into the show, how they were initially developed, or the fact that the creators "should have added them in sooner" (M25SP).

> I guess I don't find them as engaging and funny as the guys are but I think they're important to be in the show because you can't show that all scientists are male, like you have to have your backbone set up with smart sassy females in there as well to balance it out. So although I don't like the characters, like they're not as funny, but I like the fact that they do have female scientists in the show. (F20NSU)

Nonetheless, these inclusions demonstrated that "scientists can be females" (M24SU) and there are also different varieties of them.

> I think they want to have characters differently, I mean all kinds of combination[s]. You would see like scientist, female plus normal, [and] scientist, female plus not normal. (M25NSNA)

Participants felt that the inclusion of female scientists into the show created an interesting dynamic among the existing characters and helped to extend their personalities. Some perceived benefits included that it "enrich[ed] the show. It was a bit just [about] physics and [a] dumb person, whereas it's sort of branched out" (M18SU), and "how they've added to the dynamic instead of just having the four of them going out to the Cheesecake [Factory] and seeing Penny there" (F19SU). By including female scientists, the potential story-lines would also expand since "they could have some more female

scientists in the show to add interest. I think every time one comes in it makes it more interesting" (F37SA). Also, the nature of the show being a sitcom has the risk of running stale as one participant has expressed, "I quite like the dynamic between four guys and Penny and how that story was playing out but I guess you can't do that forever" (M26NSNA).

An example of one particularly interesting dynamic between the characters was mentioned: the interaction between Bernadette and Howard when Bernadette was graduating from her Ph.D. and also got an offer for a well paid job. This allowed the show to explore the situation of women in higher career positions than their partners, and to show "there are female scientists in this world as well, and even more successful than guys" (M24SU).

> When we were talking about how Bernadette is more senior than Howard, that's a whole interesting dynamic as well. Usually in relationships, or in general life or on TV, [the] woman is usually not more senior ... that doesn't happen so often or you don't see it on TV much either, so it's nice to explore that relationship. (F33SP)

A science postgraduate participant in the same focus group elaborated on this interaction between Bernadette and Howard by sharing his experience where his old director worked in the same department with her husband and was in a higher career position. This provided evidence that the situation with Bernadette and Howard also happens in real life. A more obvious dynamic introduced to the show by the addition of female scientists was that men in scientific fields have opportunities to meet women in science, and it introduced the idea of scientists being in relationships with the opposite sex.

> I was just thinking the show needed female characters and they can't just bring out more Pennys. So they have to bring something that goes with the flow, and maybe get some female characters who aren't really ugly or really pretty but just between them. I guess that's also how you see the guys evolving, like they still hang out all by themselves [with] only guys, but now they have girls as well. It's the way that it happens as well, you transition out of high school and a teenager, when you are really young you [are] only [friends with] guys, then

> soon there is this one girl, then you get another one and you start hanging out with girls. So I guess they are going through that transition a little bit later in life. (M25NSNA)

> I think season four shows scientists can get married as well. They don't have to live [in] single-hood forever. I guess [by] introducing females it shows scientists can have a very good life as well. (M24SU)

In contrast, a science postgraduate expressed that since she is a female scientist herself, she cares about the portrayal of new female scientists, and that if they are poorly constructed she would rather they did not include female scientists at all.

> If [the female scientist]'s from my field and [she]'s being described as very awful, I don't want them to add any characters any more because it influences me probably. Some people ask me "oh, I've seen *The Big Bang Theory*, but do you act like that?" ... I don't like that because how they describe in these shows probably would be, it will be funny, but it's awful I think, I mean for me if it's same kind of background [it] could be very negative impact to me. (F30SP)

On the other hand, a small number of participants explained that they would not care if there was an absence of female scientists, providing short responses such as "I don't pay attention" (M30SP), or "wouldn't worry me, wouldn't concern me the slightest" (F29SP). Some explanations indicated that the show was first designed to work without female scientists to create an atmosphere where "it's not like I was missing having female scientists" (F26NSNA) and "it's not a crisis that they weren't there before, it's just the set up of the show" (F23NSNA). Furthermore, if the show was not intending to include female scientists in the later seasons, some participants felt they "won't feel that there is any discrimination, or ... won't feel bad about it at all" (F26NSNA). One participant compared this idea to perceptions held 20 years ago.

> I think because gender is kind of less sensitive now, it's not really as serious as probably, it could be a real problem like 20 years ago, people feel like 'well, you have to be gender balanced otherwise it discriminates.' Because in real life

> [women are] kind of deprived, but now it's not really [as] serious [as] 20 years ago so people [are] less sensitive than that. So no one is really watching, 'well, this show only males, no females.' It's like people are less sensitive about this matter as well, it doesn't really bother me. (M25NSNA)

A comparison between female scientists and male characters on *Sex and the City* (1998-2004) was made to demonstrate how a male science postgraduate viewed the female scientists on *The Big Bang Theory*.

> Just as when you'd expect a lot of guys to be written in *Sex and the City* . . . but again [the men are] for the romantic situation, so you can actually spin it. It's the converse, and I'm not doing any other realm parallel except the main focus is women and then their other social interaction is men and here you have guys and their social interactions and the biggest department is women. (M26SP)

It would appear that how the female scientists are portrayed has an effect on whether the participants would want female scientists included in the show or not. There were a number of reasons for this, ranging from personal identification, the nature of *The Big Bang Theory* being an entertainment television show, and the way the female scientists were introduced and what they did throughout the show. However, the general idea that arose from the responses suggested that the participants' own views of the purpose of the show had an affect on the importance of the female scientists' inclusions irrespective of their gender or whether they had a science background or not. If the participant felt that the show was there for entertainment purposes then they would not care as much as those who felt these portrayals could affect them personally.

5.4 Gender distribution between the scientist characters

The gender distribution of the characters in physics and biology was a common discussion point among the participants. Even though there was a clear division of men in physics and women (mainly) in biology, a few participants indicated that by introducing female scientists, *The Big Bang Theory* "gave more of a balance because all the main characters that were in there are guys. It was good to see [the] girls" (F21NSU) and "there should be

more equality between males and females" (M18SU). Participants also felt it demonstrated the evolution of science as a discipline.

> It sort of balances out Penny in terms of gender profiles but I don't know, I think at the same time they are quite good characters and so therefore why not? If they were poorly constructed characters that were there simply to provide a bit more balance then I'll probably say it's a shame that they included them. But I don't, I would say they're as well constructed as the others. (F19SU)

> I guess traditionally science is a male dominated field [but] in today's world that's not what it is. I mean there's a lot of women in science these days, but I don't think it's equal ... So it is interesting that at the beginning of these series it was almost like the stereotype of science 50, 60 years ago [with] all men, whereas now it's bringing in the women as well. It's not something I've thought of before. Maybe that is also showing the development of science as a discipline as well and who's in and who's not in it over time. (F34NSNA)

However, when considering the science fields that the three female scientists are in, the participant responses differed greatly. The two main female scientists in *The Big Bang Theory*, Amy and Bernadette, are both in the biological sciences; neurobiology (and neuroscience) and microbiology, respectively. The responses from the participants created a spectrum of how they saw the gender imbalance between the science fields. The responses ranged from participants who felt disappointed at the lack of aspirational vision, to those who appreciated the realism of the science fields that *The Big Bang Theory* tries to portray. At one end of the spectrum participants discussed the fact that "Bernadette does biology or something, and so does Amy" (F25SP) and how it was "surpris[ing] that they picked for the two female characters they were both biologists" (M23SP), and also that "it's true, there are more female biologists and there are definitely way more male engineers, physicists, mathematicians" (F22SU). However, by highlighting the female scientists mainly as biologists, many participants indicated that *The Big Bang Theory* portrays a negative image because "it's kind of a shame that that's been perpetuated" (F38SNA) into the public as "Bernadette and Amy both being into biological sciences and the guys all being into engineering and physics, it's a bit skewed like that" (M29NSNA) and "I'd like to

have a balance, I think you do notice, well I notice when there's not equal representation" (F33SP).

> There is that gender difference that I also notice ... Mind you, most of the female characters are from biology aren't they? Leslie is a physicist but the others are biologists, and maybe some physical sciences would be a nice thing to have in a female character. (F44SNA)

> They follow the general gender trends of women towards more biological and men towards more physical and mathematical. I do know they have some female physicists and they had the male entomologist but I can't remember many other situations that actually have a male being more towards either conservation, environment or biological, perhaps some of the softer sciences. So I'd say they perpetuate the gender assumptions, though there are I think some attempts of guest appearances to correct that, but the more constant cast of characters I would say follow assumptions. (F19SU)

For one particular participant, the disciplinary gender imbalance had a bigger impact on her as she explained "I had, and it's quite unusual, the high school I went to my chemistry teacher was a woman and because I'm a bit of a feminist so the gender imbalance in science sort of bothers me" (F34NSNA). A reason some participants felt disappointed and bothered by this gender imbalance was because they felt *The Big Bang Theory* exhibited the idea that biology is lesser than physics and often labelled as "the female profession ... Like physics is much more male and microbiology is female if you look at who does it"(F33SP) since "it's [a] girl-friendly science, [the show has] sort of stuck with that" (F30SP).

> It annoys me that they're in these lesser disciplines ... I don't actually think it is. I mean I know that's Sheldon's attitude to everyone who isn't in his area, but I kind of think 'oh well, biology is for people who can't hack physics'. (F23NSNA)

On the other end of the spectrum were responses that suggested the portrayals of these female scientists were not intended to be discriminative or to perpetuate assumptions. Rather, the representation was reflecting the reality of the science fields.

> In that sense the show is meant to be representative rather than discriminatory in that their fields are dominated by men. They're not doing it deliberately and in a sense that's kind of what they're interested in, is this friendship group that only functions the way it does because they're all men. . . . I kind of tend to think of a comedy as it doesn't try to address the imbalance, it sort of shows up the imbalance that's already there and makes something of it. In which case, what is the point of trying to include more women, there aren't more women in science, get over it, do you know what I mean? It's humanising the part of science we already have, which isn't to say that we shouldn't try to get more women into science. (F23NSNA)

Based on this assumption of *The Big Bang Theory* perpetuating the real situation in science, some participants felt it would have been difficult to produce a gender balanced show if it was intended to reflect the real world.

> I guess if you want to relate that to the rest of the industry in the world, there's nothing really that's very female [dominated], like profession wise. If you look at any job hierarchy it's so heavily dominated by men, there's nothing where you can significantly say where it's a female dominant profession. (M25NSU)

Multiple examples from personal experiences were given to expose the reality of the science fields and the gender distribution within them. These included various experiences ranging from high school to the workforce. One science undergraduate group was particularly vocal about their past experiences in science during their high school years, sharing different situations in Sydney and Singapore. For example, the participant from Singapore expressed that there was a lack of test scores that indicated boys did better in science than girls, rather "back in school the girls beat the boys all the time in everything, boys don't study as hard as girls do" (F22SU). Whereas the other two participants in the same focus group shared their experiences attending high school in Sydney.

> In Sydney, I went to a boys school but out of my physics teachers, like the physics teachers in my school I think half were female and one was, for my maths class, the female teacher taught the top level maths and she was definitely the best maths teacher, like she was so good. Though that might be a

bit less gender segregated. (M18SU)

> Like even with engineering and computing being completely different, you still come down to the end you get weaned out of it, like girls get encouraged to go into home economics or psychology. And all through high school we always had equal numbers in like everything that we did except when we hit year 9, year 10, and then year 12, it was like boys went into this, girls went into this, and it really reduced to the point in year 12 there were two girls in my software class of around 30 and the boys got really cut that I beat them all, so it was like it was a huge thing and all of a sudden software became unpopular. ... From what I've heard that a lot of boys started talking [the software course] down and then I was talking to other people in the year below because I had more friends with year 11s as I was with year 12s and they were saying, "oh yeah, we didn't really take up software because people from last year, or your year said it wasn't very that good, like we didn't enjoy it and it didn't really come across as well". And then I talked to the people in my class and they said "oh yeah, we didn't like it, like no offence but we didn't think a girl could beat us in it, like we know you're smart but" ... We're still a little country town. All the teachers that did IT they're all male, all the home economics teachers were female, all the physics teachers ... all but two are male, then those two also mainly specialised in like biology and chemistry. (F19SU)

Following on from high school, university experiences were also provided to exhibit the disciplinary gender imbalance in university classes through to post-doc positions. Due to the number of early compulsory courses in science, one participant noted, "you won't feel it so much in first year but in maths and physics there's like, one girl to every nine guys" (F19SU). This appears to be the same as what is observed by students when they are walking around the physics department at their university, and "look[ing] at the names and you'd expect there to be more men, it's just based on what there is" (F29SP). Experiences in the early career academic fields also provided similar observations, with the variation in number of male to females at each level of the career ladder, such as in the field of astronomy where "astronomy Ph.D. students are over-represented by females. Once you get past the first post-doc level then it's massively, massively over-represented

by males" (F29SP).

Lastly, experiences from being in the science industry were explored. The gender imbalance issue extended beyond mere statistical representations but also included a description of the environment, such as women interviewing for an engineering position or being in a masculine surrounding and relating to being in that environment.

> I imagine it would not be easy to be a woman working in those places, especially if you're a good looking woman, or feminine woman . . . because my friend's an engineer and she has to work doubly hard to prove she's smart, like she goes to interviews and they're like, don't wear heels, wear pants, don't wear skirts. So she goes and like all the guys turns up wearing suits and all fully dressed for an interview and she goes in like girls suit pants with boots basically, and they're like, "you're over dressed" and she's like, "well what am I supposed to wear? Like jeans? Like what?" And they only picked on her clothing because she was the only girl there. (F22SU)

> Having worked for my first job, I was working in a lab and it was a chemistry, that was [a] very blokey work environment and I mean, it was different because people were older like all the characters in the show are all under 30, so my colleagues were a little older with different issues going on but that kind of really blokey, very sort of technical, slight social oddities, I can relate to that too. . . . I actually found the relationship between Leslie and Sheldon, you know arch-nemesis, they hate each other and always slagging each other off, I found that really annoying. For me, it ran too true of my own experience as a woman surrounded by really blokey scientists and I felt like she's quite empowered and she kind of put Sheldon down but I think because Sheldon is such a strong character in the show and he's a stronger character than she is so she's portrayed a bit loopy. (F28SP)

The gender imbalance in science appeared to be consistent with people's preconceptions of issues women in science encounter, as suggested by these experiences, and starts when a high school student decides on their courses, which is consistent with Baram-Tsabari

and Yarden's (2011) findings. These experiences demonstrated that high school students begin to segregate themselves early and held preconceptions of how the male and female students should dominate in these courses, and furthermore, the consequences when this preconception broke down. This was despite the fact that many of the teachers in the science courses were female, which gave the appearance of negating the gender imbalance. However, one may argue that the split between gender doesn't apply to high school teachers because it is in the field of education rather than a professional science career. This carried on through to tertiary studies and early research careers in the ratio of male to female in the maths-intensive sciences, with the possible exception of early post-doc astrophysicists. However, as was expressed by the science postgraduate, the scale tips over to male dominated after this first post-doc position. As for the non-academic fields, it would appear to be worse as participants expressed the conflicts a woman may face in the science industry. These experiences demonstrated that it would have been difficult to reflect gender balance in *The Big Bang Theory*. Nonetheless, this issue of gender imbalance was considered to be irrelevant for two participants who considered it unnecessary to maintain gender balance in an entertainment television show.

> It's really just a TV show so even though in real life I would think it's good to have some gender balance and different fields but it's just a TV show so to me it doesn't really matter at all. (F26NSNA)

> It's just a question about the balance [and] where it fits, but I'm not sure there's a need for it in, and partly for that reason I'd like to think we've moved beyond looking at the gender. (M50SNA)

5.5 Inclusion of other female scientists

When asked whether the participants would like to see more female scientists introduced into *The Big Bang Theory*, a mixture of responses was provided. On one end of the spectrum, participants expressed that they would like to see more female scientists since "they're fun to watch and they're engaging and they shake things up a bit" (F21NSU). Also, other participants who enjoyed the science aspects of the show favoured more inclusion because "I think introducing more female physicists could get it back more

towards [the science] in a way" (M53NSNA), as well as promoting the image of women in science since "I think there's still a perception in public that women don't do science" (M40SA).

Participants varied in what characteristics they would like to see in the female scientists. These included having the female scientists as interesting and intelligent individuals who could compete with the male scientists rather than included solely or primarily as romantic interests. One participant noted that *The Big Bang Theory* has already started portraying women as "equally as powerful, there's no male dominance" (F21NSU), however other participants wished to see more of this type of portrayal.

> Different views of science means they'll probably bring in more jokes and those things so it can be interesting. But I just hope that they don't add in romantic stuff because that ruins the fun from my perspective. (M19SU)

> If they really were portrayed in a good way then sure, but [only if the female characters] could keep up with the guys [and] they were portrayed as a whole person. I mean obviously they're going to have to have some kind of stereotyping, but without too much stereotyping, and shown as just interesting, intelligent, curious kind of people rather than one dimensional shallow 'would rather be dating than doing science' kind of people. (F38SNA)

> I think also maybe bring in like a character like Leslie but sort of softer I guess, so that Sheldon would actually have sort of the same dynamics with her as he has with Amy Farrah Fowler. That would be pretty interesting. So mutual respect for each other but then sort of compete at the same time. Because I guess they bring in female characters in different aspects of science but I'd like to see also female characters in the current fields of science that the guys are in so, more engineering and astrophysicists, in the same fields as the guys are in so you can see some healthy competition rather [than] 'oh yeah, you're a scientist and I'm a scientist'. (F20NSU)

Additionally, responses indicated that 'normal' female scientists would "add a more interesting dynamic because it is still very male heavy cast" (M25NSU), as well as a good

chance for comparison between the characters as opposed to using Penny for comparison.

> I mean it's better to add more characters, like normal people to interact with the scientists. I think it's better [and] make it more interesting, like how does a normal scientist interact. I think it shows a few, [but] all those guest appearances were not sufficient, there's only Penny. (M24SU)

In contrast, a conversation between non-science participants explored the reality of having women who are geeks where one participant reflected on his own social group:

> F43NSNA: If they were just as geeky as the others, properly geeky, [and] into the same sort of things and form part of that crowd [like] "I want to go role-playing, I want to go do this, I want to do that, I want to go to the comic store with you" would probably be good. But is that representative of reality really? And how many female scientists or otherwise are actually part of that group? And I know a lot of guys, a lot of friends of mine who are part of that group to one extreme or another and there are very few female elements to it.
>
> M32NSNA: [My female friends that] come along to the board game nights and stuff like that, I'd say that out of a group of 15, we'd have maybe on a night of 15 would have three women. Which I think that after four years and the four characters, it's kind of time to have that inclusion just for representation because it's not a 1% kind of thing [for] my social circle. I don't know what it's like in the grander population and stuff . . . but that's still one in five, and so I guess if they did bring in a female character it would be one in five.

The use of cameo appearances of real life scientists sparked ideas among participants of incorporating real female scientists as guest stars, such as the way George Smoot, Neil deGrasse Tyson, and Brian Greene made guest appearances. This would have the added benefit of introducing the public to famous women in science fields, and participants felt "that would be quite exciting" (F35NSNA) since "out of the people who have cameos they're all guys without exception . . . Some of those things you don't think about but it's quite jarring once you do" (M18SU).

> So it would be nice to see more female scientists to show that females also

> do science and they're not as weird as Amy or Bernadette, and more famous female scientists doing cameos. (F25SP)

There were also responses that either rejected the idea or showed no particular interest in the inclusion of female scientists in *The Big Bang Theory*, or were only interested in "whichever makes things better, I don't think it's a necessity" (M20NSU). The nature of the show was a major reason why participants were hesitant about including more female scientists, such as whether *The Big Bang Theory* works well with its current cast or whether the dynamics of the show would be affected by the additions.

> I mean too many cooks spoil the broth, I think you have too many actors in the show it's just going to get sort of below, I think at the moment they're pushing the max with seven or eight of them so I think keep it as it is, the dynamics are working. (M22NSU)

> I want to see it but only if it worked with the show's story, like if it didn't, if it felt like they're putting in a woman just for there to be a woman that wouldn't appeal to me. (F26NSNA)

Furthermore, many comments generally indicated that the participants "don't see it as being male or female, it's just if you're good at what you do it doesn't matter if you're a male or a female" (F23NSNA), and "I want to see a good character that fits in the show, it doesn't matter if they are male or female" (M28SNA). More specifically, the participants thought it was more important how the characters were developed, and they were more interested in the inclusion of "any new field or whatever is interesting regardless of gender" (M32NSNA), "people with different background in this show" (M26SP), and "more characters in different fields would be sufficient" (M24SU).

> If it's well constructed then great, regardless of gender or areas of science or whatever, and I guess one of the ways to have a well constructed character is to create contrast. And so therefore perhaps yes, it will require different areas, [or] different genders. (F19SU)

> It just shows more sides of it, like you can be this in the same crowd [or] you can be like this and it doesn't matter if you're male or female. You can be

> really into it and be a physicist or biologist, whichever interests you more, or even engineers. (F19SU)

Following this, the participants were asked which fields they would like to see female scientists in. Many different disciplines were noted by the participants as possible fields of research for female scientists if they were to be included in a later season. These ranged from the physical sciences to the biological sciences to the social sciences. Various justifications for these disciplines were given to demonstrate why the participants would like to see these particular areas. The science fields that would allow a female scientist to easily enter into the show were physics and biology as the existing characters were already in these fields. However, some participants preferred not to have these fields and provided different reasons, such as "there's a heavy emphasis towards physics" (F28NSNA) and "to watch [microbiology being done in a lab] would be boring but the [related] stories are good" (F34NSNA).

> One thing I was thinking was that everybody comes from what you would regard as the core sciences, so physics, biology ... and it would be kind of interesting to have somebody who is in a field which is not sort of really part of that. (M48SA)

However, on the chance that the show would introduce a female scientist, most participants asserted they would like to have "a feminine woman in the hard science role" (M32NSNA) and "that [is] actually [a] girly girl" (F24SP) who would "come in a skirt and a pink shirt or something and nice make-up" (F19SU). As for being introduced into *The Big Bang Theory*, participants felt the characters could "maybe have some of their colleagues be female" (F22SU) but different to the portrayal of Leslie "who dresses like a man" (F24SP).

> I'd like to see another physicist that could engage Sheldon and maybe occasionally get the better in the argument about science ... [whereas Leslie] seemed to just be rude to him I thought. (M53NSNA)

> It's a bit better if they have more sympathetic female hard science, I mean neurobiology isn't soft by any means but that sort of biology versus the more

> mathematically orientated sciences, it would be interesting to see more female characters. (M29NSNA)

Consequently, images that support general assumptions, such as gender distribution in different disciplines, were not favourable for the participants, such as presenting them in biology or even the humanities because "biology they have reasonable amount of women" (M40SA) and "it's [a] more common assumption that women go into arts studies" (F26NSNA). Instead, participants would like "to see other female scientists in different disciplines that aren't generally considered 'female sciences'" (F30SP).

> I guess I wouldn't like to see some of the stereotypes that we have seen in science for a while, in terms of male dominated areas and female dominated areas, reflected too much in this sort of thing, because it's not all we want to encourage into the future. So there's this automatic reaction of [the] mind to say 'oh, women are in life sciences' because that's what a lot of women tend to go for, this sort of softer side as opposed to the maths and physics hard science side of things. They've already kind of gone there with it, they've already got the women in the soft sciences and the men in the hard sciences and I think, if I was going to see anything I would actually prefer to see a woman in the hard sciences but not a hard woman in the hard sciences. And I think Leslie Winkle was a little bit of a hard woman, so I don't see why it has to [be] that way. (F43NSNA)

Another major collection of responses focused on the entertainment nature of *The Big Bang Theory*, revealing that the focus group participants would like to see female scientists in other fields for the purpose of creating humour or conflicts. By doing so, the possible storylines would increase but still maintain the entertainment nature of the show. In regards to the humour aspect, a participant mentioned the field of archaeology as a possible avenue of exploration, whereas another participant noted computer science and IT would introduce characters that fit into the comic book culture. As for creating conflict and tension with the existing characters, participants suggested "something in a science that Sheldon thought was ridiculous would be a good sort of offset" (F26NSNA) since he often disregards other science disciplines and claims they are lesser to physics.

Some common suggestions included environmental science and social science.

Nonetheless, science participants who hoped the show would include more science content highlighted the need for choosing appropriate fields so the show can potentially produce positive outcomes, such as including the sciences that haven't been "cover[ed] yet because either way it will just make me learn more" (F21NSU) and to include "the less well known disciplines would be more attractive, then that brings up more awareness" (F35NSNA). This is especially true if one of the purposes of *The Big Bang Theory* was to inspire people, especially women.

> You need to choose disciplines where women are way less interested. So you see biology, most women you see are in those categories. If [she's in] mathematics or physics [it would be good], particularly in mathematics [because] I think the population is really, really small. (M26SP)

By strategically choosing science disciplines for aspirational purposes, as well as creating awareness of the different sciences, this kind of portrayal of female scientists could potentially benefit both *The Big Bang Theory* and the public in breaking the disciplinary gender imbalance perpetuated in the show.

5.6 Discussion

During the focus group discussions, Bernadette, Amy and Leslie were often compared to the 'stereotypical images' of female scientists despite the fact that no participant specified what these images are. There were no specific examples provided in the focus groups where the participants compared these female scientists to stereotypical images of women in science as summarised in Flicker's (2003) typology, or any other type of compilation. Instead, they typically associated stereotypical images of female scientists with those of the male scientists, such as the geek stereotype or the lonely individual. Therefore, we can assume that the participants in this study did not see female scientists on the screen in a way consistent with Flicker's view.

Nonetheless, a comparison can still be made through the participants' responses

with the six stereotypical categories of the female scientists described by Flicker (2003). We find that Bernadette, Amy and Leslie only display some of the traits rather than a particular female scientist stereotype as a whole.

Firstly, participants noted that Bernadette is the 'normal' character out of the group. This is mainly highlighted by the way she is socially competent and still accomplished in her science field. In this sense, her social capabilities can be seen as part of the 'daughter or assistant' stereotype because of her social competence. Even though the show indicated that she is accomplished in her science field, participants viewed her as 'downplaying' her science career by showing her as 'ditsy'. McIntosh (2014) made the same argument by indicating that Bernadette portrayals the 'ditsy blonde stereotype' because she "remains absent-minded and careless and she fails to understand the simple jokes and puns Howard plays in order to be funny" (p.202). However, Bernadette breaks the 'daughter or assistant' stereotype. She is not shown as lesser to men, and in instances where she is referred to by her academic title, she is known as 'Dr' rather than 'Mrs' or 'Miss'. This was often in comparison to her husband, Howard, who only has a Masters degree and makes less money than her, suggesting Bernadette is more capable than Howard.

Leslie is portrayed differently in that she has a strong personality and is shown as equal to the male scientists, which the participants interpreted as her being rude or 'a bitch'. As Leslie was working in a male dominated science field - physics - the strong personality she possessed was perceived to be in retaliation to the discrimination she has to face, as noted by one participant. She can be associated with the 'male woman' because of her stronger personality. She presents a few of the traits that Flicker (2003) identified as likely attributes: a rough, harsh voice (more in the form of bad language such as name calling), and practical clothing (like the attire of a casual top and pants). However, she is not asexual; or rather is quite sexually active and is seen using Leonard and Howard for sex on multiple occasions. She also presents aspects of the 'lonely heroine' with the fact that she consistently needed to argue with Sheldon, defending the values of her research. These traits associated with the 'male woman' and the 'lonely heroine' were also noted by various fan sites (*"Biography for Leslie Winkle (Character)"*, 2016; *"Leslie Winkle"*, 2016). The fans claimed Leslie has similar appearance to Leonard (noting how

she dressed in practical clothing), 'has more confidence' than Leonard and is 'bossy' (which is portrayed by her strong personality), and often 'at odds with Sheldon' (perhaps referring to how she needs to consistently defend her work). These observations made by the show's fans strengthened the argument that Leslie followed many traits associated with these two female scientist stereotypes. However, it must be noted that her strong personality and her sexually active behaviour caused some focus group participants to dislike her as a character.

Amy appeared on the show as the smart female scientist and the female equivalent of Sheldon. Not much discussion was conducted about her as she only had short appearances in season four, where her character wasn't completely explored. Due to the lack of comments made by the participants, it was difficult to identify a particular stereotypical category which would describe her.

Nonetheless, the female characters are shown as a challenge to the male characters, which the participants saw as a refreshing relationship that they hadn't seen before. Of Flicker's (2003) six categories of female scientist stereotypes, none included this aspect. Where the stereotypes were mostly about men saving the day, men as enemies, or men as the superiors, *This Big Bang Theory* focused on the women being successful in their respective fields and on an equal footing with the men. Even though Sheldon is often shown having arguments with Leslie, it was about the merits of two competing theories rather than clear discrimination.

Another major difference from the stereotypical categories is the characters' appearance. The participants felt that the look these characters are given followed the 'standard signs' of a typical geek or nerd stereotype. The term geek stereotype and nerd stereotype were often interchanged depending on the participant, and a suggestion was that the women are more of the nerd stereotype since they are interested in the 'intellectual aspects of life' and this was something that 'breaks away' from the female scientist stereotype. However, some people saw the women as not as interested in science in comparison to the men since they didn't spontaneously talk about aspects of science. The participants thought this may be because the female characters were not in

every episode in season 4, thus they weren't given the chance to fully develop as characters.

Other than the fact that *The Big Bang Theory* conveys that scientists can be women too, having female scientists as love interests highlights that scientists can have romantic relationships and can also get married and start a family (Steinke, 1997). This also confirms the stereotype of a 'romantic plot' (R. Jones, 2005) where women are portrayed as love interests. The majority of the participants noticed this and it is evident in how Amy, Bernadette and Leslie first entered the show. This suggests that this love interest role has still been maintained even though the women are not necessarily textbook stereotypes, and a likely reason may be consistent with Jones (2005) explanation that producers believe this will make the show appeal to both men and women.

As Long and colleagues (2010) stated, not many scientists on television or film are shown to have families, communicating the idea that scientists may be focusing on their professional careers with the side effect of losing out on their personal lives. Many participants pointed out this is not the case for the scientists on *The Big Bang Theory*. However, despite the women being shown to have important science careers, their role as the girlfriend or the wife is more prominent. McIntosh (2014) made a similar argument that the female scientists' intelligence was not meant to be a contrast to the male scientists or "a feature that defines these characters for themselves, but instead functions as a means to attract and maintain the attention of their men" (p.203). An example of this is the one-off minor character Elizabeth Plimpton, who has an exceptional science career but was recognised as a sex interest since that was the method to get her onto the show (both Sheldon and Leonard were fans of her academic work). As a result, some people felt these depictions of female scientists were a missed opportunity for developing their science careers.

On the other hand, some participants expressed that they considered the inclusion of female scientists as optional and not absolutely essential. Some participants expressed the opinion that the gender imbalance issue may have been a problem decades ago but it's not as serious now, and that women only happen to be the biggest pool of guest stars not because of their gender as such, but because of the nature of the show and the main cast being awkward men.

In spite of the fact that there was greater gender balance on the show starting from season 4, another big issue was reflecting the science discipline distribution. Of the three female scientists, two are in the biological sciences. Leslie is an exception and works in physics, however she left the show in season 2, leaving the two remaining female scientists in biology and the male scientists in the maths-intensive sciences. The participants were aware of this portrayal and had different reactions to this gender split. Some participants thought there is still a belief that physics is more difficult than biology thus more men do it, and that it was a shame for *The Big Bang Theory* to follow this commonly accepted depiction of 'men in physics, women in biology'. However, other responses showed that many people did not notice or mind there was the gender split. Rather, they suggest that *The Big Bang Theory* is reflective of science industry patterns. Furthermore, it would appear that this division between 'men in physics, women in biology', which is often reinforced or developed throughout childhood and adolescence (Baram-Tsabari & Yarden, 2011), has survived even through to university and beyond. Experiences from participants demonstrated a clear segregation between the 'hard' and 'soft' sciences, where boys are more likely to go into courses such as technology, and the girls get weaned out. As participant F22SU demonstrated, women in a maths-intensive science industry may be picked on just because they are a woman, which reflects the tendency for employers to favour men over women in scientific fields, such as preferring men over women when hiring a laboratory manager (Moss-Racusin et al., 2012).

Finally, the participants were asked which fields they would like to see female scientists portrayed in *The Big Bang Theory*. Participants indicated that the inclusion of more women scientists on the show may promote an image of women being capable of having a successful science career. Including women with different attributes could show that female scientists do not all conform to common stereotypes. For example, participants suggested introducing women not as love interests but as healthy competitors to promote the idea that women are as competent as men when it comes to science. On the other hand, the nature of *The Big Bang Theory* being an entertainment television show also dictates what can be done and what cannot. As noted above, the entertainment nature of these shows is built on the characters, and in order to engage with the television

programs, the viewers must identify with or react to the characters (Dhingra, 2003). So if the show were to include more female scientists there is a possibility that the show will no longer 'work' due to the limited time allowed to develop credible characters. Despite this clear disadvantage, some participants saw the gender of any new character as irrelevant, and that the development of the new character is the most important since it is what helps us relate and identify with them more.

As established in Steinke and colleagues' (2012) paper, both adolescent boys and girls tend to prefer drama programs over cartoons or educational program, as they have more opportunities to develop the characters so audiences can identify with them, but in particular, adolescent girls had more wishful identification with the attributes of characters in drama programs. This suggests that "presenting female televised scientist characters with specific traits and in specific television genres known to promote wishful identification for adolescent girls may be critical for developing their interest in science" (Steinke et al., 2012, p.191). Thus, in an entertainment television show such as *The Big Bang Theory*, it is important to depict the wishful identification traits - dominant, respected, caring - in order to attract girls into the field of science.

In addition, with the relatively rare scenario of scientists getting married, especially to other scientists, more unique and original ideas could be explored, such as the possibility of having the wife as more successful than the husband (in Howard and Bernadette's case). The relationships and marriage between the characters also demonstrate that scientists don't have to live in 'single-hood' forever, which is often portrayed in movies and television (e.g., out of the seven scientist stereotypes noted by Haynes (2003), at least four are described as isolated, willing to sacrifice human relationships, and oblivious and detached from the world). This is particularly important for the portrayal of women in science. As can be seen through Flicker's (2003) typology of female scientists, women in science have rarely been depicted in stable relationships where there was a mutual respect for each other's science knowledge. However, one participant stated that these situations do happen in real life, suggesting *The Big Bang Theory* is exploring more realistic scenarios rather than 're-hashing' the classic portrayals of female scientists. This may be beneficial in helping to deconstruct the idea that having a science ca-

reer and having a family is mutually exclusive for female scientists, as well as assist in creating a more inclusive image of female scientists actively involved in the world of science.

In many instances, we see the three female scientists having these specific attributes (but more specifically Amy and Bernadette since they are better developed characters than Leslie). The attribute of dominant is shown through these characters being equals to the male scientists rather than working under them as a research assistant or so on. The female characters are respected in their fields, being in a successful job and being invited to conferences or recognised for their achievements. The attribute of caring is abundantly demonstrated because the female scientists can be seen in social situations as caring for their friends and partners. By possessing these character attributes, the female scientists in *The Big Bang Theory* can potentially become role models for adolescent girls. However, it must be noted that Amy and Bernadette are both in biology, therefore they are only role models in biological sciences. Since Leslie was only in a few episodes in the first two seasons, her character was not as well developed as Amy and Bernadette's characters, thus it would be undesirable for her to be seen as a role model. Since their role as love interests appear to be more important than their science backgrounds, this implies that Amy and Bernadette may be better role models for romance more than science.

Chapter 6

Importance of the science content for audiences' enjoyment

This chapter links back to one of *Inspiring Australia*'s key principles, the need to strengthen the media's role in communicating science (Department of Innovation, Industry, Science and Research, 2010), and the subsequent recommendation, to establish funding to encourage the inclusion of science content in television and film (Expert Working Group, 2011). As part of this recommendation, a suggested implementation tactic was proposed which included running a pilot program and evaluating its success before seeking further funding. However, there were no attached guidelines for how to make a successful entertainment product for communicating science, and more importantly, what aspects other than the science content were important to the audiences' enjoyment. Therefore, it is important to understand why people enjoy watching television shows since it will provide science communicators and television producers with ideas for what to include to make their show successful.

The participants in this study listed different reasons for their enjoyment of *The Big Bang Theory* and five main factors were identified. Perhaps expected from focus group participants who wanted to discuss the science and scientists in *The Big Bang Theory*, the science content in the show had a major influence on their enjoyment. However, the other four factors – relatability, characters, humour, and geek culture references – were sometimes equally or more important than the science content. In contrast to these four factors, the participants indicated the science has been presented as secondary or part of the background as opposed to the central theme in the show. The participants also noted that despite the science content being presented as secondary, the scientific accuracy of

the information had a major influence on their enjoyment of *The Big Bang Theory*. The participants' responses were used to answer the main question:

> How important is the science content in *The Big Bang Theory* to people's enjoyment of the program?

6.1 Enjoyment research

Numerous theoretical frameworks and accompanying empirical research in the fields of psychology and communication studies have looked into the ways entertainment media stimulate enjoyment in viewers. Some studies reported on how different theoretical frameworks interact with each other since "the enjoyment that lies at the heart of the entertainment experience is a product of numerous interactions between motives to be entertained and conditions of this experience on both the media user's and the media's side" (Vorderer, Klimmt, & Ritterfeld, 2004, p.401). In the following literature review, I will explore a few of these theoretical frameworks to provide some insight into how entertainment media are being used. These particular theoretical frameworks were chosen because sections of the frameworks focused on television shows. Despite that they typically generalised entertainment television shows as drama, the theories could still be extrapolated for sitcoms like *The Big Bang Theory*.

Based on social psychology theories, there are different explanations as to why viewers are motivated to watch television. One of these theories is *uses and gratifications* which examines the motivation behind people's choices of using different media and genres, including television shows, to fulfil various needs. These needs could be generalised into two main types of uses: (1) ritualised (or diversionary) uses describe the need to 'kill time', and include motivations like habit, passing time, entertainment, relaxation, companionship, and escape, whereas (2) instrumental (or utilitarian) uses describe the need to seek particular media content, and include motivations like information seeking and learning (Rubin, 1983, 2002; Oliver, Kim, & Sanders, 2006; Rubin, 2009).

Furthermore, Rubin (1983) noted that the different motivations were often interrelated. For example, viewers who watched television for entertainment also had motivations

in information seeking, escape, passing time/habit and seeking companionship. Similarly, viewers who watched television for information had motivations related to entertainment, companionship and escape. The only motivations that had no direct relationship with each other were information and passing time/habit (Rubin, 1983), since an instrumental use aims to seek information, it is more "active and purposive than ritualized use and suggests greater audience utility, intention, selectivity, involvement, and potential influence" (Rubin, 2009, p.151). This also suggests that ritualised users and instrumental users are likely to choose different media sources. The former will result in people who will watch a substantial amount of television but "with no obvious program preferences" (Rubin, 1983, p.48) and the latter will exhibit "overall higher television viewing levels, and particularly the watching of talk-interview, news and game show programming" (Rubin, 1983, p.50).

Another social psychology theory that explains why people choose to watch television is *mood management theory*, which explains and predicts the viewers' choices in television shows by how they will change and regulate their mood. More specifically, it "posits that viewers' entertainment choices should [...] reflect the motivation to maximize pleasure and minimize pain" (Oliver, 2003, p.86). Mood management theory is similar to uses and gratifications since they both explore the reasons why people select certain media sources, but they are distinctively different in two ways (Oliver et al., 2006). The first is that mood management specifically investigates how people use media to change their mood, and secondly, mood management does not assume that the viewers are aware of their motivations behind the use of that medium, rather "they act in accordance with behaviors that were successful in the past" (Oliver, 2009, p.163). The principles of mood management theory can also be applied "to the broader realm of mood optimization" (Knobloch-Westerwick, 2006, p.240), where mood optimisation:

> relates to levels of arousal ... [where] individuals are likely to avoid unpleasant degrees of arousal, namely boredom and stress. By selecting media content, media users can regulate their own mood with regard to arousal levels. For example, after a stressful workday, media consumers will enjoy unwinding by watching a televised travel magazine (Knobloch-Westerwick, 2006, p.240).

Four mood-impacting characteristics were identified by Zillmann (1988) as important contributors to the viewer's choice of media:

1. *Excitatory potential* describes how the excitation level of the chosen media content can change or maintain the experienced mood. For example, people who have low levels of excitation (e.g., boredom) may choose exciting media content, whereas people who have high levels of excitation (e.g., irritation) may choose soothing materials.

2. *Absorption potential* describes how the absorption level of the chosen media content can intervene with the experienced mood. For example, people who want to change their negative mood might expose themselves to high absorption content (e.g., an intriguing mystery story), whereas people who are already in a positive mood may look for low or non-absorbing content.

3. *Semantic affinity* describes the level of affinity between the media content and the context and reason for the experienced mood. For example, people who are in particular states of mood (e.g., depressed after a bad break-up) will likely avoid media content that has high affinity (e.g., romantic movie).

4. *Hedonic valence* describes pleasantness/unpleasantness of the media content and how it impacts the experienced mood. For example, people will watch pleasant media content to intervene in bad moods or presumably maintain good moods, whereas unpleasant messages will have a negative effect on a person's mood.

Since these four mood-impacting characteristics address different issues with various types of mood, television shows – with a focus on sitcoms but also including action, drama and game shows – can have a wide application in modifying, manipulating and maintaining positive moods (e.g., Zillmann & Bryant, 1985; Anderson, Collins, Schmitt, & Jacobvitz, 1996).

Irrespective of why viewers choose to watch particular media sources or content, it is likely that they will enjoy what they watch for two reasons. The first reason is based on emotion psychology's definition of enjoyment. Deci (1992) generalised enjoyment as the process of a person performing an activity they are interested in and are intrinsically motivated to do, and linked this to the importance of a person's free-choice in choosing

the activity. Deci noted that two characteristics were important contributors to making certain activities interesting: *optimal challenge* and *novelty* (Deci, 1992, p.50). In terms of an entertainment television show with science content, the science concepts and information can be both new and challenging to understand, and in turn stimulate interest in the viewers. However, further research will need to be conducted to determine whether viewers will always react to these characteristics for science in television shows, and whether optimal challenge and novelty is necessary to their enjoyment.

The second reason viewers are likely to enjoy what they watch is based on communication theory's definition of enjoyment: an experiential state within the overall entertainment experience (Vorderer et al., 2004). Vorderer and colleagues summarised several observable manifestations of enjoyment and the main media entertainment sources they are associated with: (1) serenity, exhilaration, laughter are mainly related to drama, (2) suspense, thrill, relief are also most frequently associated with drama, (3) sadness, melancholy, thoughtfulness, tenderness are often related to melodrama and love songs, (4) sensory delight is generally from aesthetically pleasing media sources, and (5) achievement, control, self-efficacy are typically from playing video games (p.394). It must be noted that Vorderer and colleagues (2004) specified that the viewer's response may be dependent on the individual themselves and could potentially display multiple manifestations at the same time. It seems likely the first item would be most relevant for explaining audiences' enjoyment of *The Big Bang Theory* but the audiences may also draw aspects from other manifestations.

In further consideration of the importance of viewers' individual differences, various studies have shown that "individuals' enjoyment of media content is undoubtedly influenced by the personality characteristics of the viewer" (Oliver et al., 2006, p.332). Individual differences, such as personalities and backgrounds, will influence viewers' preferences in selecting different genres, as well as the reasons behind the viewers' enjoyment (Oliver, 2002; Oliver et al., 2006; Rubin, 2009). This also means that when viewers with different personalities "choose to view identical entertainment offerings, their reasons for doing so may differ considerably" (Oliver et al., 2006, p.330), and the reasons behind their enjoyment of entertainment media sources, such as television shows, depends on various

aspects other than personality, including prior knowledge and experience, and social identity (Oliver, 2002). Oliver summarised the importance of individual differences when it comes to media communication studies:

> Aside from individual variations in general media use [...] the diversity that exists in media *content* is also evidence of the importance of individual variations in preferences for, enjoyment of, and responses to specific *types* of media fare (Oliver, 2002, p.508; original emphasis).

Therefore, it is also important to understand *why* viewers enjoy what they choose to watch. There are a number of theories that investigate how viewers enjoy different entertainment media including comedy. One example is psychology's *disposition-based theories* which "describe how people appreciate jokes involving the disparagement of a person or group" (Raney, 2006, p.137). Raney noted the relationship between viewers' personalities and their social identity with disposition-based theories:

> One leading explanation of the media-enjoyment process centers on how individuals evaluate and form affiliations with media characters and how enjoyment is impacted by what happens with and to those characters (Raney, 2006, p.137).

There are many branches of disposition-based theories, one of which is the *disposition theory of humour* (Zillmann & Cantor, 1972, 1976; Raney, 2006). Raney summarised Zillmann and Cantor's (1972) study into three types of reactions people will have when encountering humorous situations based on the roles and activities of another group or individual. The first reaction is "empathy toward characters whose roles and activities we associate with positive experiences"; the second reaction is "counterempathy toward characters whose roles and activities we associate with negative experiences"; and the third reaction is a mix of both (Raney, 2006, p.138). Zillmann and Cantor (1976) further modified their 1972 definition by incorporating a continuum effect for this theory. This suggested that empathy has a significant impact on how different people will react to disparagement in humorous situations. This could be extrapolated to humorous situations in television shows where the viewers will react to the disparagement of different characters depending on who the viewers empathise with, and thus allowing the viewers

to enjoy the television show through this disparagement.

Another disposition-based theory is the *disposition theory of drama* – originally introduced as the *disposition theory of mirth* (Zillmann & Cantor, 1976) – which "predicts that enjoyment will increase when liked characters experience positive outcomes and/or when disliked characters experience negative ones" (Raney, 2006, p.140). Axiomatically, the viewers will not enjoy situations where their liked characters have negative experiences and/or their disliked characters have good experiences. Similar to the disposition theory of humour, a continuum effect is also applied to this version of the theory. The difference between the two disposition theories is a simple one: "humorous disparagement and disparagement in drama could be distinguished conceptually by the fact that humorous situations involve joke work and dramatic ones do not" (Zillmann & Cantor, 1976, p.109). This means for television shows, viewers will judge the characters depending on aspects like morality to determine which of the characters are 'right' or 'wrong'. Viewers tend to enjoy television shows more when the consequences of the characters' actions match viewer expectations (i.e., characters who are morally correct will have justice, whereas characters who are morally wrong will be punished to varying degrees depending on the severity of their crimes) (e.g., Zillmann & Bryant, 1975; Raney & Bryant, 2002).

Raney (2006) argued that the disposition theories of humour and drama are interlinked, since when certain characters are well liked, the viewers will become more empathetic toward them. In contrast, when characters are disliked, viewers will be more counterempathatic towards them. Therefore, "enjoyment increases in proportion to our dispositions as the outcomes we wish for are portrayed [and conversely] enjoyment suffers in proportion to the dispositions held if the outcomes we wish for are not portrayed" (Raney, 2006, p.141).

Another psychology theory that discusses how viewers enjoy different entertainment media is *transportation theory* where enjoyment comes from the experience of being immersed in a narrative world (Green & Brock, 2002; Green, Brock, & Kaufman, 2004; Green & Brock, 2005). Green and colleagues (2004) summarised four attributes of transportation theory that can be extrapolated for analysing television shows: (1)

"the phenomenology of media enjoyment can be characterized as a flow-like state", (2) "positive content is not a necessary condition for enjoyment", (3) "the personal 'safety' of a narrative world, even when characters encounter trials, may be a basic underpinning of enjoyment of stories", and (4) "enjoyment may stem from the exercise of fundamental empathic abilities that allow us to connect with others" (p.317). Furthermore, transportation theory has also shown a positive correlation with perceived realism and prior knowledge within a narrative (Green, 2004). More specifically, a person's prior knowledge, experience, and familiarity with events or characters that have been mirrored in the narrative would increase their transportability since these are "factors making it easier to identify with or understand a character" (Green, 2004, p.261) irrespective of whether the narrative was positive or not. This suggests that the viewers will enjoy the television show more when they recognise events and characters consistent with their prior knowledge, experience, and familiarity since they are more easily transported into the narrative world.

The overview of these psychology and communication theories demonstrates that television shows such as *The Big Bang Theory* are used for different purposes and motivations, even when the viewers' main goal is to be entertained. The process of being entertained can be associated with enjoyment, and the viewers can enjoy the content of the television shows in different ways, like disparagement of certain characters or being transported into the narrative. However, since different people will enjoy the same show for different reasons, it is important to understand the association between individuals and the reasons why they appreciate and enjoy watching certain television shows. This is particularly important for this study since *Inspiring Australia* aims to produce entertainment programs with science content as a way to engage Australian public. This means it is essential to understand whether science content in television shows contributes to the viewers' enjoyment since it would be difficult to engage the public with science if they don't enjoy it, causing them to neglect the science content or to choose another television show all together.

However, to avoid 'preaching to the converted', it is also important to create a television show that is accessible, to attract viewers who are not generally motivated to watch television shows that have science content. Therefore, it is also necessary to find out what

these viewers look for in entertainment television programs. The combination of these two findings can potentially help with producing an empirically based list of ideas of what is needed to create a successful entertainment television program that has a decent amount of science content but is also accessible for the public. My participants' responses as to why they enjoy watching *The Big Bang Theory* can potentially assist in this.

6.2 Role of science versus other factors in participants' enjoyment

There were many participants who specifically named science as an enjoyable aspect in *The Big Bang Theory* and how it made them "feel good about having an interest in science and being a science nerd" (F52NSNA). The responses indicated that participants appreciated different aspects of the science presented in the show and that their personal interest in science strongly affected their comments. For example, the participants who are very interested in science, or had a science background, often credited science as a main reason for their enjoyment since "the concepts are all pretty current, like when they talk about quantum loop gravity and string theory, [which] are all topics that [are] really relevant" (M22NSU). In addition, the participants appreciated the inclusion of 'hot topics' in science.

> [Whenever] Sheldon mentions string theory, like that's still a hotly debated topic. And I guess it's good that he mentions it because you know what scientists are talking about these days and you know what's going on [and] learn whoever the next Nobel Prize [winner] is. So they talk about string theory, [and] whoever figures out what it actually uses, [or] what [the] next big thing is going to be, so I guess it gets people involved in the big issues of science ... When Leonard won the prize to go to the Large Hadron Collider and that was just after they were talking about it on the news and I was like "wow, so topical." They were probably [watching] it and [said] "oh, we should probably work that into one of the episodes" so I thought that was a good episode especially how [they] can go at the end. I thought that was so funny ... I think I remember reading something about [lunar ranging], like an article about that

> just a couple of weeks after that episode came up and I was like "oh, wow" and I actually know what they were doing now with measuring the distance to the moon and see how long it takes to come back so that was interesting. (F20NSU)

As a result, the science assisted in constructing the intellectual content in *The Big Bang Theory* and was often the reason why participants enjoyed watching the show.

> I like it that it's there because like there's not many other things that I would call on for sitcom ... Most sort of sitcoms annoy me because they're such contrived and artificial little problems, like somebody didn't hear somebody else or somebody misunderstood somebody else and then you just get this stupid misunderstanding. Whereas even though a lot of the social sort of things in *Big Bang* are sort of similar, they are looking at bigger issues. It's incidental to the plot in a way but they have bigger issues on their minds [which are] relevant [to] what they do. (M29NSNA)

This idea was shared by other participants who appreciated the creativity the writers incorporate into the show.

> F43NSNA: The difference between most of the other American sitcoms is that [*The Big Bang Theory*] does have intellectual content. It does not just speak to the stupidity of life and stupidity of people and the inability of people to think through problems, and I like that.
>
> M32NSNA: It doesn't have the subtle humour that you get from the British TV shows that I like. But it does have, as you said, the higher level of intelligence where it's not just 'dick and fart' jokes and it's not just slapstick. They put some creativity into the show.

The ability to understand some of the science content and jokes became a particular source of enjoyment for participants since it gave them an ego boost, or what the participants referred to as "elitism" (M32NSNA), since the participants felt they were among the elites in the audiences and that "knowledge is power" (F43NSNA).

> I think maybe there's also this element if you're a physicist, you can get the 'in' jokes and you'll feel a little more privileged when you watch it . . . I guess that's what I was referring to when I said it's appealing because of these 'in' jokes. You feel a bit like an insider because you can read these things on the whiteboard and [be] like "oh, I recognise that." (M40SP)

> It makes me feel clever like especially in the beginning when I get the nerdy jokes, I was like "haha, I'm clever" . . . and I don't study physics, but I understand [the reference] so it just strokes my ego. (F22SU)

This phenomenon also created curiosity among the 'elites' in the focus groups since they would want to know "how many people really understand 100% of all the jokes and all the references to things like entropy and things like that" (M22NSU). Again, this could be another form for an ego boost where the audiences would rank themselves according to the level of science understanding.

Participants appreciated how *The Big Bang Theory* "does a really good job of portraying the science side, particularly [what] the experimental and theoretical physicists do, as being both really important and almost ridiculously abstract at the same time" (M26NSNA) and the rivalry between theoretical physics and experimental physics where "they kind of expose the little tug-of-war that goes on between theoretical physicists and experimental physicists as well" (M22NSU). This comparison between the two branches of physics also demonstrated that there are different ways to approach scientific research which helped one participant relate to the science content.

> [I] love that there is no single right way all the time [to do science]. There's a lot of areas I suppose that's attracted me towards applied science, rather than [the] pure research form. [So] driving towards solving a more short term problem rather the blue sky research [like in the show]. So that interplay in *Big Bang Theory* touches a note for me. (M50SNA)

By incorporating different types of research methods, such as applied science, *The Big Bang Theory* could also attract new viewers who recognise what the characters are attempting to do.

> I remember one time my dad even got into [the show] because he's an engineer. [In the episode where the characters] were doing [work on the space] toilet [and Howard's] doing fluid dynamics, my dad just walks past the TV and looked at the board that they were working [on and said] 'is that fluid dynamics?' and he just sits down and watches it. (F20NSU)

Furthermore, participants also enjoyed that *The Big Bang Theory* extended the scientific thought processes into social situations, or "appl[ied] scientific processes to something that is quite simple to most other people, [and] that shouldn't involve that level of thought" (F20SP). Some examples mentioned by the participants included "optimising a trip to the movies" (M25SP), creating an "algorithm for making friend" (F30SP), and the "reasons why [Sheldon] likes his spot [on the couch]" (M23SP), thus incorporating "science as an everyday thing" (F38SNA). A science participant alluded to another example where he referred back to the episode *The Luminous Fish Effect* (S01E04).

> I reckon it's very much formal science investigation, like the episode where Sheldon gets fired and one day decides that he's going to determine whether scrambled eggs can be made any better and sets out to systematically test all the methods of making scrambled eggs, and comes to the conclusion that they're about as good as they are ever going to be. But I mean, stuff like that presents to someone who's in the general populous how science is undertaken and that without it having to be in the lab. (M25SP)

The fact that the characters apply scientific thought processes to everyday situations resonated with one participant where he enjoyed how *The Big Bang Theory* demonstrated science is not confined to the lab and that science is important to the people who practice it.

> I think there's beyond what they do in their labs. I mean they talk about science as an idea, whether it's their work or other people's work or theories on a daily basis, in every episode. I think that's what's important for me and that it shows that science is not just something that gets done in the lab. They talk about it, it's important to them, and that's really important as well that

> they care about it enough that they'll bring it home with them and they talk about it, and they try to teach Penny scientific theories. (M25SP)

Many participants indicated that their enjoyment of the science aspects of the show related to their science understanding, and that the more they understood, the more enjoyable the show was for them. For example, a non-scientist participant expressed that "when I go look up the science behind the actual title of the [episode on] Wikipedia, it opens up the episode and you get the deeper meaning so much more than the surface glance" (F34NSNA). Another example was the mathematical equations on the whiteboards, where one participant asserted that "I try to look at the equations on the whiteboards, and I like it [that] I can understand what they're talking about" (F37SA), and another participant expressed:

> I remember reading online [that] throughout all the series there's always a whiteboard in the room with physics equations and it's a problem that Sheldon's working on through the entire series, and I thought that was really cool. Just cute little sort of things like that [which] makes it more interesting and mean different things to different people. (M22NSU)

As for the participants who do not have an in depth understanding of science, they often commented on how they appreciate that the science was framed into an easy-to-understand context. One example of the science was Schrödinger's cat, specifically how *The Big Bang Theory* linked it to everyday occurrences.

> It is very clever they link concepts in physics to everyday occurrences, like the whole idea with [Schrödinger's cat] was [whether] the relationship [is] alive or is it dead, or you don't know until you've actually done it. It's just so true, [and] very clever. (M22NSU)

> Like one of my favourite ... was Schrödinger's cat and just the extent that Sheldon goes to explain what that means to Penny. And it was [explained in] a very easy and understandable way for general people to understand the concept of Schrödinger's cat. (M25NSNA)

> [For the] Schrödinger's cat thing, I'd always wondered what that was and if I didn't watch *The Big Bang Theory* I still wouldn't know what it was. (F44SNA)

Schrödinger's cat was used on multiple occasions through different descriptions. In addition to using Schrödinger's cat as an example to describe the relationship between Leonard and Penny, Sheldon also used this physics concept as a way to describe his own relationship with Leonard on one occasion:

> Like Schrödinger's cat, didn't they use it like a joke? Because Leonard wasn't cooperating with Sheldon, so [he said something like] "until you make up your mind whether or not you're going to cooperate with me, you're Schrödinger's friend", [implying] you're at the same time my friend but not my friend. (F22SU)

This link between physics and everyday life has made the show more enjoyable for the science participants because they felt *The Big Bang Theory* is attempting to "make it understandable for common people" (M27SP). Furthermore, this link between physics and everyday life also has the potential to popularise physics concepts such as Schrödinger's cat, since "now the general population knows about things like Schrödinger's cat. Like, that was a very obscure reference until this show came on" (F28SNA). This resonated with another participant who also made a reflection that "it's not an obscure science fact as it used to be maybe about 20 years ago. It's one of those cool bits of scientific theory people know about [now]" (F26NSNA). However, not all the participants felt that the way Schrödinger's cat was presented contributed to their enjoyment. Rather, one participant with a philosophy background felt frustrated by the way *The Big Bang Theory* communicated this idea:

> The one with Schrödinger's cat is a philosophical problem, and I feel like they totally bypassed that fact. And I'm standing there going "the reason why Penny doesn't understand it is because you're explaining it as a scientists", like, explain it as a normal person! (F23NSNA)

However, a fellow participant in the same focus group responded "but that's why it's funny" (F34NSNA). This interaction between the participants demonstrated that the science in the show has different meanings for different participants (Oliver et al., 2006). For example, even though in this instance Schrödinger's cat is linked to quantum physics, it can also be thought of as a philosophical problem. Also, as demonstrated through the responses above in regard to Schrödinger's cat, some participants took this physics

concept at face value but others took it as various triggers for the humour. Schrödinger's cat is a rare case where the participants can enjoy the different dialogues from different angles, such as through the relatability, the characters, the humour as well as the science. These different aspects listed here also contribute to the audiences' enjoyment of the show, and will be discussed later on.

Some of the non-science participants also specified that they enjoyed the science content, but often not in the same way as the science participants. Since many of the non-science participants did not have an interest in science, they appreciated the fact that they didn't need to understand the science or have prior science knowledge to enjoy the show.

> I think a lot of the real talent in the show is writing to a variety of audiences so that you can watch it with a strong physics background and you can really engage with it, but you can also watch it knowing very little of science and it's still quite funny. (F21NSU)

The following comment demonstrated how the participants thought different people would feel toward the science presented in the show, specifically between viewers with a science background and those with no science background.

> [For] regular people, [like] mini-man scientists or non-maths people, [they] don't need to know [the difference between] differentiate or integrate. But the fact that Sheldon immediately brushes it off is what I think appeals to the non-scientists, whereas the integrate [and] differentiate thing appeals to us, the scientists. So I just like to see what is going to be the next science joke, and how are they going to make science relatable to the general public again. (F41SA)

Therefore, despite the fact that *The Big Bang Theory* does communicate complicated science content, the non-science participants could also engage with science through other avenues. Non-science participants who aren't interested in science still appreciated the presence of science in *The Big Bang Theory* as part of the plot for an episode. For example, the participants appreciated how Sheldon dressed as the Doppler Effect for Halloween in the episode *The Middle Earth Paradigm* (S01E06). Despite that the science explanation "doesn't exactly go into great depth [and] you wouldn't expect it to in that setting"

(F28SNA), participants "identified with the sentiment behind it" (F23NSNA) where Sheldon "dressed up as the Doppler Effect as opposed to explaining what it actually is" (F23NSNA). On the other hand, for non-science participants who have a hard time understanding the science, they would often assert that "I'm not from a physics background so I think it's harder for me to understand [the science], but the trivia science facts were quite interesting" (F26NSNA). There were a number of other specific examples which targeted the trivial science aspects to demonstrate the range of science incorporated in *The Big Bang Theory*.

> I think they also have different branches of the science. There was one where they were stuck in computer algorithms when Sheldon was trying to make a new friend, and then the next day they'll go to the hospital and end up in the bio ward because he walked into a contaminated room. So it's different branches of science. It's not always just the physics, which makes it a bit more entertaining because you're not continuously stuck on the same thing. So you get different opinions of different ways the science is put out. (F19SU)

The computer algorithm mentioned in this previous response was the friendship algorithm, which appeared in the episode *The Friendship Algorithm* (S02E13). Different participants had different opinions of what this example represented. While one participant felt that the friendship algorithm displayed parts of maths and reasoning, another participant asserted that the friendship algorithm doesn't include any science, as demonstrated through the following responses:

> The episode where [Sheldon was] trying to become friends with Barry Kripke so he can access to the super computer, [you] see [him] drawing this diagram 'how to become a friend'. So he has a flow chart, [and] if yes then follow this, if no, [follow this]. That's a perfect example, he's bringing maths and the reasoning side. (M26SP)

> When Sheldon was trying to find a friend, to me that wasn't a computer algorithm, it was just logical reasoning. If you try and drive out friendship that's what it comes down to when you're really a nerdy person. I understand

> why he does it [but] it doesn't seem like very sciencey, more like common sense sometimes. (F22SU)

The difference in the interpretation of the friendship algorithm demonstrated how personal views may affect how the participants understood the science in the show (Oliver et al., 2006). In these two responses, the first participant saw the friendship algorithm as something that is embedded in science whereas the second participant thought it had nothing to do with science. It might be interesting to note that the first participant is a postgraduate in astrophysics and the second participant in an undergraduate in biology, which perhaps could have affected this difference in interpretation. Another example of the 'trivial' science content was noted in the episode *The Cornhusker Vortex* (S03E06):

> Even some little things that they talk about, [like] the everyday sort of science. There was an episode where Sheldon is going into Penny's house and asking for bread, and she says it's in the fridge. He [then] goes on a rant about how you shouldn't keep bread in the fridge because that's why it goes mouldy. That kind of stuff I didn't really think about, [like] don't put bread in the fridge, but there's little science stuff that goes throughout [the show] that isn't the big [science like] what they are researching. They do that in every episode where there's little science stuff as well and I think people would learn from that. (M23SP)

However, this participant remembered this piece of trivial science of bread in the fridge incorrectly. In the episode, Sheldon borrowed bread from Penny and was told she stored her bread in the fridge. Sheldon then mentioned that bread should not be stored in the fridge because it goes stale quicker. The response made by this participant indicated that despite these small pieces of science being accessible to the audiences who do not have an in depth understanding of science, the information may be retained incorrectly despite being relatable to the audiences. Another example was the positive reinforcement in episode *The Gothowitz Deviation* (S03E03), where Sheldon used chocolates as a positive reinforcement when Penny does something he deemed 'appropriate' or 'correct'. One participant expressed that she found that for "the Pavlovian conditioning, having studied it, that was a much better explanation than I ever had before" (F31SNA). However,

this was not Pavlovian conditioning, rather it is operant conditioning. In this episode, Sheldon clearly stated he was "employ[ing] operant conditioning techniques, building on the work of Thorndike and B.F. Skinner". Nonetheless, similar to the case of the bread in the fridge mentioned above, the scene might be memorable and relatable but the science information may be interpreted incorrectly.

The focus group participants also compared the first few seasons to the later seasons as a way to demonstrate the importance of the science content to their enjoyment. Participants felt that the depth of science content was affected in the later seasons, and their explanation was the nature of *The Big Bang Theory* being an entertainment television show. The differences in the seasons seemed to have been an issue, with one participant noting that the science content "was [explained deeper] in the earlier episodes" (M53NSNA) and that they were disappointed with the decreasing amount of science in the later seasons.

> But I do feel that it's really gone down after season two. The science has almost left in my opinion. It used to be the science was in pretty much everything but now it's just in the corner somewhere being hidden ... [Personally], I think it peaked at season two and then it went down. I'm just really against it now. (M19NSU)

> I would have stopped the show if there isn't any science background to it. Like, if they moved on to the usual stuff like dating and what not, I think I would lose interest in that, so there has to be some science background to it. (M25SP)

Thus, it would appear that for some participants the science is an important part of *The Big Bang Theory* and makes a substantial contribution to the audiences' enjoyment, as well as an impact on whether they would still watch the show. This idea resonated with other participants who expressed that they appreciated the science content.

> I think [the science is] important because it's a key element, and also there's a lot of ideas. You can almost say it's a very unique show where it's using science as the base of comedy. I think it's a pivotal construct of the show and if it didn't have it, it would lose out. Like in the first episode [of the series] with quantum physics [and] how a photon could be both a particle and a wave

> at the same time. And just stuff like that that most people would not even dream of learning or even be interested in, but when it's presented in a quite trivial context it's amusing and interesting. (M25NSU)

> If the science wasn't there it wouldn't be the same show, so I think it's important. It's great to have it there because it grounds it in something that I understand and I appreciate and I find interesting. And it sets up the characters as the kind of people that I understand and know and appreciate and feel empathy for ... They sort of swing between from incredibly complex quantum mechanics and quantum physics and things like that where they've just got a whole bunch of formulae on the whiteboard in the background of a shot and they don't bother explaining any of it. Or Sheldon is just going off on one of his little rants and they don't explain any of it. They will just put it in there to make people go "oh well, that's science, that's cool." Or they [will] go completely the opposite end where they are using it as a gag. So Leonard is explaining something in terms of some scientific theory like Schrödinger's cat or something, and again they sort of explain it a little bit but it's just used as a set up for a gag. But because I kind of get that and that's the way I talk and I appreciate having that in there, so it wouldn't be the same show without the science. (F38SNA)

Even though the science content in *The Big Bang Theory* appeared to have an important influence on the participants' enjoyment, the majority of the responses that discussed their enjoyment were targeted to other aspects of the show, suggesting that science is not the *main* reason for their enjoyment. The participants expressed they found the relatability of the overall content an important contribution to their enjoyment since they can identify with the characters or the situations. In addition, the humour is also important since by its nature, *The Big Bang Theory* needs to firstly entertain the audiences. Characters appeared to be one of the most important aspects of the show as well, and as one participant asserted, "the science doesn't matter, the fact that they're scientists matters because it's a series of personalities based around behaviour but the science is not important" (M48SA). Lastly, the geek culture references are also important but to a lesser extent in comparison to the others. The geek culture references have the

capability to attract viewers who aren't interested in science but can relate to things such as science fiction.

By incorporating these four elements – relatability, characters, humour and geek culture references – *The Big Bang Theory* can attract audiences from different backgrounds and interests that are not necessarily related to science. However, what was interesting was that many of these comments were associated with science, suggesting that other than being specified as a reason for the participants' enjoyment, science is also interconnected to other aspects of enjoyment and a running theme throughout the entire show. An explanation for this could be because of the recruitment method. Since I recruited participants who were willing to talk about science in *The Big Bang Theory*, it was highly likely that the participants were already interested in science and felt that science had an important relationship to their enjoyment, thus provided responses from different angles while still conscience of the influence of science. Nonetheless, it would appear from the number of comments made by the participants that the other aspects, which will be discussed below, are considered more important in their contribution to enjoyment than the science content.

6.2.1 Importance of relatability

Being able to relate to the situations and the characters in the show was one of the most important influences on the participants' enjoyment. The participants' responses regarding relatability often revolved around how the characters reflected people they know or themselves, as well as how they have experienced similar situations that the characters encountered. One participant identified with the stereotypical attributes that are usually associated with the scientist characters, as well as sharing experiences with the characters.

> I think [I can relate] to a lot of the people in [*The Big Bang Theory*] because I've always been pretty nerdy and introverted myself . . . [I'm] rubbish at sports and I'd rather read a book than do something physical and so I really relate to these people who are similarly nerdy. My partner [is] an engineer so that just adds to the nerd factor in our house. We like science, we like books, we're not very outdoorsy, we have weird conversations. The people on *The Big Bang Theory* are younger than us but I think we still enjoy their communication

> . . . I've just spent eight years hanging out with scientists at CSIRO too, and guess that I feel like I've found my tribe. I can relate to people who are nerdy and talk about science and so this is a really light-hearted [way to enjoy that] outside of working hours. (F44SNA)

Many participants could relate to how the characters felt about different situations. One example was of the Large Hadron Collider which was integrated into the episode *The Large Hadron Collision* (S03E15) and a participant expressed "I lived in Switzerland and went to see it myself so I can completely identify with the excitement about going to that" (M53NSNA). Science participants could also identify with some of the everyday aspects of science as a job and appreciated how it has been made humorous so that science may be seen as more accessible.

> It's just fun sometimes to see what is, for the most part, [your job] and your everyday life made funny somehow, [let it be] through a joke, or through a situation. It's nice to see what you work on day by day and what you are committing your life to made accessible and enjoyable for the public. (M23SP)

A biologist noted a particularly familiar aspect of her job in the episode in *The Vacation Solution* (S05E16). In this episode, Sheldon was forced to take his annual leave but instead went to help out at Amy's biology lab, and this participant asserted that "it's very real, like when Sheldon goes and work in the [biology] lab and he just has to wash up the glasses, and that's so true" (F33SP). Another example was from a participant who felt that she could identify with Sheldon's thought processes for creating the friendship algorithm for making friends in *The Friendship Algorithm* (S02E13).

> One thing that particularly got me and possibly because it's relevant to my psychology and computing background is the friendship algorithm. I absolutely loved that, I thought that was a very cool episode and I'm not in a position to judge whether the rest of the physics and stuff in the show is real or not but I thought the friendship algorithm was a really, that registered for me, I thought that was quite good. (F44SNA)

The identification wasn't limited to science situations, rather non-science participants could also relate to other aspects which were not related to science. For example, a non-

science participant asserted that she personally identified with the scene where Sheldon was trying to calculate when he will die in *The Cruciferous Vegetable Amplification* (S04E02), because it was being taught as part of her university degree.

> I think in one episode [Sheldon] was worried about ... how long it was going to be until he died and he was working out all these stuff on the board and it was all stuff like actuarial [and] statistics. I was like 'Wow! That's so awesome' because I just started doing the life contingency course which is where we learnt [how to do this]. (F20NSU)

Another example was the room-mate agreement that Sheldon often references in the show. A non-science participant expressed she really enjoyed this inclusion of law knowledge "because I'm from a law background ... so [I enjoy Sheldon's] ability to put everything into details" (F35NSNA). In contrast, perceived errors that *The Big Bang Theory* displayed in the show may also draw attention and relatability, such as an anthropologist noticing an error in the social science information in the show's theme song, where the show is "great with their representation of hard science but they said the Neanderthals developed tools. The Neanderthals didn't develop tools" (M37NSNA).

The information errors in *The Big Bang Theory* were not limited to non-science information. Some scientists in the focus groups noted errors and inconsistencies in the science related situations, but they asserted that these could also contribute to their enjoyment. One example was from a science post-doctoral fellow who expressed that when he was asked whether he identified with Sheldon and Leslie's debate about string theory and loop quantum gravity as presented in *The Codpiece Topology* (S02E02), he said that he did not. He also pointed out that, as a theoretical physicist himself, he does not agree with Sheldon's various viewpoints.

> No, [I don't identify with the debate] but it is quite funny because you are sort of aware that this is going on and [the show does] exaggerate it slightly so a lot of people just shrug, or take it, or don't really care. I think for most people, if they are in theoretical physics they think the sort of things [portrayed in the show], but that's only a very small aspect of theoretical physics with some

> various fields that are particularly mathematical and geeky. Or at least that's what I think ... I'm a theorist so I certainly enjoy [theoretical physics] more [than experimental physics]. More importantly I think very few theorists would actually behave like Sheldon, sort of relegate experimentalists [and] basically consider them as close to totally useless ... I mean if it is empirical science [then] that means you'll have to test it ... I think even [the] string theorists [that] I know are actually quite upset that [they] can't really test string theory. (M40SA)

The inconsistency in Sheldon's behaviour elaborated in the above response contributed to the participant's enjoyment since he was able to reflect on his own experience in theoretical physics. Another example was from a science academic who identified with the characters when they were invited to a conference as panel speakers but the discussion was derailed in *The Love Car Displacement* (S04E13). The participant felt this was unrealistic:

> There was one when they were at a conference. I think Leonard and Sheldon had to present something in a conference and it totally wasn't like [a] scientific conference at all. It was really funny. Instead of talking about what they were talking about they went off at a tangent ... Conferences are not like what they show in [*The Big Bang Theory*]. So I think in some [cases], the characters themselves are similar to what it is like [in real life] but I don't think the situations are necessarily similar and that's actually what I find amusing. (F37SA)

This above response highlighted an idea that was raised throughout the discussions, which was the similarities between the characters and the scientists that participants know. It is also interesting to note that the situations the characters are in do not necessarily represent real life, such as the scientific conference described by the participant. Weitekamp (2015) elaborated on this idea by providing examples from other episodes in *The Big Bang Theory* where the situations are not realistic. She then addressed how "Fundamentally, *The Big Bang Theory* fails to grasp the structure of academic life at a university. At best, the show repeatedly ignores such details in favour of funny plot devices" (Weitekamp, 2015, p.87). Indeed, the show does portray these aspects of academia as a funny plot device, but it does not necessarily mean has a negative impact on the participants, as can

be seen through F37SA's response of finding it 'funny' and 'amusing'. Nonetheless, some participants expressed that, from experience, the characters in *The Big Bang Theory* were quite realistic portrayals of scientists.

> There is something actually realistic about each of the characters [that's] not too far from reality in physics, and a lot of people [who know] a scientist ... can probably put them in a category of one of those characters ... The characters are really similar to the people we have [in astronomy], and wow, there's a Sheldon in just about every department. (F37SA)

> I guess it's the inability [to] teach science to everyday people ... because I've heard a lot [of] maths lecturers who were not very good at explaining mathematical theories to a student. So that kind of reminded me of my time in the university, like [the lecturers are] really smart but they have [an] inability to teach people who [are] learning these new concepts and science. (F21SU)

As a result, many of the comments indicated that 'recognition humour' from the characters and the situations was considered an important contributor to the participants' enjoyment. This extended to aspects which are related to the real world of science, such as the inclusion of awards, grants, and scientists appearing as cameos.

> There's these little things that [they include which] you wouldn't expect, like when they had the episode with the really good looking physicist who just won the MacArthur Genius Grant. We all know about the MacArthurs, right? so the fact that they tied that into an episode was interesting. Then when George Smoot came [on the show], that was interesting [too and] I've met George Smoot so it's all these little things that kind of [come together in the show that I enjoy]. (F21SA)

> I love how [they have] the cameo appearances with scientists. Like when they had Brian Greene who wrote *The Elegant Universe*, that was an excellent cameo. And they had people like George Smoot, [who was a] Nobel Prize winner and it's excellent when you actually know these people. It's just great to see that physicists have a funny side and they'd agree to do the show and

> Sheldon will make fun of them, and they can take it with a pinch of salt. I think that's really, really good, I love all the cameo appearances. (M22NSU)

In addition, a science postgraduate had strong opinions about Sheldon's reaction to a recent Nobel laureate who was mentioned in a later episode. This participant had personal emotional attachment to this particular scientist, thus identified it as a very prominent episode from a personal standpoint and a major contributor to his enjoyment of the show.

> This is more a personal thing. [The show was making] fun of [a] Nobel Prize in Physics [laureate] . . . they made fun of the science [with] Sheldon [saying] 'I would have been able to draw diagrams of the early expansion of the universe with the contents of my diaper [better] than Saul Perlmutter', so I appreciated [that reference]. (M26SP)

Recognition humour was not limited to the portrayal of scientists, and this was demonstrated through one non-science participant who asserted that he "can relate to every single one of the characters on their faults as well as their prime characteristics and the situations that they put themselves in" (M32NSNA). In addition, his parents loved the show because of the similarities between the characters and their sons, and "they call [it] the documentary about their sons . . . [if we were on the phone and the show was on] they're like 'oh, can't talk, your documentary is on'" (M32NSNA). Furthermore, these portrayals provided the opportunity for the participants to see what being a scientist is like, allowing it to "tap into the fantasy of what I could have been if I was smart enough to be a physicist or engineer" (F34NSNA). Another non-scientist participant also explained recognition humour using the general traits of the four male characters which he identified in his own friendship group.

> [It's] almost like you can find a character that's very similar to one of your friends. Like there's always someone that's quite anal like Sheldon in your friend group, and someone that's perceived as Howard. Or someone that's quite shy and introverted like Raj. You can almost see yourself mirroring your friendship groups with them, and there's always one girl that's really pretty that acts like Penny. I guess that's what makes it easy to relate [to] and why we enjoy it more. (M25NSU)

Despite the characters being scientists, the fact that non-scientists also identify with them suggested that they found the characters relatable because of other reasons, such as being a geek or from a specific ethnicity.

> I certainly know people that are a lot like [the characters], and some are in science and some aren't. So I see them as geeky characters who happen to be scientists rather than scientists [who] are geeky. (M28SNA)

> [Even though] I wasn't really interested [in the beginning], I was super excited [because] my background is Indian, [and] to see someone representing your ethnicity on American TV, especially when you're a minority, it's quite exciting. (F34NSNA)

Being able to relate to the show even if they don't have a background in science has allowed the participants to use *The Big Bang Theory* as a social stimulus where friends of different backgrounds can watch the show together and still enjoy it.

> I feel because we're on [university] campus and most of my friends are students as well, the back drop is just so familiar and it's something we can all watch together ... I think it's just something familiar [for my friends and I] ... like my friends actually make jokes like [the characters]. (F22SU)

> I always watch it with friends. I don't download and I don't buy series so if I ever watch it I'm always with someone who has it so for me it's a way to connect with my friends who have it. Like I enjoy watching it, and I'll always be like 'I want to watch *Big Bang*.' [All my friends will] come and it's usually like three or four of us who watch it at the same time. [So] for me it's the social aspect I suppose, and we all laugh at the same time and have that connection ... And I have a lot of science friends who are nerds. [When we watch the show together] they all laugh at the same things I laugh at, so for once we laugh at the same thing and it's not about acronyms. (F23NSNA)

> I watch it with my partner and she's not in a scientific career at all but she's quite nerdy so [the show] sort of gives us a nice shared language. We watch all the episodes together so I can relate some of what I do to things we [see] on *The*

> *Big Bang Theory*. It makes what I'm doing in my weird area of computational physics and chemistry a little bit more understandable [for her]. (M33SP)

6.2.2 Importance of characters

The majority of the responses in regard to how the characters in *The Big Bang Theory* affected the participants' enjoyment were usually associated with how the scientists are portrayed. However, there were also many responses that discussed the non-scientist characters and their interaction with science. Therefore, this section will be divided to examine the responses regarding the scientist characters, then explore what the participants thought about the non-scientist characters.

Scientist characters

The scientist characters in *The Big Bang Theory* were often mentioned in relation to their behaviours. The characters' portrayals were important to the participants' enjoyment since "you don't often see a show centred around nerds and geeks" (F26SP) where "everybody in the show ... [is] unbelievably stupid in various ways and it's the contrasting levels of stupidity that I find really interesting" (M48SA).

> I like the way that they show there are these four guys [who] are really smart in their fields but on common tasks they have to do or common situations they have to deal with, they act really stupid. (M27SP)

This suggested that one of the reasons why the participants chose to watch *The Big Bang Theory* was because it was uncommon for the main characters of an entertainment television show to possess the nerd stereotype. This was evident in the participant responses, where many participants expressed that Sheldon was their favourite character because he is the most different compared to the other characters who become less stereotypically nerdy in later seasons.

> Sheldon is quite funny, and how high an IQ a person [has] usually determines how low his EQ is as well. So I think in the show [it] depicts that how high an IQ is [there are still] bits that cannot be achieved. [It's] because they feel like [they're] quite smart and these cause a lot of funny stuff. (M24SU)

> I mean the show is about, like, people who aren't what you'd normally see and this season they sort of become more and more sort of normal, like with all the relationship stuff, and just the normal life stuff. And I think that's maybe one of the reasons why everybody really, really likes Sheldon. Its because he's the one who stays super different from, like, anything you would ever see normally. (F26NSNA)

Participants also appreciated the portrayal of the human side of scientists. This included how *The Big Bang Theory* showed that scientists are not always serious people, and even though "they're quite good at their job and serious when they're working, they're funny when they're at home being people" (M54NSNA). A non-science participant felt that she could identify with the characters and the representation of academia in the show even though she was not in science.

> I watch it because I feel the more you get into it, the more it exposes things about parts of life or particularly attitudes to academia. Generally as someone who doesn't come from science, [the characters] are incredibly like people that I've grown up with and worked with, and what I am like myself. It's really refreshing to see a show that is capable of treating the serious aspects of why it is hard being in academia but also make them funny. (F23NSNA)

In addition, another participant asserted that she appreciated how the show demonstrated the difficulty that these characters had to go through to obtain their qualifications, and their dedication to their jobs even though it may not directly involve their academic career.

> I like the characters are not intellectually shallow, they're all extremely intelligent people. They're all dedicated to their careers. You sort of see Bernadette working really hard through the first few series doing her Ph.D. [while] working part time. (F26NSNA)

The development of the show through the seasons and the changes to the characters' personalities were another reason the audience enjoyed the show. There was a perceived change in the scientist characters' behaviours in the later seasons because of their constant

interaction with Penny, and the characters have "now developed, like you can see how ... they've learnt how to communicate" (F19SU).

> It makes it so much better for me ... [also] watching the characters grow and change and interact and see how – 'the dumb blonde' so to speak – Penny is teaching the boys how to interact in social life and the boys have been able to sort of teach her and help her grow [to] be more mature as a person. (F30SP)

Another participant compared this to the reality show *Beauty and the Geek* (Australian version, 2009-present) where "there's a lot of character growth and how they improve their social skills" (F26SP). This was particularly evident in season four when Amy was introduced. The interaction between Sheldon and Amy became a highlight for the participants' enjoyment since they are "so funny together" (F22SU).

> It's like a human side to the nerdy scientists ... it is that stereotype of nerdy scientists being really socially awkward and being completely devoid of any ability to have any social interaction, and I think through having [the] Penny character and then later on you get Amy ... and it creates that human interaction side. These people are people as well even though they're nerdy scientists. (M25SP)

However, a problem with focusing on the relationships and the interactions between the characters was the diminishing amount of science content.

> I think later in the show ... the boys and the girls are developing into a more mature relationship, and science has somehow become the second priority [even though] that's how [the boys] bonded at the beginning. They were all the scientific geeks or the next door [neighbour]. (F35NSNA)

Despite the fact that there has been less science in *The Big Bang Theory* in the later seasons, the development of the characters due to their relationships allowed their personalities to be explored. By extension, the characters could then grow into someone who is more than just a scientist and eventually break the usual scientist stereotype.

> I think also the development of characters. Like if you go through all the seasons, [you'll find] in [the] first season Howard's impression is that he's a

> really low life, sleazy sort of guy but then [during] the second season, it shows some background. [It shows that] inside he's just a hurting guy that's quite lonely before he's engaged to Bernadette, and you see that all these insecurities are brought on because he's just lonely and deep down he's actually quite a decent guy. (M25NSU)

Non-scientist characters

The majority of the responses about non-scientist characters were made by non-scientist participants who especially referenced Penny and expressed sentiments like, "I don't think I'd watch it if Penny wasn't in this show" (F23NSNA). The character of Penny is considered to be a way for the audiences without a science background to access and engage with the show (Weitekamp, 2015).

> I don't understand a lot of it but I can kind of get that it is funny, and the fact is I kind of see myself a little bit like Penny because she's just not into all that geeky stuff and I can kind of relate to her. She's kind of like Rachel from [the sitcom] *Friends*, one of those [characters that] non-science people can relate to. So the way I look at Sheldon is how [Penny] looks at Sheldon. (F26SP)

> Going back to the whole friends from different fields [and all of us watching the show together], I suppose I identify more with Penny where I don't have any interest [in science] and I don't really care. Like the Doppler Effect, if someone was actually going on about what it actually was, I'm just [like] 'Okay, cool! Next subject, I want to keep watching!' (F23NSNA)

The fact that Penny isn't a scientist and is completely different to the other characters showed the contrasting aspects of personality and knowledge. This was a highlight for non-scientist audiences because "she makes you really realise that being smart is not everything if you can't actually function like a human being" (F26NSNA).

> I really like the way they make [Penny] up. I mean the guys kind of see her as like a dumber character but there's so much stuff that she knows about that they don't. Like she doesn't pay for her own cable, she always messes up

> her own computer and need one of the guys to fix it, but [she's better] just in everyday things like in meeting people [and] talking to people. (F26NSNA)

The interaction between Penny and the others was considered "interesting" (F22SU) since it demonstrates that Penny and the scientists "have an effect on each other" (F26NSNA). One participant noted that it is likely that Penny is a reflection of people's relationships with scientists.

> I think the Penny character [is] a vehicle of the show, that she is a character and that's how she gets thrown in with them. But I think most science types are going to have that kind of relationship whether it's with through family or friends, or relationships or whatever, there's going to be that kind of [relationship with non-scientists]. (M37NSNA)

However, some participants believed that the interactions between Penny and the characters were unrealistic. A participant explained that Penny only interacted with the guys "because she's the neighbour and it's the show. Whereas in real life I wouldn't see that situation, [and] I haven't seen that situation" (F23NSNA). In contrast, another participant expressed that, from experience, she knew scientists who married non-scientists as a reflection of Penny and Leonard's relationship. This participant's experience showed that even though it seemed like an unrealistic situation that would not happen in real life, it actually happens quite regularly, and not just to scientists.

> F34NSNA: I have friends who are the smartest scientists in the world [and] are married to some woman that are not to that intellectual level. I'll be bluntly honest especially at [my former university's maths department] you did see that.
>
> F25NSNA: I work in [a prescription glasses retail store] in the city, so we have [trained] optometrists. So for optometrists, they study a lot [and it's a] hardcore science. All of them marry non-science background people.
>
> F34NSNA: It's a relief for them, one of the guys in maths [told me]. Because I think he caught my eye-rolling [at] something his wife said and he said "I know, but it's great not talking about work at home." Because it is literally

> one of those things that I was like "oh my god, did she just say what I think she did?" in a group situation.

There were also discussions around other non-scientist characters in *The Big Bang Theory*. One particular focus group discussed another non-scientist character, Zack, who was briefly Penny's boyfriend. Zack was a special case in that even though he did not understand science and had lower intelligence than Penny, he showed interest and enthusiasm towards science on many occasions. An example was in *The Lunar Excitation* (S03E23) where he wanted to observe the lunar ranging experiment that the male scientists were conducting on the roof of their apartment, and another example was with the confusion of a picture on the cover of a magazine being planets rather than an atom in *The Justice League Recombination* (S04E11).

> M27SP: It's the attitude they show for one of Penny's boyfriends (Zack). [The characters] were [shooting] some lasers at the moon and [Zack's] saying "you'll blow up the moon."
>
> M48SA: But Zack's actually a really nice case because he actually likes what they're doing . . . He thinks it's really cool. He can't understand it but he does think it's cool.
>
> M27SP: And that's how most of the people [in society] are.

It would appear that both the scientists and the non-scientists in *The Big Bang Theory* are important to the overall show, with scientist characters appealing to one portion of the audience and the non-scientist characters appealing to another. The mix of the scientist and non-scientist characters caters to a wider range of audiences and also allows personal identification with the situations they get into. This helps the audiences relate to the show and enjoy it on multiple levels through the different characters.

6.2.3 Importance of humour

Humour was another major reason the participants enjoyed watching *The Big Bang Theory*. More specifically, participants noticed the standard of the jokes was quite high in their intellectual content.

> It's not a dumb comedy show, it's not going to get a dumb laugh . . . the comedy is on the more intelligent side of things for some of it. I mean there is some people [for] who bits of the science and some of the interactions will go over their heads but they will still think it's funny because they'll get the lower aspect. (F28SNA)

It would seem the participants divided the type of jokes into differing levels of science understanding, such as working "on two levels. You can really engage with . . . the physics but also it is just slapstick and it is a funny comedy" (M22NSU), or "it can be watched on many levels so you can watch it with only minimal scientific understanding or greater [and] you [can still] get more or less of the jokes" (F19SU). Overall, the jokes were identified to accommodate three particular groups of audiences: scientists, people who have an interest in science, and those who don't have an interest in science. This was clearly seen through an example of a joke concerning 'a spherical chicken in a vacuum' in *The Cooper-Hofstadter Polarization* (S01E09).

> Apparently there's . . . a whole level of jokes that the normal people don't see, like I don't know, some joke about a rubber duck in a circular vortex or something like that, and I was just like 'oh, that actually was a joke?' . . . so [the show] goes beyond the normal sort of jokes for the real science people, and then people with a science interest and then even normal people. So it sort of caters for each demographic with the level of jokes that they have. (M25NSU)

> I think that's why I like watching [*The Big Bang Theory*] with my folks because I laugh at it [since I understand the IT related talk] and they laugh at it because [the characters are] telling this joke about something which they don't understand. And they know they're not meant to understand it and they're meant to perceive these nerds as being 'big nerds talking about their fancy technology and science and stuff.' Meanwhile I might gain a glimpse of the science they're talking about and understand. It's kind of like watching the *Shrek* movies where it's great for kids, but then there's that higher level for adults where you're like "oh! oh!" (M32NSNA)

The integration of science in the humour was noticed by many participants, and a few of the participants specifically noted how the science and jokes were intertwined. As a result, a participant asserted, "I wouldn't separate the humour and the science, they're the same thing, they are using science humorously" (M22NSNA).

> What I noticed from when I [watched] it last night is there is actually a lot of science that are not physics. Physics is something that I almost know nothing about, but there were lots of other jokes. Like one of my favourite jokes that Sheldon makes is when he meets Penny in the laundry and he's talking about lying. He says "when I lie, I have more muscle ticks than a research institute studying Lyme disease", and I thought that was really funny because Lyme disease is caused by ticks. Penny obviously doesn't know that but that's something I'm interested in – diseases – so that's why I know that. It's got nothing to do with physics, and I think you'll completely miss that if you didn't know what Lyme disease was obviously. So I think it's things like that, there's lots of little things that require a bit of prior knowledge ... The science information and the jokes are very much intertwined. I don't think they say much that's not funny banter. [I think almost all the] jokes [in the show are] using science. It's generally to make a funny [point] or a smart point or a comeback, so it's always going to be a bit funny. (F28SP)

On the other hand, not all participants made positive comments regarding the interplay between science and humour. Occasionally participants who did not understand the science presented did not care much about this relationship. As a result, these participants often asserted that the science was only "funny surface-wise" (F23NSNA). The majority of these participants in the non-science groups and the science undergraduate group.

> Generally I take [the science] as humour, like, "oh, interesting", but sometimes ... it's something that I know [and] I can relate [to]. Like when Sheldon was trying to teach Penny physics and they solved [Newton's law of motion] $F=ma$ on the board and I was like "oh, I took a physics class once. I know that." So sometimes I can relate [to the science], but generally you just [take it as] "oh okay, that's funny", not like "oh yeah, that's true. Interesting." (M20NSU)

In contrast, some participants felt "the jokes are very rarely about the science, like the jokes are usually about the situation" (F29SP). An example was Sheldon's attempt to use his peripheral vision to help him solve a physics problem in *The Einstein Approximation* (S03E14).

> [Like the episode] when Sheldon is standing there and he's trying to get the formulas and things in his peripheral vision because it's got some link to his brain or something, and that getting that will help him understand [what to do] . . . I mean he goes and throws the whiteboard out the window but I think that there are pivotal moments that you sort of remember. (F28SNA)

Again, the relatability was an important contributor to the participants' enjoyment since the participants could identify with the situations that the characters are in, making them humorous.

> I remember a lot of the humour just because it's relatable . . . [like] organising how to get to the movies, unfortunately I do think that way. Before, when I try to organise something for my friends I try to take in every little piece of information and then come up with this optimised setting instead of just going "alright, you know what, we're going to see a movie at six. If you can make it, you can make it, if not, not." (M25SP)

Another example of a humorous situation that the participants enjoyed was from the episode *The Gorilla Experiment* (S03E10) where Sheldon was trying to teach Penny physics. Although there was some physics facts that were involved in this scene, it was mainly the situation that the participants remembered and enjoyed.

> M50SNA: You get the dumb blonde learning and repeating bits [of physics], and that becomes part of the humour. [It's] like "how did you know that?"
>
> F28SNA: [And] like when she said that one line about Leonard's work that Sheldon has taught her and she just learnt that one line. That was easier to do than to teach her physics.

This conversation between the two science participants demonstrated that people who have a science background will tend to enjoy the humour that comes with the

disparagement of people without a science background because they are more likely to empathise with the scientist characters, which is consistent with the disposition theory of humour (Raney, 2006).

The inclusion of the two female scientist characters, Amy and Bernadette, added another dimension of jokes, since the way these two different characters interact with the other characters were unique, allowing for different humorous situations to be included into the show.

> [I enjoy] the nerdy jokes and all the female characters that have come in, and how they've got all different types of females [now] like there's Penny and there's Amy ... [and] Bernadette. They've all got different intelligence levels and they have their own jokes in themselves, and then the boys have their jokes that include the smarter two girls. (F19SU)

6.2.4 Importance of geek culture references

Comic book science and superhero science also appealed to the audiences, since participants asserted that, "I like reading comics and so for me when they start talking about how real the science is behind the comic characters ... I loved the fact that they did that" (F34NSA). An example of the superhero science was provided by another participant where Sheldon was explaining the physics of Superman catching Lois Lane in *The Big Bran Hypothesis* (S01E02).

> They had this argument about superheroes, and Superman catching Lois Lane [who] falls out of a building and it's like "okay, so he decelerates from 200km/h to zero at this far [to catch her]. But sure, her arms and legs would fall off [once he catches her]" ... Maybe people learnt some things about Newtonian Dynamics, [so] it's good. (M40SP)

One the other hand, participants also enjoyed the non-science related "popular culture references ... [like] Facebook updates and tweeting and blogging, and playing [the online game] WOW (World of Warcraft)" (F28SNA). The participants saw the geek culture in *The Big Bang Theory* as an important contributor to their enjoyment especially when the characters were portrayed as "being geeky, [which] makes them more funny" (M20NSU).

> They have all these pop culture references and they are always talking about stuff like IT and going to Comic Con, and being really obsessed with gaming and stuff like that. I just really like that part [with] those situations where they are really obsessed [and] really funny. (F26SP)

Portraying the scientists in situations where they talk about popular culture suggested that scientists can have interests other than science, such as watching movies or playing video games. It communicated that scientists can appreciate things that non-scientists also appreciate, thus bringing scientists closer to society and dismissing the idea that scientists are lonely individuals. By doing this, the show could potentially connect scientists to non-scientists since it caters to multiple types of audiences.

> The reason why it's so popular is because there are a lot of comic book nerds out there that would watch it for that aspect of [geek culture], because they're interested in that as much as we're interested in the science. (F24SP)

Many participants asserted that they related to the show because of the geek portrayals of the characters and also understood many of the geek culture references. Specific examples of geek culture portrayed in the show were raised to identify the different aspects the participants related to. These included the video games the characters played, the events the characters attended, and their love for *Star Trek* and other science fiction television shows and movies, including their actors.

> I look at the people that I know who are in my social circle [and] are scientists then there's a bit of comic book stuff there and a bit of action figures stuff occasionally, but not to the extreme of mint condition, in-package, signed [and] worth fortunes [like in the show] . . . I go into comic book stores and I buy comic books. I have a lot [of] friends who may not be working in science, maybe working in IT, but they buy comic books as well or they like going into [those kind of] shops. We play board games, they play board games on *Big Bang Theory*. The card game where Sheldon lost to Wil Wheaton, it's similar to [the game] *Magic: The Gathering*, and my husband used to play that. (F28SNA)

> I certainly appreciate a lot of the geeky references, and there's a lot of them. There's been times when I've been watching [the show] with friends and there's

> been some random *Star Trek* reference that's come out, and I've laughed but no one else has. I really appreciate some of the references that they are putting in there. (M28SNA)

As a result, this shared appreciation of the geek culture references between the characters and the audiences allowed one participant to connect to the characters even though he doesn't have a science background.

> I think I can identify a lot [with the characters] with [the] things they enjoy. I'm [a] really big [science fiction fan], I like the board games they play, so once you can relate to a few things that they do in the everyday [you will identify with them]. I do a lot of the same thing but I'm a completely different person to them so it just shows that [you don't] necessarily truly need to have a science background to be a bit like them. (M25NSNA)

6.3 Is the science content primary or secondary?

Despite the fact that some participants felt the science content was an important part of their enjoyment while watching *The Big Bang Theory*, other participants expressed that other aspects were more important than the science. A reason for this was that they felt science was not a major feature, or a primary focus, of the show. The vast majority of these responses were by scientists, with only a few non-scientists who shared similar views. The participants refuted that although the characters were scientists and often shown at work, they were not doing or talking about science, suggesting "their jobs aren't a big part of the show" (F22SU). Participants suggested this was due to the entertainment nature of the show.

> I don't think they really show a whole lot of [the characters] actually doing their jobs in terms of real research science. Like even the scenes in their office are mostly personal interactions or showing arguments in between them ... Most of the science seems to be Sheldon standing in front of a white board thinking about an equation and occasionally someone else will come in and change a minus sign and fix it. (M33SP)

> The episodes that focus on their work are very few. There are mainly only two or three episodes per season out of 13 or 14 episodes where they're actually in somebody's lab, or they're working on a computer and talking about their work ... And so there is very little of the show [that] is really about their science. (F41SA)

The complexity of the science in *The Big Bang Theory* created a barrier for the participants with absorbing the science information, since as one participant indicated, "I'll say we wouldn't recognise [a lot of the science] either" (F31SNA). As a result, the participants recognised the science in the show to be secondary, that the show is not "focused on the science" (F37SA) or that it has become secondary due to how the show has evolved through the seasons.

> I think towards later on [in] the show, the boys and the girls are developing into a more mature relationship. And science has somehow become the second priority because that's how they bonded at the beginning, that they were all the scientific geeks. (F35NSNA)

> I guess the program doesn't really talk about science. [It] only [shows] bits and pieces of it and it comes [from] everywhere around the environment. So I think the show focuses more on how people interact, [more specifically] how normal people interact with clever people. (M24SU)

A discussion between two science postgraduates demonstrated that the science can be presented in the foreground but treated as secondary, but at the same time was intertwined with the characters' interactions and the storyline.

> M30SP: The writer is a clever guy [because he is] making the science [the] background ... but the joke [itself] is not in the science.
>
> M26SP: I think a good example is in one of the earlier episodes when Leonard's dating ... Leslie Winkle, [who is] in the [same] physics department, and in the end Sheldon's arguing over string theory versus loop quantum gravity. And she says "what about the children", because they can't get along so how can you raise children not understanding loop quantum gravity. The joke wasn't about the science aspects of it but the judge of the positions.

> M30SP: Because normally if it happens in real life it's in religions. If the mother's religion and the father's religion [are different], how would [you] decide [for your kids]?
>
> M26SP: That's right, so people can understand that parallel if they were that passionate about it.

However, even though the science may be considered secondary, the participants felt that the "theme of the show is not to deliver science in any way, but rather to use as references to characterise things in the show" (M26SP), such as helping to construct the characters as scientists.

> I suppose the [science] level is really high. Sometimes it's too quick, I mean they speak too fast for me to get all the points. But I think it's effective for them to give a sense [of] the way [the characters] are thinking, [like] how quickly and how sophisticated the way they are thinking. So it's effective to want to achieve [that mindset]. (M25NSNA)

> [The characters] are locked into their way of viewing [science]. I'd say I don't care about the science in the show but I care about it as a way to kind of bring out things that are emblematic about each of the characters. Like, I think the fact that even they don't know what Sheldon is on about, it tells you where Sheldon's at. [Then there's] Wolowitz and his waste disposal system, [and] that is much more [relatable and] tells you about the real world, even if it does blow up. (F23NSNA)

Therefore, the participants mainly saw the science as part of the characters of the show. They believed that science was rooted in the characters being scientists which affected their personality developments. As a result, it's the characters that affect the science inclusion since "mostly only Sheldon cares that much [about science]. If not for Sheldon, half the science in the show probably wouldn't even be there" (F22SU).

> [The science is] only shallow I would say, like they are there because it's based on scientists. What if they didn't base it on scientists? I wouldn't think it would be there so I think it's really shallow. Although they cover a lot of stuff [because of] Sheldon. (M19SU)

> I think it just happens to be the characters are in science fields. So like the science facts [are] a peripheral thing. If they are, for example, painters, they'll [be] talking about a lot of artists and stuff like that, you know what I mean? It's a framework, so maybe that's why you couldn't remember much of [the science] because it was just used as a tool, like as a background noise. (F25NSNA)

In comparison to the science being in the foreground but treated as secondary, some participants identified the science as more of a background or a backdrop. By having the science as a backdrop it has the benefit of "not making [science] too pushed in and too obvious. They make them feel natural as much as possible" (M28SNA). Participants interpreted the science as something that "doesn't really feature strongly in the storyline or the script. It's just places them [in an environment], that's where they work sort of thing" (M54NSNA).

> I mean the science is there for the background and sort of explains why they are so into such things and why they're so terribly hopeless at real life relationships. It's not an essentially critical part of the humour I think. (F26NSNA)

> It's like [a] background, [science is] like a backdrop and then the characters and the plot of each episode is on top of that. So I don't think they're really presenting science in a way that a TV show that's focused on presenting science would be. It's more that they happen to be scientists which makes them funny, which makes them appeal to the audience, and when they want to make a successful series. (F37SA)

The participants often used metaphors to describe how the science has been portrayed as part of the background.

> I don't think it's focusing on science . . . I think if you actually look at [it] as some sort of food, I don't think it's the main dish. I think it's some sort of additive or something that actually gives [it a] better flavour. (M19SU)

> It just kind of feels like the whole show is floating in a sea of science and every so often in the flow of the show they'll go past a little bit of science as part of the scenery, but they don't really make a big deal out of it most of the time. (F38SNA)

A reason why *The Big Bang Theory* was considered to use science as a backdrop was raised by many science participants. These science participants were concerned about the wider public's interest in science, and the possibility of deterring viewers from the show if the writers were to increase the amount of science content. An undergraduate noted that as the audiences watched the show, "you accept the show as a bit edging on science so when it pops up it doesn't really faze you, but you notice it's there" (F19SU). If the science content increased and *The Big Bang Theory* "happened to be a science show, I don't think [it] would have been that popular, and we wouldn't have this discussion here" (M27SP).

> They can't make it too technical because that would turn people off the show. So it's just people can enjoy the show and have a good feeling about physics and not worry that they don't understand. (F33SP)

> [If it was a science show it] would be really boring. It would be really, really boring if it wasn't based on funny characters doing funny things and the occasional comment about science. (F37SA)

It is interesting to note here that non-science participants did not make any assumptions about how the 'general public' would interact with the science content in *The Big Bang Theory*. It is unclear why they didn't discuss this, although it could be attributed to the fact that there were no focus group questions explicitly directed to explore this issue. Nonetheless, due to the lack of non-scientist responses, it is difficult to determine whether the assumptions made by the science participants are right or wrong.

6.4 Importance of scientific accuracy

When discussing the accuracy of the science information in *The Big Bang Theory*, it would appear that it has a strong impact on the audiences' enjoyment, particularly for scientists. However, due to the multivalent nature of the word 'accuracy', rather than simply meaning a 'right' or 'wrong' answer (e.g. Hansen, 2016), the use of this word was interpreted as the audiences' *perceived* accuracy of the science content.

The scientist participants consistently highlighted the importance of scientific accuracy and how it affected their enjoyment. One participant expressed that it "makes me happy actually" (M26SP) to have the writers of the show attempting to maintain scientific accuracy in *The Big Bang Theory*. Another postgraduate had strong feelings towards the science and asserted, "I do [care about the science] but I'm an astrophysicist and a physicist. So to me, I care about it being accurate. I care about it from the point of view that [the characters] care about it and they're passionate about it as well" (F30SP). Another participant, a science undergraduate, also appreciated the amount of scientific accuracy in *The Big Bang Theory*.

> I think also because, personally, I want to have Sheldon's job in the future. So I find [that] even [if the science is] the backdrop, the sort of science he's doing I find that quite interesting. [It's] sort of interesting to see stuff that you wouldn't expect to be in TV and how they get it right. (M18SU)

A reason some participants felt the accuracy was important was because of the damage that perceived scientific inaccuracy would cause for the show. First of all, the inaccurate science information would damage the participants' enjoyment since it would turn their focus away from enjoying the show towards feeling more sceptical.

> I think being accurate is really important to my enjoyment. If it was clear to me that [the science] was not accurate then I don't think I would enjoy it as much because I would just be sceptical the entire time. Whereas I do get a feeling that most of it is accurate even if they make a few mistakes here and there [and that] is possible with anybody. I think [the science] being accurate is really important to me. (M25SP)

> I don't think I've caught [any character] say something that I thought "no, that's definitely wrong." And it would actually break the show for me in some ways if that happened . . . It would actually break the suspension or the [dis]belief that's going on . . . and it's part of the process of making the science invisible in some sense is that they don't make mistakes like that. So you don't think "wait a minute, that's wrong!" [and] you're concentrating on the actual behaviour of the people. (M48SA)

Secondly, scientific inaccuracy would not just affect the show but also the believability of the characters as scientists. For example, one participant asserted that the appearance of accuracy in the science dialogue was an important aspect of the characters, because if the science was wrong "it would just remind you that it's a show. Like when the science is right, you think they're real people, you don't pretend [they are actors]" (F22SU). Therefore, the accuracy in the science information is important in many ways, especially "if they've attracted the IT geek crowd then they probably get less complaints [because] they want to be accurate" (M37NSNA).

> Because [the writers] already drew a famous show and if they present something wrong it would create a big [problem], at least on forums and the Internet. [It] would not be a good publicity for their show. [People] would take it [less] seriously because all the fun lies in the fact that these scientists are good scientists. (M27SP)

A few participants shared this view about the show's publicity. It is likely that *The Big Bang Theory*'s image would be damaged due to scientific inaccuracy since, according to the participants, a major target audience of the show will be sensitive to the scientific accuracy in the show's content, and therefore would broadcast any inaccuracies on the Internet and potentially damage the show's reputation.

> If the science was wrong, it would be a big No-No. Like if you could pick it up you'll tell other people, other people will tell other people and it would get round so fast [that] the show wouldn't have the reputation it has before. (F19SU)

> I'd be curious to see someone having a look at the [whiteboards] and see if they actually knew if it was right or not. Because I think the sort of the audience they're aiming at will get on the Internet and email them and say "look, your boards are wrong." (M29NSNA)

An example from a science undergraduate demonstrated the extent to which the perceived scientific accuracy must be maintained in exchange for the entertainment and the humour.

> I think with TV they have to keep it real to a certain regard so it's actual, [and that] someone's not going to come and rip it apart . . . Keep it factual to an extent like when they were talking about . . . Schrödinger's cat, like that was actually an actual theory. [They] had something that exists, like the idea of that cat so they've got to keep it factual to a point and then after that they can make a bit of fun. (F19SU)

As a result, many participants from both science and non-science groups indicated that "I care that they don't say anything inaccurate" (M28SNA) or "I do get annoyed if they misrepresent something [but] they tend to be pretty good about it" (M29NSNA) rather than actively appreciating *The Big Bang Theory* for including accurate science information.

> I guess from my perspective, I don't really care about the science . . . because I'm not watching it for the science, but if it's wrong it would annoy me . . . I guess I ignore it because it's correct, whereas if it was incorrect then it would bug me. (F29SP)

This idea resonated with other participants who indicated that "the science seems secondary because they're doing a good job at that" (F37SA), since "part of their hook was that the science [is accurate]" (F30SP). Therefore, for participants who have a background in science, they often asserted:

> I care [about the science] because I really want them to be accurate. I see no reason why not put accuracy [in] the theory. But I don't care how they do it or to what extent to make the humour, but definitely [I care that] they speak of accurate theories. (M26SP)

> I care about the science on the show in that they're showing science in a positive and an interesting light. And that they're not saying anything really stupid or wrong [that] we're going to get people thinking the wrong ideas about science, or turn them against science or anything like that. Just that it's accurate and interesting. (M28SNA)

This was also demonstrated through the participants' experiences with the perceived accuracy in the content of other entertainment television shows, where it appeared to be

important to the audiences' enjoyment. These participants were often more sensitive to their own sciences and specified the television programs that included accurate science information. For example, a computer scientist noted an example of "mathematical structure of the person of Bender [in *Futurama*]" (M48SA), whereas an astrophysicist in the same focus group noted that the science in "*Red Dwarf* is pretty good" (F37SA). Some non-scientists who had a background in science also noted accurate science information, such as a participant with a chemistry background who noted *Breaking Bad* (2008-13) "has some real chemistry in it" (F28NSNA) and a participant with a statistics background noted that in the television show *Numbers* (2005-10), "from where I can see it's all right, it's all correct for the bits that I do get" (F28NSNA). These examples demonstrated that each individual television show has a group of audiences who felt that the science content was an important part of that particular show, that they do notice when the science content appears accurate and as a result, attribute their enjoyment to the perceived accuracies.

However, the participants appeared to be aware that entertainment television shows still have the potential to get things wrong. This was demonstrated through responses which explained that it was reasonable to have a few scientific inaccuracies if the general science content appeared accurate because the show is "mainly there for entertainment so the facts don't always have to be right" (F21SU).

> I think sometimes you can just [be] like "oh, it's a TV show" [or] a "comedy show." [Science is] not generally more important but it's good to get the science right because that's what the show is about. I [am] sometimes [quite] sceptical, but generally it's nice. It's a plus on top of the entertainment if you learn something. (M20NSU)

Occasionally, the participants could only identify instances where the science 'sounded' correct. These participants were usually audiences who did not have a background in physics or biology and felt it was more difficult for them to determine whether the content was scientifically accurate or not. These participants generally answered in the form of "I'm not a physicist so I don't know, but it sounds right" (F34SNA) or "my impression is that [the science] is quite accurate. I think I've heard interviews that the creators [said]

they want to be accurate about it" (F26NSNA), and "I don't do that much physics and stuff, so I'm not quite sure if it's right or not. Apparently it is but I don't quite understand it" (F21SU). This also meant that participants could not distinguish instances where the science content was incorrect or 'wrong'. Such examples included "I don't think I've ever sat there with [this] particular show going 'yeah right, as if"' (F43NSNA) and "I think the science is actually generally true. Like I can't think of [any science] off the top of [my] head [as] an example [which is] false or anything like [that]" (M20NSU).

> I suppose the issue is you don't expect in normal TV sitcoms or entertainment to get an accurate chunk of science. There will be [an] allusion to it, but you expected that they sort of faked it up somehow. Whereas *The Big Bang Theory*, at least it seems more plausible. You don't see the obvious holes, [but] half the time I don't actually look. (M43NSNA)

> From a computer background, I love watching *24*. It's hilarious because of the inaccuracies and the stuff that they've made up. It's kind of like watching *Die Hard 4* where the people are trying to steal the Internet and stuff, it's fantastic. But some of the stuff in *The Big Bang Theory* feels more true, like some of the stuff they talk about occasionally. Obviously the jokes need to be fairly accurate or intentionally inaccurate for it to be funny, but some of the stuff [that] I know nothing about, [like] string theory and quantum physics and mechanics and stuff, what they are talking about it has a ring of truth to it. (M32NSNA)

> I haven't actually found anything that's explicitly incorrect, but then I'm not studying physics so I wouldn't be confident enough in some of the references to physics to comment whether it's precise. I think the science is quite superficial, but I haven't found any glaring inaccuracies. (F19SU)

It seemed many participants felt that appearance of scientific accuracy was not a crucial part of the show since "you don't really know whether the science that they are doing is really justifiable . . . I think the humour is more important to attract the public" (M24SU), and as a result, these participants tended to become more sceptical about the science content and its accuracy.

> It's not accurate I think, I mean I wouldn't trust any of it to be factually accurate. Even if it's 'factually accurate' so to speak they always present it out of context so until you go and look it up online or on the dictionary or whatever, you can't take it for granted that it's what they claim it is in the TV show I think . . . I mean that's a [whiteboard] full of incomprehensive equations and god knows how much of that is real and how much of that is just made up anyway! (F26NSNA)

However, a science participant made a similar observation while reflecting on science documentary about the likelihood of it having the same perceived scientific 'accuracy' problem and the importance of 'trust'.

> It comes down to trust. I mean, okay, it's called a science documentary [and] maybe it's a field about something you don't know, [but] because I don't know about fields outside my own, I'm sort of sitting duck for whatever they present and I don't know if they are telling me the truth or not. Whatever the scientific field is, why should I trust a documentary maker? (F53SP)

Therefore, often the non-science participants would only consider *The Big Bang Theory* to be fulfilling its role as an entertainment television show and would not accept the science content as completely accurate.

> [I'm] sometimes sceptical. Like I guess because it's still a TV show so sometimes the jokes are more important than the science . . . And I guess also because it is a comedy, it's expected that some things aren't going to be totally accurate. (M25NSU)

> I have to say [I] think that the general principles are probably fine but I wouldn't quote it verbatim . . . I suspect they slide a bit with *The Big Bang* because I think the total percentage of people out there who actually understand what Sheldon works on – nil. We're all at the level of Wolowitz and he's only a Masters. (F23NSNA)

For example, a science undergraduate pointed out how *The Big Bang Theory* would dramatise science concepts for the purpose of humour. He referenced a scene from *The*

Gothowitz Deviation (S03E03) which discussed operant conditioning to illustrate that the show may also cater to general audiences for the entertainment value.

> I think since [*The Big Bang Theory* is] entertainment and it has to target a general audience. It has to be dumbed down a little, and they usually dramatise a lot of elements of it. For example [with] reinforcement [or operant conditioning], I don't think you can actually go that far [with] reinforcement [like in] that episode with Penny and Sheldon, [where he is] giving Penny chocolates for the things that she did right. I don't think that is possible so I think you actually will get wrong information, but [you can understand the] general gist of it. (M19SU)

This argument extended to the perceived scientific accuracy within entertainment television shows in general, where participants had different opinions and used various kinds of television shows as examples. As one participant expressed, it "depends on what you mean by accurate science, like I don't know how accurate I would expect TV to be" (F26NSNA) but "I think there's a difference between being real and being probable" (F23NSNA). This was demonstrated mainly by medical drama since, by its nature and the importance of medical science in society, there needs to be a certain level of scientific accuracy even though "it's not representative" (F23NSNA), such as "the survival rates" (F29SP). As a result, participants thought a medical drama such as "*House* teaches more [about medical] science than *The Big Bang Theory* about physics" (M30SP). Whereas for television shows involving crime and forensics, the participants became concerned with the scientific accuracy and questioned, "do you think you can do it the other way round? [Because] I think you can learn inaccurate science quite easily" (M33SP). The participants asserted there is little accuracy involved in the science content in crime shows, especially in the success rate of lab tests:

> I guess I'm talking specifically about *Crime Scene Investigation* style TV shows where they pick up a bit of blood and "oh, let's do a DNA analysis" and it's done in two hours and they match it straight away and they find who it is. [Then] you go read about it, [and] in reality the DNA analysis is not 100% accurate or fingerprint analysis is not 100% guaranteed match kind of thing.

> It is sort of accurate around the edges in a general sense but it's really out of context I think. (F26NSNA)

Therefore, the level of scientific accuracy would depend on the television show itself and the purpose it serves, as well as whether the appearance of scientific accuracy is considered to be a driving force, or a hook, for that particular show. It would appear that the science content in *The Big Bang Theory* is important to many participants who have a relevant science background or an interest in science, but can also cause scepticism in those who do not have the relevant background. Nonetheless, the effects of scientific accuracy on the audiences' enjoyment depend on the individual.

6.5 Discussion

Even though the participants of this study were anticipated to indicate that the science content was one of the main reasons they enjoyed watching the show because of the recruitment method, the participants had different reasons for why they enjoyed the science content since they have different experiences and backgrounds. This is consistent with Oliver and colleagues' (2006) study. Some people asserted that the science content helped with constructing intellectually stimulating content, making it different to other television shows, and thus was a reason they were motivated to watch it. The intellectual content consisted of up-to-date science information, some of which is quite theoretical, like string theory and quantum loop gravity. Also, it included experiments and information that participants may not have known about beforehand, such as lunar ranging. It would appear that the higher level of intelligent content in an entertainment television show creates an element of difficulty and challenge for the viewers, so according to emotion psychology's definition of enjoyment (Deci, 1992), the viewers may enjoy the show more because of it. This was particularly evident when the viewers' understanding of the difficult and challenging science information gave them an ego boost, and subsequently led them to rank themselves against other audiences based on the level of science understanding.

The science information in *The Big Bang Theory* could also attract scientists because of familiarity (Green et al., 2004), such as the case for one participant's father who

works as an engineer and recognised the equation for fluid dynamics. This demonstrated how the science information allows the "fans who do recognize the equations on the whiteboards, which often relate to the content of the episode's plot, [to] find the programme even more enjoyable for understanding that connection" (Weitekamp, 2015, p.84). For the participants who did not have an in-depth science background, they appreciated the familiarity in a different way. The science information in *The Big Bang Theory* was often delivered in a familiar context that the audiences may find relatable, such as optimising a trip to the movies or creating an algorithm for making friends. The easy-to-understand explanation of the physics concept Schrödinger's cat was particularly raised as an iconic science concept that the audiences found memorable. The participants appreciated *The Big Bang Theory*'s writers for making an effort to communicate difficult physics concepts for the audiences, and in turn popularising science.

The non-science participants also expressed their enjoyment of the show, and how science contributed to this enjoyment. Despite the fact that they didn't have an in-depth science understanding like the science participants, they appreciated the humour that came with the science content and the presence of science as part of the plot for an episode, such as Sheldon dressing up as the Doppler Effect. Occasionally, some participants did not recognise the science content as 'science', such as the example of the friendship algorithm where one participant felt it was maths and reasoning but another participant felt it was logic and common sense. Again, this demonstrated the importance of individual differences since different participants would see the same scene in the show differently (Oliver et al., 2006). In addition, sometimes non-science participants, and those new to the science field, misinterpreted or misremembered the trivial science facts. This suggests that relatability and familiarity may not be enough for the audiences to remember science information accurately despite having the correct information presented in the show.

The science content appeared to be a particular motivator for some science participants to continue watching the show since they expressed disappointment that in comparison to the first few seasons of *The Big Bang Theory*, the later seasons lacked the presence of science. As noted before, this could be due to the nature of *The Big Bang Theory* being an entertainment television show where its priority is to entertain audiences. However,

it would appear that the lack of science has turned some participants against the show, or made them lose interest all together. This demonstrates that, for some participants, science was a key motivator for watching the show in addition to ritualised uses like passing time, entertainment and relaxation (Rubin, 2009). Participants elaborated on the importance of the science content in the show, asserting that the science made the show unique and it wouldn't be the same show without the science. What was interesting was that both science and non-science participants acknowledged this importance but from slightly different viewpoints (Oliver et al., 2006). Nonetheless, the focus group participants alluded to the fact that the science content was not the only – or even the main – reason they enjoyed the show.

Relatability was perhaps the most important contributor to the participants' enjoyment. Being able to relate to the characters when they resemble close friends, family members, colleagues or the participants themselves increased the participants' appreciation of the show as well as the transportability into the narrative of *The Big Bang Theory* (Green, 2004). The same was true when the participants related to situations the characters encountered, such as understanding the characters' excitement going to Switzerland to see the Large Hadron Collider. Furthermore, science participants appreciated how the show portrayed their work in a humorous yet accessible way.

There were also instances where the participants appreciated some non-science content. By presenting different scenarios that audiences from different backgrounds can enjoy, the show expands the number of viewers enjoying the show. Even though occasionally *The Big Bang Theory* would have errors and inconsistencies in the show's content, these were often used as a tool to create humour, and the participants who identified these situations were not particularly annoyed or upset about the misrepresentation but instead enjoyed how they could relate to the situations. This may not be the case for every audience member, since there was an anthropologist who criticised the error in the theme song, thus demonstrating again the contrasting opinions based on individual differences. Nonetheless, the recognition humour applied to both the show's content and the portrayal of the characters. This is consistent with what Weitekamp (2015) noted, that the:

> fans who can do more than just chuckle along, who fully get the jokes and understand the references, gain an extra thrill from recognizing their subculture depicted on-screen, whether by identifying particular equations or appreciating the specific comic book references (p.83).

Recognition humour was most frequently applied to the participants' friendship groups, specifically how the characters have the same traits as friends, thus prompting the participants to express that these character traits are not scientist traits but are geek traits. Similar to the relatable scenarios above, the different character traits allowed audiences who recognised similar traits in friends to enjoy the show.

The characters were another reason the participants enjoyed watching *The Big Bang Theory*. Unlike recognition humour, the participants often enjoyed the way the characters are portrayed rather than resembling people they know. This included both science characters and non-science characters. Sheldon was the most liked character since he is the only character to maintain the stereotypical nerd behaviour. The participants enjoyed the fact Sheldon is the most different character in comparison to his three scientist friends, while they became more 'normal', by being in relationships and doing activities associated with a typical normal life. Nonetheless, participants indicated they appreciated how the scientist characters were portrayed with a human side.

The human side did not just mean that the characters were portrayed as normal people when they are at home, but also included aspects such as what a working scientist is like in academia. For example, science participants identified with why it was hard being in academia, whereas non-science participants appreciated how the characters are dedicated, intelligent individuals. The human side also included characters' personal growth and development, and the constant learning from interacting with people who are different to them. This hinted at the disposition theory of drama, since the participants like these characters and the characters experience positive outcomes (Raney, 2006). Despite the fact that having more focus on relationships meant less focus on the science content, participants indicated that portraying the characters as changing individuals who are capable of relationships could potentially help break typical scientist stereotypes,

suggesting the focus on the characters can have other benefits for science.

The non-scientist characters in *The Big Bang Theory* were often liked by the participants as well, with particular focus on Penny and Zack. The character of Penny was consistently accredited as the relatable character for the non-science participants, who said they would not watch the show if Penny was not in it. There were many reasons the participants particularly appreciated her presence in the show, including being able to relate to the fact she doesn't understand what the scientist characters are talking about either, and the importance of 'street smarts' and being socially competent. Penny also demonstrated the possible interactions and relationships between a non-science person and scientists, where a few participants expressed they encountered similar situations. On the other hand, participants expressed they enjoyed the character of Zack because even though he doesn't understand science, and has a lower intellect than Penny, he was interested in science. This prompted science participants to assert that they believed most people in society are more similar to Zack than Penny.

Overall, the idea of showing the human side of the characters, especially the scientists, is particularly important for practical applications since as *transportation theory* suggests, the empathy that the audiences feel allow them to connect with others, in this case, the characters. By showing scientist characters as 'real people', who have problems with relationships and social situations like everyone else, it can attract more audiences, both from a science background and non-science background. The addition of the non-scientist characters, such as Penny and Zack, also help attract audiences, but perhaps more from the non-science background. Nonetheless, the development of the characters into 'real people' with universal problems is the first step in attaining a range of audiences in an effort to more widely disseminate the science information in the show.

Humour was another factor that the participants felt was important for their enjoyment. Since there are different levels of jokes in *The Big Bang Theory*, participants asserted that the show catered to different audiences. This made the show different to other similar sitcoms since the higher intellectual content meant the show is not a 'dumb comedy' that is expecting a 'dumb laugh'. Rather, audiences who have a science

background can enjoy the science based jokes, but it also has non-science jokes to cater to non-science audiences. Some participants shared their experience to demonstrate how different people found the show's jokes funny, asserting that they enjoyed the science related jokes while their friends and family enjoyed the humour associated with the characters being nerds. The difference here demonstrated how science participants, or those who like science, enjoyed the science content because they are familiar with it based on prior knowledge and experience (Oliver, 2002) and may lead to a feeling of superiority (Riesch, 2015), whereas the non-science audiences were more likely to enjoy the humour associated with disparagement (Raney, 2006).

Either way, some participants felt the science and the humour were intertwined. This may be true, since the science audiences are likely to find humour in the science jokes and the non-science audiences are likely to find humour in the way the characters talk about science. On the other hand, there were participants who felt the jokes were rarely about the science, but rather tended to be about the characters doing funny things while they attempted to do science. This reflected the non-science audiences' reasons for enjoyment noted above, where the humour is associated with the disparagement of a character. However, the humour that comes with the disparagement of a character is not limited to scientist characters, rather people with a science background can also enjoy the show through the disparagement of non-scientist characters. As noted above, the episode *The Gorilla Experiment* (S03E10) showed how it was easier for Sheldon to teach Penny one line about Leonard's physics research than it was to teach her physics. In this case, the humour was the process of teaching Penny physics, as well as the expressions on the other characters' faces when Penny repeated the one line about Leonard's research.

To a lesser extent, the geek culture references in *The Big Bang Theory* also contributed to the participants' enjoyment. Other than the occasional inclusion of the science of science fiction movies (e.g., Superman catching Lois Lane), the geek culture references tend to be associated with the characters exhibiting nerd stereotype traits, such as having discussions about superheroes and video games. The participants felt the geek culture references made the characters appear more geeky, especially in cases like the characters having a serious arguments about comic books, which causes the situation to

be funnier. Again, this could be explained using disposition theory where the participants enjoyed these jokes because they disparaged the identified geek group (Raney, 2006).

However, the inclusion of geek culture also demonstrated that scientists have lives outside their labs, and that they have interests in things other than science. Some participants indicated that by portraying the scientist characters in this manner, it may assist in bringing scientists closer to society, and potentially connect scientists to the audiences of the show. This latter point was demonstrated by many participants who expressed they identified with the geek portrayals of the characters as well as the geek culture references. By having similar experiences or opinions with the characters, both science and non-science participants could potentially have a higher chance of transporting themselves into the narrative of *The Big Bang Theory* (Green, 2004; Green et al., 2004).

Upon reflecting on the five main factors for the participants' enjoyment, it would appear that even though the importance of science was a recurring theme throughout these factors, it was not the most important factor. As noted before, a reason may be because the science content is not the focus of *The Big Bang Theory*, and that it is only there because the characters are scientists. For example, participants asserted the science is often presented when the characters are at work, and there are only a handful of these episodes, suggesting their jobs are not a big part of the overall show. Therefore, the science content was often included as part of the characters' dialogue outside of work, which then became secondary since, as the participants identified, the main purpose of the show is to explore the interactions between the characters. This means that one way the science is included is through incorporation into the dialogue (i.e., in the foreground so people notice the presence of science) but treated as secondary. The participants justified the occasional use of science as assisting in building and reminding audiences that the characters are scientists, but it does not overshadow the fact that *The Big Bang Theory* is about relationships.

In addition, some participants felt the science content was treated as the background of the show and that it is part of the characters' environment. This method of including science in the show contrasts with treating science as secondary because it is not made to be obvious for the audiences, thus presumably would not deter or faze any audiences

because of an overabundance of science content. By treating the science as background or secondary, it allowed the characters to focus on the other factors that the participants identified as enjoyable, thus increasing the transportation potential into the narrative.

Despite the fact that the science content in *The Big Bang Theory* is treated as secondary or as the background, the participants felt the perceived scientific accuracy had a major influence on their enjoyment. Many of the participants who felt this way were science participants, but there was also a small number of non-science participants. The reason these participants felt it was important was because the science content constructed the characters' credibility as good scientists, and that they are good scientists because they care about the science and are passionate about it. Therefore, if the science content in *The Big Bang Theory* was inaccurate, it would destroy the credibility of the characters as well as bring out the audiences' scepticism, causing the audiences to turn their focus away from enjoying the show itself. Weitekamp (2015) made a similar argument, justifying the importance of authenticity in relation to the audiences' understanding of science and the entertainment value:

> *The Big Bang Theory*'s comedy relies on audience recognition and empathy. For that matter, both comedy and science rely on understanding a specific subculture based on an insider-outsider dynamic ... And, in practice, laughing along with 'insider' jokes reinforces the audience's sense of belonging. Such content only works if its entertainment value enhances the performances – and such authenticity only works if it seems believable (p.83).

Again, this could be associated with transportation theory, where if the information in the show does not match the beliefs of the viewers, it is harder to transport the viewers into the narrative. It would appear the science participants felt more strongly towards this issue. Responses that discussed other television shows also demonstrated the effect on viewers who have a background in that particular show's science content. The fact that some participants extended their discussions beyond the science in *The Big Bang Theory* suggest that the importance of accuracy may be a general feature that the audiences inherently expect from their entertainment product, and could potentially apply to other specialised professions. However, further research is required to verify this claim.

In contrast, the non-science participants were more tolerant of perceived scientific inaccuracies because they felt the main purpose of *The Big Bang Theory* is to entertain, and most of the time the participants asserted they could only identify when the science 'sounded' correct. Nonetheless, these participants indicated there were no obvious 'holes' in the science content, but because the show was made to be an entertainment source, they were still sceptical.

Participants compared *The Big Bang Theory* to other entertainment television shows as a way to discuss the importance of the science content as being 'real' or being 'probable'. For example, the participants expressed that medical dramas are more 'probable' than completely 'real' since they still have scientific inaccuracies, such as the survival rates. This suggests that viewers who watch different genres of television shows would expect different amounts of scientific accuracy in the show's content.

Overall, the science content in *The Big Bang Theory* appears to be important to the audiences' enjoyment of the show, but may not be considered the *most* important contributor.

Chapter 7

Conclusion

In this chapter, I draw on my four substantive chapters to answer this thesis' research question: How does *The Big Bang Theory* influence its audiences' perceptions of and attitudes toward science and scientists? I also address *Inspiring Australia*'s expert working group recommendation and implementation strategy, and determine whether *The Big Bang Theory* met their aims of a television show that successfully communicates science to the wider public. I conclude by discussing how *The Big Bang Theory* has helped to achieve a more scientifically engaged public to frame this study within the wider science communication discipline.

In general, *The Big Bang Theory* influenced its audiences' perceptions of and attitudes toward science and scientists to different extents. This was because each individual person has a different demographic background and personal experience with science and scientists, which strongly affected their answers. This is consistent with what Orthia and colleagues (2012) found in their study regarding science and religion in *The Simpsons*. The following provides a detailed summary of the influences the show had on its audiences' perceptions of and attitudes toward the science in *The Big Bang Theory*:

- **Participants who had no prior experience changed their attitudes toward science.** The participants who didn't have a science background or prior experience with science indicated they were more interested in science after watching *The Big Bang Theory*, and a few of them regretted not learning anything about science during school. However, it is important to note that those who work in or study science were less likely to change their attitudes since their prior experience had a stronger influence, but the show can potentially lead to an entrenchment of their beliefs.

- **Participants were stimulated to find out more about the science in the show.** Eighteen of the 54 participants who specified that they have engaged with the science presented in *The Big Bang Theory* by seeking further information were mainly non-science participants. Many of these participants went to Google or Wikipedia. Two participants said they changed their behaviour after being inspired by the science in the show, for example by subscribing to a physics channel on YouTube or becoming less intimidated to attend public science lectures. This suggests that *The Big Bang Theory* has the potential to attract audiences who are not actively seeking science-related content.

- **Participants retained NOS-related knowledge peripherally.** Specifically, the participants indirectly mentioned that science is empirically based, is subjective and theory-laden, and is socially and culturally embedded. The vast majority of the comments were focused on the last element, and one reason why this NOS element is mentioned most frequently may be because *The Big Bang Theory* puts science in a social context. The number of responses suggests that the show made a significant impact on the image of science being a socially embedded endeavour.

- **Participants were surprised that science could be presented as interesting and accessible.** Being able to present science in a relevant and engaging way is a noteworthy advantage of *The Big Bang Theory* being an entertainment television show. Both the science and non-science participants were surprised that science could be presented in this manner, especially since they expressed that science is usually presented as quite 'dry' and 'boring'. In contrast, *The Big Bang Theory* changed their views of how science can be presented as funny, enjoyable and engaging.

As for how the scientist characters in the show influenced the audiences' perceptions of and attitudes towards scientists, the responses were more complex due to the fact the image of scientists has been consistently portrayed on television and movies through different stereotypes for decades. This has created a well established image of what scientists are like in the media, and it is not necessarily similar to what scientists are like in real life. Since the participants had well established understandings related to scientists (i.e., through personal experience images and images based on stereotypes), there was less discussion of how the scientist characters in *The Big Bang Theory* had affected the participants'

perceptions of and attitudes toward scientists. Nonetheless, the following list provides an overview of how the characters in *The Big Bang Theory* were perceived by the participants, and how the show changed the image of scientists for some of them:

- **Participants affirmed the characters were exaggerated portrayals of real scientists.** Similar to the responses about the science in the show, the responses regarding attitudes toward scientists were also affected by the participants' demographic backgrounds and their prior experiences. The participants who work in or study science often used their pre-existing images based on scientists they've met, such as friends, colleagues, or tutors and lecturers, to compare how accurate the scientist characters are portrayed on *The Big Bang Theory*. In addition, non-science participants who grew up surrounded by family members or family friends who are scientists also indicated that personal experiences had a more significant influence on their image of scientists than watching *The Big Bang Theory*. The participants indicated that rather than changing their perceptions of who scientists are, the characters were an exaggerated reflection of certain scientists' traits reflected in people they've met. This caused some participants to express that these portrayals often reinforce their pre-existing images of scientists.

- **The portrayal of the characters challenged some scientist stereotypes.** The participants critiqued the scientist characters' portrayals and indicated that although some common stereotypical traits were preserved, the characters also broke some stereotypical images. Participants expressed that the varying degree of stereotypical portrayals allowed the show to first establish a recognisable image of scientists, which the producers and writers then slowly developed and 'broke' through the seasons. As a result, the participants felt it communicated to other viewers that scientists are changeable people who can influence others and be influenced themselves. The constantly changing portrayals, including the different portrayals of the minor scientist characters who made a brief appearance, engaged the participants in a wider range of scientists and helped them to reconstruct their own ideas of who scientists are.

- **Participants realised scientists have social lives and were surprised they can be in romantic relationships.** In contrast to common stereotypes where scientists are portrayed as solitary individuals, the characters in *The Big Bang Theory*

are often shown in social groups and having conversations. This impacted the participants' impressions by showing that scientists have social lives, including pursuing romantic relationships. Some participants indicated that by humanising the scientist characters, it helped clarify what scientists are like, and consequently built more tolerance toward real life scientists.

- **Participants could better relate to scientists after watching the show.** Following on from the previous point, the participants indicated they could relate to the characters more after they had a better understanding of a scientist's social life. Specifically, the characters are shown as having interests other than science, such as going to the movies, having conversations with Penny who has no science background, and of particular importance, their interest in geek culture. This influenced participants' perceptions of what scientists are like other than being science enthusiasts, and consequently helped them relate to scientists as normal people who have similar interests.

- **Participants had a better understanding that scientists come in different shapes and sizes.** Often the stereotypical image of scientists is that they are older white men, whether presented on television or movies, or the image created by well-known scientists such as Einstein. However, the characters in *The Big Bang Theory* are youthful, and some are non-Caucasian, which came as a surprise for some participants. In particular, the youth aspect contradicted a few participants' prior experiences with scientists. By portraying scientists as young and from different ethnic backgrounds, it expands on the participants' pre-existing image of who scientists are in real life.

Furthermore, specific attention was given to the portrayal of female scientist characters. It is important to note here that a division between the participants' responses was observed, with more women voicing their opinions than men. It is difficult to determine the significance of this finding, but it is likely due to the fact that women are more sensitive to the distinction between the different genders when it comes to specific science fields. This was demonstrated through one male participant's assertion, where he did not realise the main female scientists were in the biological sciences until it was raised in the focus group discussion. Nonetheless, there were mixed responses regarding the female charac-

ters' portrayals that were not readily evident with the male characters. In particular, these discussions revolved around whether these images of the female scientists were positive, portraying women in science as capable and on an equal footing to their male counterparts, or negative, portraying them as the girlfriend or wife (i.e., included primarily for the romantic storyline). This discussion expanded to explore whether it was important to include more women in science on television shows. Even though the participants did not comment on whether their image of female scientists was influenced by *The Big Bang Theory*, the inclusion of female scientists on the show provoked discussion about the situation of women working in the sciences in real life. More specifically, the participants engaged with the portrayal of the female scientists in the following ways:

- **Participants expressed the female scientists were 'normal' people in comparison to the male scientists.** The participants felt that the female scientists, in particular Bernadette, were portrayed as more rounded characters and socially adept than the male scientist characters. This was shown through scenes where Amy and Bernadette conversed with Penny, and went clothes shopping together. It also introduced the idea that scientists are not all into geek culture like the male characters, and perhaps created another relatable image for the general public.

- **Participants found some aspects of the female scientists' portrayals refreshing.** This included aspects such as showing female scientists as capable and on an equal footing to their male counterparts. Even though Amy and Bernadette are in the biological sciences, they are equally accomplished in their respective fields as the male characters are in theirs. Participants indicated that this type of portrayal of female scientists helped break the initial set up of the show, where the main male characters are smart and the main female character, Penny, is not. The participants expressed that by showing Amy and Bernadette as capable and well-established scientists, it addressed the sexism in the earlier seasons of *The Big Bang Theory*.

- **The show brought attention to situations in science that are rarely portrayed on television.** Specifically, the idea that women can be more successful than their husbands was introduced through Bernadette and Howard. This is not often portrayed on television, rather the opposite is usually what is shown. The participants appreciated this particular interaction between male and female scientists

since, as many of them demonstrated, these situations happen in real life and are important to acknowledge.

- **Participants were frustrated that the female scientists were often portrayed as love interests.** Even though the female scientists have been portrayed as capable and on equal footing, the participants noticed that much of the female scientists' dialogue did not revolve around science, or they are not portrayed as interested in science as the male scientists. The participants indicated that this could be because they were included mainly as love interests, so the science dialogue may not be an important part of their characters. However, a participant expressed that the fact the female scientists were initially included as love interests could be viewed as a way to introduce an idea that is not often touched on – that scientists can be in romantic relationships and get married.

- **The female characters raised awareness about the issues women encounter while working in science.** A discussion point about the inclusion of female scientists referred to the history of women in science, and how the show demonstrated the increasing number of women entering a science career. However, once the discussions extended to the fact that there were more female characters in the biological sciences rather than the physical sciences, the participants voiced their concerns about this portrayal. For example, some participants indicated that the only female physicist, Leslie, is often portrayed as a 'bitch' especially when she is arguing with Sheldon. The participants argued that this is because she works in a science field dominated by men, so she needed to have a strong personality. Many female participants shared their own experiences of the gender distribution of women in the different sciences, and how discrimination and pre-conceived ideas about science contributed to this distribution. As a result, a few participants were concerned about the possible influence the gender distribution in the show will have on future generations.

In summary, *The Big Bang Theory* influenced its audiences' perceptions of and attitudes toward science and scientists to varying degrees. Even though many participants did not demonstrate a significant change in their attitudes *per se*, their perceptions of how science can be presented as an interesting endeavour, and scientists as approachable people, were influenced after watching the show. One reason why some

participants did not change their attitudes was because they already had a positive perception and attitude from prior experience, thus the show only induced further appreciation of science and scientists. This reason is mainly relevant for people who have a science background, but also included participants with no science background who knew scientists personally, or already enjoyed science. This highlighted the fact that prior experience was a major influence of the participants' responses, and perhaps more important than the demographic background. What is important to note then, is that since different individuals will have personalised experiences with science and scientists, it is difficult to determine how a television show such as *The Big Bang Theory* will specifically influence any given individual. Nonetheless, in this study, I identified several aspects of how *The Big Bang Theory* can influence people in a broader sense.

Another reason why many participants didn't change their perceptions and attitudes was that they were conscious of the fact that *The Big Bang Theory* is a fictional entertainment television show whose main purpose is to be entertaining. This was consistently observed throughout the focus groups, where the nature of *The Big Bang Theory* being an entertainment television show hindered the participants' acceptance of the show's science and scientists. Specifically, the participants made assumptions that scientific accuracy is not important to other audiences since *The Big Bang Theory* is just a television show, or that the scientists needed to be exaggerated for the purpose of humour. It would appear that the participants believed there are other forces behind the show that may push the producers and writers to go in another direction, such as the need to produce a more profitable television show. This will subsequently cause the scientific accuracy to become secondary or the characters to have exaggerated traits or personalities. This reasoning was found among both science and non-science participants' responses.

Nonetheless, of the participants who did not have prior experience or knowledge, the show changed their attitude towards science and scientists by presenting science as interesting and scientists as people who are part of society. This is perhaps the most influential aspect of shows like *The Big Bang Theory* since it is capable of putting science and scientists in a relatable social context, thus making science more mainstream and relevant. This is consistent with one of Rennie and Stocklmayer's (2003) visions of a scientifically

engaged public, consisting of "people who feel that science and technology lie within their interest and their personal lives" (p.771). Being able to place science in a social context is important, since:

> the personal significance of [science] facts is influenced by the social, cultural and political conditions in which they were produced and promoted. Science facts, without social significance are essentially meaningless and useless to society. It is therefore critical to actively involve all participants in science communication and to frame their interactions in a meaningful context (Burns, O'Connor, & Stocklmayer, 2003, p.196).

The Big Bang Theory can address this vision since it puts science and scientists in a social context by presenting science as a hobby or an interest, as well as a career, that people choose to do in their day-to-day lives. *The Big Bang Theory* can also present science in an entertaining and engaging way, which, as shown through the participants' responses, can potentially increase public interest in and engagement with science. Since *Inspiring Australia*'s purpose is to find ways to engage the Australian public with the sciences, it would appear that the involvement of media, particularly entertainment television shows, is a potentially fruitful avenue to pursue. Therefore, the recommendation proposed by the expert working group to establish a supplementary fund to create entertainment television shows with a scientific basis may be a beneficial way to engage the wider Australian public with the sciences, especially with reaching people who are not actively seeking science information.

Additionally, the participants' reasons for watching *The Big Bang Theory* were also analysed in order to assist in the expert working group's implementation strategy. In particular I sought to answer the question, is the science content in *The Big Bang Theory* important to the audiences' enjoyment? The participants indicated science was important, which is encouraging since "Enjoyment and other affective responses may evoke positive feelings and attitudes that may lead to subsequent, deeper encounters with science" (Burns et al., 2003, p.197). Also, it is important to note that enjoyment of the science content does not require the audiences to fully engage with the science. Rather science can also be enjoyed on a superficial level, where "enjoyment may be

described as a pleasurable experience with science as a form of entertainment or art" (Burns et al., 2003, p.197). Therefore, even though science was only one of the reasons the participants enjoyed watching the show, the show's scientific basis can simply be enjoyed as entertainment and may lead to further appreciation of science.

It is also essential to identify the other aspects that played a significant role in the participants' enjoyment – namely the relatability, characters, humour and geek culture references. The identification of these other aspects of enjoyment may assist television producers and their science consultants to create another successful entertainment television show with a scientific basis that the general public will enjoy. Even though these aspects of enjoyment may be more closely associated with sitcoms, some of the elements can also be applied to other genres. By addressing these other aspects of enjoyment, the possibility of attracting a wider range of audiences also increases, thus the science content included in the television show can potentially reach audiences who are not actively seeking science information. It is interesting to note here that based on participants' responses, these other aspects of enjoyment may be a more important contributor for the audiences' enjoyment in comparison to the science content. However, many participants identified that, for them personally, the accuracy of the science information in *The Big Bang Theory* is of the utmost importance and makes a critical influence to their enjoyment, contradicting this idea that science is not one of the most important factors. Their explanation was that the show is based on scientists, and if the science was inaccurate then it would ruin the show by breaking the illusion that these characters are good scientists (consequently reminding the audiences these are just actors playing a role). Therefore, it is important to know that, above all, scientific accuracy is critical in producing a scientifically based entertainment television show that the audiences can engage with.

But how exactly does *The Big Bang Theory* engage the audiences in the sciences when television shows are predominantly a 'one-way' communication model, that disseminates information "with no expectation of a response" (People Science and Policy Ltd & Taylor Nelson Sofres, 2002, Annex 1, p.41)? Firstly, even though television shows generally only disseminate information, they also have the potential to affect audiences. Stocklmayer noted that an aim for one-way communication is typically to inform the public about

the sciences and "to affect [their] attitudes (and possibly behaviour)" towards science (Stocklmayer, 2013, p.30). Through this current study, the participants have consistently shown that *The Big Bang Theory*, as a one-way communication tool, has indeed influenced their attitudes toward science and scientists, as well as affected some of their behaviours. However, it is unknown how useful a one-way communication model can be when trying to engage the audiences with science. This is important because, as Burns and colleagues (2003) noted, one requirement of making an effective communication tool is that "There is a critical need for feedback in any effective communication" (p.195). Trench (2008) specified three models of science communication that vary according to the amount and kind of 'feedback' involved:

1. Deficit model: Science messages are disseminated in one direction, usually by experts to a public who is thought to have inadequate awareness and understanding of science. The deficit model is one variation of disseminating science messages.

2. Dialogue model: This is a two-way dialogue between scientists and other groups of people, and can be used for various purposes. Trench posits two variations of the dialogue model. One is 'consultation', which focuses on specific applications of science, and the other is 'engagement', which concerns a broader dialogue between the two groups about "a relatively open agenda, the content of which can change, in a process [that] might not be strictly time-bound" (p.130).

3. Participation model: Science is communicated in the form of a conversation in multiple directions between diverse groups "on the basis that all can contribute, and that all have a stake in the outcome of the deliberations and discussions" (p.132).

Of particular interest here is the two-way communication model, specifically the variation of engagement. According to the UK Research Councils (2002) report, engagement is defined as "stimulating interest in science and generally raising awareness of science and the issues it raises among the public" (Annex 1, p.42). Even though engagement in this sense could be associated with all three of Trench's models, it works most effectively in two-way or multiple direction communication because of the need for feedback in effective communication. This includes television shows, which despite being "modeled as simple linear communication processes, [are also] affected by feedback" (Burns et al., 2003,

p.195). However, it must be noted that television is not a two-way *dialogue* model since scientists and the other groups of people do not communicate with each other on a shared platform or on equal grounds. Rather, television works like a one-way communication model with a feedback loop, or what is commonly known as the two-way asymmetric model of public relations.

The two-way asymmetric model of public relations was initially proposed by Grunig and Hunt in 1984 (Fawkes, 2012), and was one of four models used to explain how organisations communicated with other groups of people. Fawkes (2012) briefly summarised Grunig and Hunt's four models (p.34-36):

1. Press agency/publicity model: This is a one-way communication model with the main purpose of drawing the public's attention. This model generally doesn't require the disseminated information to be absolutely true.

2. Public information model: This is a one-way communication model that disseminates information that focuses on the accuracy of the information communicated, and the information tend to be more relevant to the targeted groups of people.

3. Two-way asymmetric public relations: This model is also known as the persuasion model. It is a two-way communication model that introduces the idea of a feedback loop. In public relations, the asymmetric model is used to change "the audience's attitudes or behaviour rather than [changing] the organisation's practices" (p.35).

4. Two-way symmetric public relations: This is a two-way communication model similar to Trench's dialogue model, where the dialogue between an organisation and other groups can lead "to both management and publics being influenced and adjusting their attitudes and behaviours" (p.36).

There are clear similarities between the communication models of science communication and public relations. This permits me to use the two-way asymmetric model to explain how television shows are potentially effective communication tools. In *The Big Bang Theory*, science information is portrayed and communicated through the scientist characters. Even though the show's aim may not necessarily include changing audiences' attitudes or behaviour, the participants in this study demonstrated that their attitudes

toward science and scientists have indeed been influenced by watching the show. The audiences subsequently provided feedback to *The Big Bang Theory* in various ways (see Chapter 1 for examples), but the show itself may not necessarily have changed because of this feedback. In this sense, it would appear *The Big Bang Theory* has, at least to some extent, met one of the criteria for effective communication stated by Burns and colleagues (2003), which is the importance of feedback.

It is also interesting to note that the two-way asymmetric model is not the only communication model associated with *The Big Bang Theory*. Rather, it is possible that the science in the show can be used for other models of communication. For example, the science information in the show can lead to a public information model in the form of a blog, such as the one created by *The Big Bang Theory*'s science consultant. On 'The Big Blog Theory', Saltzberg explains the science presented in the show, and makes the science accessible to audiences who are interested in the science content. This demonstrates that *The Big Bang Theory* can engage the audiences through different ways. In addition, *The Big Bang Theory*'s influence on non-scientists' level of confidence to engage with science may in turn encourage them to participate in decision-making processes regarding science issues in the future, so the show may function as an enabler for more participatory models of science communication. It would appear, then, that shows like *The Big Bang Theory* can potentially contribute to meeting the requirement that *Inspiring Australia*'s expert working group is looking for in terms of engaging the Australian public with science.

7.1 Limitations and recommendations

There were a number of limitations faced in this study. Like many qualitative research projects involving human participants, a common limitation is that only a small sample of people was able to voice their opinions. As mentioned in Chapter 2, it is likely that the people who signed up for this study already had a natural inclination and affection towards science due to the recruitment method. This meant that the participants cannot be read as representative of the general public, but rather are a sample of audiences keen to talk about the science content in *The Big Bang Theory*. Therefore, a recommendation is

for future studies to recruit people who do not have a particular inclination towards science.

In contrast to the present study, the recommendation of recruiting people who do not have an inclination towards science will determine whether the science content is important for this other sector of the public when it comes to a science-based entertainment television show. However, it must be noted that a potential barrier of this recommendation is that there may be a lack of science-related discussion if the audiences are not interested in science or think science is not important. This may have been a reason why there was a lack of non-science postgraduate and academic participants in this study. Due to the recruitment flyers specifically stating that the discussions will be around the science and scientists in *The Big Bang Theory*, it may have deterred any potential participants from expressing their interests. Therefore, this gap in my study may also be answered through this recommendation.

In addition to this particular limitation, further studies can potentially include other methods of data collection such as the use of questionnaires and surveys. As this current study is exploratory, aiming to understand the audiences' perceptions of the science and scientists, it was solely focused on the qualitative aspects. The use of questionnaires and surveys will be complementary in following this study as it can be used to quantify the responses presented by the participants in the focus groups.

Alterations could also be made when forming the focus groups. As mentioned in Chapter 2, the allocation of the focus groups was based on the participant's academic background and occupation in an attempt to avoid uncomfortable environments for some of the participants. A few of these environments include a student being placed in the same group as their lecturer, or a lawyer being placed in the same group as a practising scientist, and these environments can potentially affect the type of participants' responses. However, this also meant that some critical information might have been missed because of this particular allocation method. Therefore, future studies can potentially include mixed group made up of different occupations to explore different types of responses.

Similarly, future studies may include participants who are fans of the show and those

who have not watched the show before. In this case, it would work best if these two types of participants were separated into different focus groups, as this would provide comparable discussions and themes. Having participants who have not previously watched *The Big Bang Theory* could highlight any changes in behaviour and thought processes after watching the show.

Another major limitation of this study is that it focuses on the first four seasons of *The Big Bang Theory*. Even though it was made clear the reason for this was because the first four seasons were the only seasons available in their entirety when this study started, the portrayals of the characters changed considerably through the later seasons. This means the audiences may feel differently towards the characters now that their personalities and backgrounds have been further developed. Therefore, this limitation has a few accompanying recommendations. Firstly, since this study has shown that the participants had more comments on the scientist characters than the science itself, further studies on *The Big Bang Theory* can investigate how the change in characters' personalities affects the audiences' views of these characters being scientists.

Secondly, the personalities and backgrounds of the female scientist characters – Amy and Bernadette – were not as fully developed as the male characters in the early seasons of the show. As a result, many participants felt they were poorly constructed. Therefore, one recommendation is to better understand how the female scientists have been constructed by investigating what people think about their portrayals in the later seasons where they have a prominent presence in the show. Both of these recommendations can use the results from this current study as a comparison. Another possible recommendation addresses the decreasing science focus in the later seasons. It would be interesting to explore how the audiences feel about this to understand the importance of the science content to the viewers who continue to watch *The Big Bang Theory*.

Focusing on how the focus groups were run and the recommendations for potential future studies, there are various ways to stimulate more specific discussions. For example, rather than relying on the participants' memories of *The Big Bang Theory*, focus groups can be organised around a showing of an episode or a few episodes. In contrast to the

current study, the showing of a few episodes can pinpoint specific aspects of science and the characters' portrayals for discussion. However, it must be noted that this method would be fundamentally different to this current study since one of the motivations of this study was to determine what people *remembered*. Therefore, it would be difficult to compare these results. Nonetheless, a more focused discussion may be beneficial in identifying difference in the presentation of science and scientists when comparing episodes in an early season to those from a later season.

As part of the analysis throughout this thesis, there were a number of ideas that warranted further investigation. One of these ideas is that people learnt aspects of NOS when watching entertainment shows as part of the their leisure activities. This idea is a relatively new concept that has rarely been examined. A potential argument of why this is the case may be that *The Big Bang Theory* is a unique show that presents science and scientists in an everyday context, allowing the audiences to observe something that is generally not presented on television. Despite this possibility, the way people learn about NOS through engaging with entertainment products outside educational settings promises to be an interesting avenue of investigation.

Another idea is the importance of accuracy and its affect on the audiences' enjoyment. It would appear that the participants acknowledged the importance of (perceived) scientific accuracy since it influenced the believability of the characters as scientists. It also affected the chances of immersing oneself in the storyline without being distracted by obvious scientific 'holes'. However, there is a lack of formal studies done that specifically examined this link. Therefore, this is a noteworthy area that require more exploration, both with a focus on science, as well as other professions including, but not limited to: police dramas, hospital dramas, political dramas, or shows based in modelling agencies and law offices.

In light of *Inspiring Australia*'s expert working group implementation strategy, a notable recommendation is to conduct similar research using other scientifically accurate entertainment television shows in different genres. As noted in Chapter 1, the expert working group provided examples of possible avenues to introduce science content in re-

ality shows (i.e., *The Biggest Loser*), dramas (i.e., *Numb3rs*) and soap operas (i.e., *Home and Away*). In consideration of *Inspiring Australia*'s aim to engage Australian public with the sciences, it is essential to study how different genres, both with an educational and an entertainment focus, affect audiences' perceptions of and attitudes toward science to cater to the wider Australian public.

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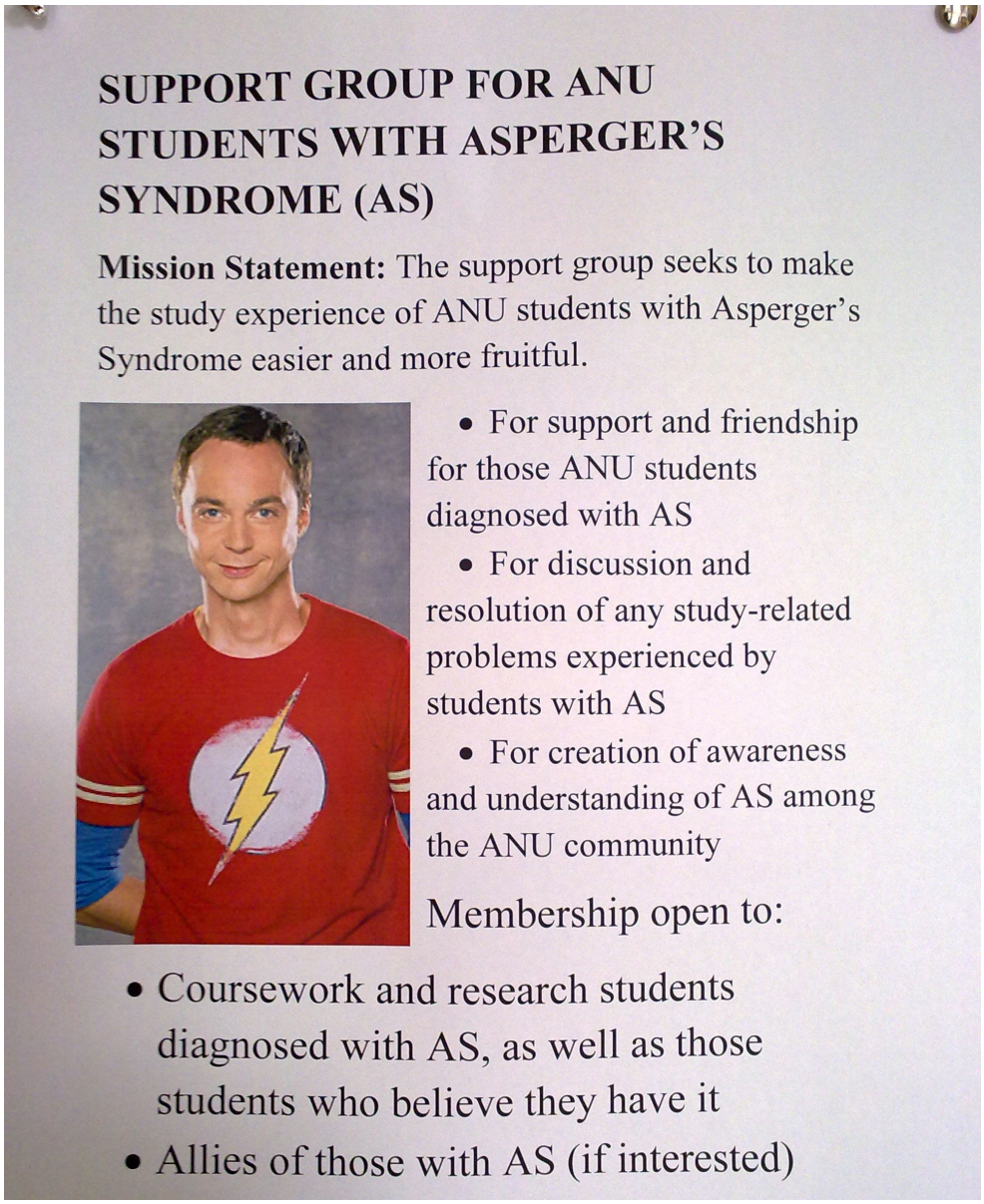
ANU Asperger's Syndrome support group poster



Appendix B

Participant demographics and focus group allocations

The participants who are categorised as postgraduates under the current occupation column were undertaking their Ph.D. candidature at the time of data collection.

Focus group 1: Science postgraduates and academics

Gender	*Age*	*Academic Background*	*Current occupation*
Male	25	Doctor of Philosophy in Astrophysics	Postgraduate
Female	53	Doctor of Philosophy in Science Communication	Postgraduate
Female	41	Doctor of Philosophy in Planetary Science	Academic
Female	30	Graduate Diploma in Astrophysics	Postgraduate
Male	25	Doctor of Philosophy in Engineering	Postgraduate
Female	24	Doctor of Philosophy in Geology	Postgraduate
Female	23	Graduate Diploma in Environmental Science	Postgraduate
Male	25	Master of Engineering	Postgraduate
Male	23	Master of Science Communication	Postgraduate

Focus group 2: Science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Male	59	Bachelor of Science (Forestry)	Retired
Male	50	Master of Science (Computer Science)	Public servant
Female	28	Bachelor of Education	Science education officer
Male	28	Bachelor of Science (Biotechnology)	Plant-biological researcher

Focus group 3: Science postgraduates and academics

Gender	*Age*	*Academic Background*	*Current occupation*
Male	28	Doctor of Philosophy in Computer Science	Postgraduate
Male	26	Doctor of Philosophy in Earth Science	Postgraduate
Female	28	Master of Studies	Postgraduate
Female	30	Master of Science Communication	Postgraduate
Female	26	Master of Science Communication	Postgraduate

Focus group 4: Science undergraduates

Gender	*Age*	*Academic Background*	*Current occupation*
Male	18	Bachelor of Science with Honours (Maths)	Undergraduate
Female	21	Bachelor of Science (Maths and Statistics)	Undergraduate

Focus group 5: Non-science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Female	29	Graduate Diploma in Science Communication	Business owner
Male	43	Master of Business Management	IT consultant
Male	26	Master of Social Research	Public servant
Female	43	Graduate Diploma in Science Management	Public servant
Male	32	High school graduate	System administrator
Female	52	Nursing and Community Care	Administrator

Focus group 6: Non-science undergraduates

Gender	*Age*	*Academic Background*	*Current occupation*
Male	19	Bachelor of Actuarial Studies	Undergraduate
Male	22	Bachelor of Arts, Bachelor of Law	Undergraduate
Female	21	Bachelor of Arts, Bachelor of Law	Undergraduate
Female	22	Bachelor of Arts (Development Studies)	Undergraduate
Female	20	Bachelor of Actuarial Studies, Bachelor of Finance	Undergraduate
Female	20	Bachelor of Arts	Undergraduate

Focus group 7: Non-science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Female	25	Master of Health Communication	Sales
Male	26	Master of Hotel Management	Administrator
Female	23	Bachelor of Philosophy (Arts)	Administrator
Female	34	Master of Public Administration	Public servant
Male	37	Doctor of Philosophy in Pacific Asian History	Student
Female	23	Bachelor of Arts	Public servant

Focus group 8: Non-science undergraduates

Gender	*Age*	*Academic Background*	*Current occupation*
Male	25	Bachelor of Arts Media	Undergraduate
Female	21	Bachelor of Commerce	Undergraduate
Male	20	Bachelor of Actuarial Studies	Undergraduate

Focus group 9: Science undergraduates

Gender	*Age*	*Academic Background*	*Current occupation*
Female	19	Bachelor of Philosophy (Geology)	Undergraduate
Male	24	Bachelor of Science (Information Technology)	Undergraduate
Male	19	Bachelor of Science (Psychology)	Undergraduate

Focus group 10: Non-science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Female	34	Bachelor of Science (Statistics)	Public servant
Female	31	Background in Communications and Marketing	Data analyst
Female	28	Graduate Diploma in Aviation (Air Traffic Control)	Environment specialist

Focus group 11: Science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Female	38	Graduate Diploma in Science Communication	Advisor
Female	44	Background in Psychology and Computing	Research assistant

Focus group 12: Non-science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Male	29	Bachelor of Arts (International Relations)	Public servant
Male	25	Bachelor of Arts, Bachelor of Asian Studies	Tennis coach
Female	26	Bachelor of Arts	Administrator

Focus group 13: Non-science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Male	54	No degree	Communications Manager
Male	53	Doctor of Philosophy in Political Science	Advisor
Female	35	Bachelor of Commerce, Bachelor of Law	Accountant/Lawyer

Focus group 14: Science Postgraduates

Gender	*Age*	*Academic Background*	*Current occupation*
Male	26	Master of Neuroscience	Postgraduate
Male	26	Doctor of Philosophy in Astrophysics	Postgraduate
Female	29	Doctor of Philosophy in Astrophysics	Postgraduate
Male	30	Doctor of Philosophy in Quantum Physics	Postgraduate
Female	33	Doctor of Philosophy in Biology	Postgraduate

Focus group 15: Non-science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Female	26	Master of Arts (History)	Research assistant
Male	25	Master of Business Administration, Master of Professional Accounting	Bookkeeper
Female	26	Master of Financial Management	Project officer

Focus group 16: Science non-academic occupations

Gender	*Age*	*Academic Background*	*Current occupation*
Male	48	Doctor of Philosophy in Computer Science	Research engineer
Female	37	Doctor of Philosophy in Astrophysics	Professor
Male	27	Master of Astrophysics, Master of Maths	Research assistant

Focus group 17: Science Postgraduates

Gender	*Age*	*Academic Background*	*Current occupation*
Male	26	Doctor of Philosophy in Chemistry	Postgraduate
Male	33	Doctor of Philosophy in Computer Science	Postgraduate
Female	25	Doctor of Philosophy in Astrophysics	Postgraduate
Male	40	Doctor of Philosophy in Physics	Post-doctoral researcher

Focus group 18: Science undergraduates

Gender	*Age*	*Academic Background*	*Current occupation*
Female	22	Bachelor of Science (Biology)	Undergraduate
Male	18	Bachelor of Philosophy (Maths/Physics)	Undergraduate
Female	19	Bachelor of Software Engineering	Undergraduate

Appendix C

Where did the participants get their science information from?

As part of the introductory section in the focus groups, a few questions were asked to gain a better understanding of how the participants accessed science information. This appendix is used to provide an insight into the participants' general science information seeking behaviour based on whether they were a science participant or a non-science participant. An analysis of the data showed the various sources the participants preferred, as well as the similarities and differences in how the two groups used them.

C.1 Non-science groups

For non-science participants, the media was one of their main sources of science information. Undergraduates expressed that they mainly get their information through television channels like the Australian Broadcasting Corporation (ABC) and the Special Broadcasting Service (SBS), as well as through various documentaries. The non-academics added the American science television series *Nova*, the documentary channel *Nature*, and more specifically documentaries by David Attenborough and Carl Sagan. Participants expressed they mainly watched space and nature documentaries since they are more 'visually arresting' than lab-based science documentaries. In addition to documentaries, the non-academics also noted television news and podcasts as regular science information sources. Some participants from both undergraduate groups and non-academics groups admitted to having absorbed information through entertainment television shows such as *The Big Bang Theory*, forensic and law shows. Overall, participants from both groups explained that if they became interested in the science that they were exposed to then they would do further research. In this case, participants would seek further

information on the internet since it is the easiest way to find specific science information. Non-academic participants expressed they also used the internet to follow science blogs and access science websites. Some examples of these websites included Slashdot, Reddit, Whirlpool, space.com, Life's little mysteries, and xkcd. Social media were also used where participants explained that Facebook is a good source if they follow they the 'right people', like science organisations and scientists.

Non-academics specifically asserted magazines were another source they gained science information. The most common example was *New Scientist*, but also included *Scientific American*, *National Geographic*, *The Economist* and various university alumni magazines.

Undergraduates, and a few non-academics, noted that a lot of the science information they retained was mainly through their education. For undergraduates it was through high school science classes, whereas for non-academics it was through finishing a science degree even though they did not pursue a science career.

The non-science groups often considered having conversations about various science topics as a source of science information. Talking to friends, family and colleagues who have science backgrounds appeared to be easier than doing the research themselves since the participants expressed they would have difficulty understanding the science without previous knowledge in the area.

An interesting source for the non-academic participants was through their jobs. Although they are not scientists, they are occasionally required to read journal papers. The main purpose of this is to understand the science background so they may have a better standpoint when making decisions on policy analysis, research developments, or government related science projects.

There were also a number of other sources which were not as prominent as those listed above, included attending events such as science festivals and lectures, and reading books (both fiction and non-fiction) which may stimulate the participants' interests and

lead to further research.

C.2 Science groups

The internet was a common information source for all science groups, although the uses varied. Science undergraduates tended to mainly use the internet to access science blogs and websites with interesting 'facts', whereas postgraduates and academics used the internet for researching things outside their own science field. For example, a participant who is a neuroscientist learnt physics through the online Feynman lectures, and an astrophysicist used Open University to learn things about medicine. As for the non-academics, websites with heavy science focuses were often visited, such as the CSIRO website, *British Psychology Review* and *The Conversation*'s daily digests. It is interesting to note that both the undergraduate, and postgraduate and academic groups emphasised the use of social media as part of their sources. In contrast, the non-academics did not mention using social media. Social media sources such as Facebook, Twitter and Youtube were considered useful when following pages and people who often talked about science, such as the Australian Academy of Science and other various scientists.

Similarly, entertainment media was a common source for undergraduates, and postgraduate and academics, but not for the non-academics. Undergraduates expressed that they tend to absorb science information from television shows such as *The Big Bang Theory*, science cartoons but also documentaries. In contrast, postgraduates and academics focused more solely on watching documentaries. As for the non-academics, no television shows or programs were mentioned, but they expressed that they occasionally listened to podcasts.

The science groups also nominated news media, like newspapers and radio programs, as a source for their science information. All three categories used these sources but some participants showed concern with the potential biases involved. Books and magazines were rarely mentioned as potential sources.

Education during primary and secondary school were considered important con-

tributors for undergraduates. In contrast, the postgraduate and academics groups and non-academics groups considered journal papers, departmental newsletters, feeds and seminars to be more important.

Similar to the non-scientists, conversations with friends, family and colleagues (and the occasional student) also provided science information. In addition, non-academic participants often talked to particular scientists for specific information as part of their job. It is interesting to note that the postgraduate and academic groups rarely mentioned interacting with other people on seeking science information.

Appendix D

Focus group questions script

This is the original focus group question script that was used during each focus group. I occasionally reiterated some questions in slightly different ways as a prompt for more participant discussion.

D.1 General interest in science and *The Big Bang Theory*

1. How did you come across *The Big Bang Theory*?
2. Why do you watch the show?
3. What do you enjoy about the show?
4. Where do you normally get your science information?
5. Have you ever expected that you can learn accurate science from entertainment TV (e.g., sitcoms, reality TV, comedy)?
6. Which would you rather watch for your science information, *The Big Bang Theory* or documentaries? Why?

D.2 Science in *The Big Bang Theory*

1. What do you think about the science in the show?
2. Do you care about the science in the show or do you take it as humour from the characters?
3. Do you remember the science information in the show?
4. Why do you remember it?

5. Is there a scientific concept, experiment or theory that came to know of from the show rather than in school or through other educational means?
6. Has the information given in the show stimulated you to do more in depth research on your own? Why?
7. What was your attitude towards science before watching the show?
8. Has this show changed your views towards science? Why?

D.3 Cameo appearances

1. Do you know of any real scientists that have made cameo appearances in the show?
2. During the break, you have taken a look at these photos I placed here of scientists who appeared in the show. Do you recognise them?
3. Do you remember which episode they were in? Can you describe the episode?
4. Do you recall which field they are in and what they are famous for?
5. Would you have known about these people if they weren't in the show?

D.4 Scientists in *The Big Bang Theory*

1. What did you believe a scientist looked or acted like before you watched the show?
2. How do the characters in the show differ from your original idea of a scientist?
3. Have you changed your view of scientists in real life after watching *The Big Bang Theory*? How?
4. How do you feel about the way the characters are represented?
5. Do you think the characters are stereotyped?
6. What do you think about the different kinds of scientists appearing in the show apart from the main characters?
7. How do you feel about the incorporation of more female scientist characters in season four?

8. Would you like to see more female characters in different fields of science? Why?

9. If they were to cast more female scientists, which discipline would you think they belong to?

10. Did this show change your views of scientist stereotypes or did it reinforce them?