Communicating evolutionary theories

A quantitative content analysis of news coverage about evolutionary theories in Dutch newspapers between 2007 and 2020

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Abstract

Evolutionary theories are not commonly researched in social sciences but are, however, influencing scientific, political, and personal spheres in a variety of ways. How news media report about evolutionary theories can influence the public perception, because most people learn about scientific topics mainly or exclusively through news media. There is, however, little research on how news media write about evolutionary theories. From a science communication perspective, this is relevant because an accurate portrayal of scientific findings is important for people to participate in society. Yet, it is known that communication of science can be distorted in many ways. News media produce news in a changing media landscape and face many challenges that influence the routines of news production. In this research, news coverage about evolutionary theories between the years 2007 and 2020 was analyzed by conducting a quantitative content analysis. The central research question was: *in what way and to what extent are evolutionary theories covered in Dutch newspapers?* To answer this research question, an automatic analysis, including a structural topic model to identify news topics, was conducted. In addition to the automatic analysis, 450 articles were manually coded to find latent meanings. The content analyses were specifically focused on three parts of news production: the selection of news, the frames used, and the sources quoted. Focusing on Dutch newspapers added the possibility to analyze whether popular, quality, and religious newspapers differed in their news coverage about evolutionary theories. These differences could possibly arise due to the Netherlands' history of pillarization. The results showed that quality and religious newspapers reported significantly more about evolutionary theories than popular newspapers over the years. The news topics associated with evolutionary theories differed strongly between religious newspapers and the other types of newspapers. The biggest topic present in news coverage about evolutionary theories in religious newspapers was evolution and religion, whereas popular and quality newspapers reported mostly about ancestor fossils and the history of life. Religious newspapers framed news coverage about evolutionary theories significantly more from a conflict perspective than the other types of newspapers. Uncertainty, the extent to which science can be confirmed or denied, was only to a small extent communicated in the news coverage of all newspapers. Scientists were mainly quoted and paraphrased in all newspapers, but religious figures and theologians were mostly used in religious newspapers. Balanced and accurate science communication was found in some aspects of news coverage about evolutionary theories, but news coverage was also inaccurate and out of balance in multiple ways. The implications of these results are discussed, as well as suggestions for further research.

Keywords: evolutionary theories, content analysis, news coverage, framing, science communication

Preface

Ideas have consequences. That is the shortest summary of my motivation to research fundamental topics, in this thesis specifically evolutionary theories. I hope that this thesis reflects a kind of curiosity about how a fundamental topic is communicated through news coverage, and that the results will be useful for further research. First, I want to thank my supervisor Eline for constructive feedback and trust along the process of writing this thesis. Eline helped to bring this thesis to a higher level. I also want to thank Nel for answering all my question about R Studio. Finally, I want to thank Marjolein, who became my wife during the period of writing this thesis, for her support and editorial feedback.

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1. Introduction

"Many people think of evolution as a fascinating topic, but one with little relevance to modern society" (Lenski, 2014, p. 727).

Evolutionary theories are not commonly researched in social sciences but are, however, topics that exist on the boundaries of scientific, political, and personal spheres. All these spheres are affected by evolutionary theories in different ways. According to Losos et al. (2014) "many disparate areas of modern life—medicine, the legal system, computing— increasingly employ evolutionary thinking and use methods developed in evolutionary biology".

In scientific research, evolutionary theories are an important foundation for explaining and interpreting phenomena. One example of this is the emergence of evolutionary approaches for studying human behavior. According to Koerner & Floyd (2010, p. 27), "evolutionary theory is poised to become the standard explanatory framework for any scientific explanation of human behavior". The widespread use of evolutionary theories within scientific research led The National Academies to call evolutionary biology the cornerstone of modern science (Nisbet, 2009).

In the political sphere evolutionary theories are for example adopted in educational curricula, which is a governmental affair. The United States' *Next Generation Science Standards* (n.d.) states for example that students must be able to construct an explanation of how earth's 4.6-billion-years-old history is organized, based on evidence from rock strata. The national curriculum of the United Kingdom states that pupils should learn about fossils that "provide information about living things that inhabited the Earth millions of years ago" (GOV.UK, 2015).

On a personal level, evolutionary theories can influence how someone views himself and the world. One area of influence for example is morality and ethics, where evolutionary biology is not only used to explain moral behavior, but also to prescribe it (FitzPatrick, 2021).

A correct understanding of scientific issues such as evolutionary theories is important for full participation in society because the public opinion influences policymaking in a representative democracy (Stocking, 2010; Campbell, 2011). Because scientific research can be detached from society, many citizens and policymakers gain information about science and evolution exclusively through news media (Strömbäck, 2005; Schäfer, 2017). The extent to which journalists write about evolutionary theories, the frames they use and the sources they quote all influence the public perception of evolutionary theories.

From a science communication perspective, it is important for news media to give an accurate and honest portrayal of scientific findings and theories, because the public needs this information to make well-informed decisions and participate as voters (Stocking, 2010; Campbell, 2011). An accurate and honest portrayal of evolutionary theories includes communication of uncertainty (Campbell, 2011), and a balanced attention to the large variety of topics within evolutionary science (Losos et al., 2014).

News reports, however, are not simply mirroring reality (McQuail, 2003). News is the result of a process that involves journalistic choices, whereby information is selected and framed according to routines and news values (Entman, 1993; Cook, 2005). This production cycle takes place in a changing media landscape, in which commercial news values are becoming more important. News media must select content based on the preferences of their readers to survive financially (Schudson, 2003). This is the reason science writer Carl Zimmer (2014) stated that much of the news coverage about evolutionary theories consists of social conflicts. This could possibly lead to a false balance in which mostly conflicts are addressed rather than the science of evolutionary theories itself. It is scientifically known that uncertainty is often left out of science news (Simis, 2013; Gustafson & Rice, 2019) and that journalists tend to seek easily explained conflicts (Friedman et al., 1999; Semetko & Valkenburg, 2000).

The Dutch media landscape is specifically interesting because it is possibly influenced by its history of pillarization, which has shaped the country's political and educational system, but also led to segmentation of newspapers based on moral and religious worldviews (Spiecker & Steutel, 2001). Evolutionary science is a topic where differences between religious and secular newspapers would be expected to manifest, because evolutionary theories are often perceived to conflict with religious worldviews (Kim et al., 2012), and this conflict is known to occur in news coverage about evolutionary theories (Setälä & Väliverronen, 2010). These characteristics can lead to differences in coverage between newspapers with religious and secular backgrounds, in respect to the amount of news coverage, the frames used, and the sources quoted.

There is, however, little research on how evolutionary theories are communicated through newspapers, while newspapers still contribute for a big part to the communication of evolutionary theories (Zimmer, 2014). Therefore, this thesis focusses on the following research question:

In what way and to what extent are evolutionary theories covered in Dutch newspapers?

The research question is answered by conducting a quantitative content analysis on news articles about evolutionary theories of popular, quality, and religious newspapers between the period of 2007 and 2020. The quantitative content analysis is automatic as well as manually conducted. This combination makes it possible to analyze a large amount of data, but also to find latent meanings in the dataset.

1.2 Scientific relevance

This research contributes to the literature on communication of science, specifically in news media. Because most people learn about science through news media, content analysis on news about science can be used to give insights into communication and possible distortions. While research has been conducted on communication of scientific subjects like climate change or neuroscience (Boykoff & Boykoff, 2004; Webster, 2007), research on communication of evolutionary theories especially in news

media has been lacking. Furthermore, there is extensive literature on communication of uncertainty in science communication (Gustafson, 2018; Gustafson & Rice, 2018; Gustafson & Rice, 2019; Gustafson & Rice, 2020), yet specific content analysis of uncertainty communication in news coverage about evolutionary theories is lacking. Therefore, this research contributes to the knowledge about (uncertainty) communication in general and evolutionary theories specifically. The results of this research may contribute to further research about the communication as well as the effects of uncertainty on the public.

1.3 Societal relevance

The public has a need for balanced and accurate information to participate in the democracy. News media have the responsibility to give that information in an accurate portrayal of scientific findings. Because framing of scientific controversies can have an impact on policy decisions (Nisbet, 2011), this research has societal relevance next to contributing to theory about the communication of science and evolutionary theories. As discussed above, educational curricula are examples of areas where evolutionary theories are implemented in society. The educational curriculum in the Netherlands that was established in 2006 is currently being revised (Rijksoverheid, n.d.). The educational curriculum is an example of a science policy which is influenced by the public opinion, which is thereafter dependent on news media. By analyzing news coverage about evolutionary theories, this research contributes to knowledge about how evolutionary theories are covered and framed, and how this possibly influences the public opinion.

2. Theoretical framework

In this chapter all relevant concepts and dimensions are discussed that are used for answering the research question: *in what way and to what extent are evolutionary theories covered in Dutch newspapers?* First, a definition will be given of what is meant by evolution in this research, as well as a brief overview of the current social scientific research on evolutionary theories. Second, news coverage of evolutionary theories will be discussed in more detail. This includes a brief overview of the current research on news coverage about evolutionary theories, theory about the communication of science, the role of news in a representative democracy and the current media landscape. The last point will be discussed in general but also specifically in relation to the Netherlands. Third and last, the research questions and hypotheses are introduced according to the three different areas of research in this thesis: the selection of news, the framing of news, and the use of sources in news coverage about evolutionary theories.

2.1 Evolutionary theories

While the focus of this research is how news media report about evolutionary theories, it is first necessary to specify what evolutionary theories are and which definition is used in the context of this research. This is because, as argued in the following chapter, evolutionary theories can refer to multiple meanings and are not commonly researched and defined in social sciences. The first part of the theoretical framework will therefore be used to give an overview of evolutionary theories and the role of evolutionary theories in- and outside scientific research. This includes a brief overview of the current social scientific research on communication of evolutionary theories.

2.1.1 Defining evolution

Evolution can have different meanings in different contexts. Philosophers of science Esther van Dijk and Thomas Reydon (2010) make a distinction between discussing evolution in everyday context and in biological terms. "In everyday contexts, 'evolution' is often used to refer to a variety of processes of change in time: languages, societies, cities, culture, the economy, the universe, technology, car models, etc. all are commonly said to evolve" (p. 659). Thus, evolution in the everyday contexts refers to a general 'development' of things.

Because the theory of evolution is an umbrella term for multiple theories of evolution, the theory of evolution in this research is referred to as evolutionary theories. Ideas about evolution in scientific and biological terms, which is the focus of this research, date back to the scriptures of Hinduism and Ancient-Greece (Bardell, 1994; Padalkar, 2018). In modern Europe, ideas about evolution became popular after Charles Darwin published *The Origin of Species* in 1859. This can for example be seen in the significant increase in usage of the word evolution in English literature (Google Ngram Viewer, 2021). Since that time, evolutionary science has grown into a large body of different theories and disciplines. Philosopher of science Joshua Moritz (2016) lists, for example, the following

theories: Lamarckian Evolution, Darwinian Natural Selection, Neo-Darwinian Evolution, Niche Construction, Evolution Through Symbiogenesis, Evo-Devo, Process Structuralism and so on.

Biological questions concerning evolution are asked on multiple levels, ranging from ultimate causes billions of years ago, to developmental explanations of the diversity and evolution of living things we perceive in the world today (Kampourakis, 2020; Lull, 2020). According to Futuyma (2005, p. 2), evolution is "change in the properties of groups of organisms over the course of generations…it embraces everything from slight changes in the proportions of different forms of a gene within a population to the alterations that led from the earliest organism to dinosaurs, bees, oaks, and humans".

Besides the growth and development of evolutionary science as a discipline on its own, theories of evolution are also used in other scientific research fields. It is, for example, used in climate change science and neuroscience (Boykoff & Boykoff, 2004; Webster, 2007). The widespread use of evolutionary theories within scientific research led The National Academies to call evolutionary biology the cornerstone of modern science (Nisbet, 2009).

Modern evolutionary science is a highly complex and large collection of different theories and research areas, which expand well beyond evolutionary biology and Darwin's theory of natural selection. Table 1 displays these different areas as well as keywords to identify them with. This overview is given to illustrate the diversity and wide range of evolutionary theories and because they are used in the content analysis of this research. The areas and keywords in table 1 are based on the topical overview provided by *The Princeton Guide to Evolution* (Losos et al., 2014), which distinguishes seven major areas within the field.

Table 1. Areas within modern evolutionary science according to the Princeton Guide to Evolution

Area	Keywords
Phylogenetics and the history of life	*Phylogenetic trees, phylogenetic inference, molecular clock dating, historical biogeography, phylogeography, character macroevolution, fossil record, origin of life, prokaryotic grade, eukaryotes, land plants, fungi, origin of animals, arthropods, tetrapod evolution, human evolution*
Natural selection and adaptation	*Selection in populations, kin selection, inclusive fitness, phenotypic selection, evolutionary limits and constraints, modifier genes, reaction norms, life histories, biochemical and physiological adaptations, ecological niche, adaptation to biotic environment*
Evolutionary processes	*Genetic drift, mutation, geographic variation, population structure, migration, recombination and sex, genetic load, inbreeding, selfish genetic elements, evolution of mating systems*
Genes, genomes, and phenotypes	*Molecular evolution, genome evolution, comparative genomics, evolution of sex chromosomes, gene duplication, evolution of new genes, evolution of gene expression, epigenetics, molecular networks, genetics of phenotypic evolution, dissection of complex trait evolution, ancient DNA*
Speciation and macroevolution	*Species and speciation, speciation patterns, range evolution, speciation and natural selection, speciation and sexual selection, gene flow, hybridization, genetics of speciation, adaptive radiation,*

	macroevolutionary rates, macroevolutionary trends, extinction, species selection, evolutionary innovations, evolution of communities
Evolution of behavior, society, and humans	*Brains, behavior, hormones, game theory, male-male competition, mate choice, evolution of communication, parental care, cooperation and conflict, cooperative breeding, human behavioral ecology, evolutionary psychology, evolution of eusociality, cognition, nonadaptive behavior, aging, menopause*
Evolution and modern society	*Medicine, parasite virulence, antibiotic resistance, microbial forensics, domestication and agriculture, conservation, directed evolution, computing, human language, cultural evolution, notions of human race, future of human evolution, evolution and religion, creationism and intelligent design, evolution and the media*

The relevance of researching evolutionary theories is not self-evident (Lenski, 2014), but can be argued. According to Losos et al. (2014) "many disparate areas of modern life—medicine, the legal system, computing— increasingly employ evolutionary thinking and use methods developed in evolutionary biology". Lenski (2014) describes four themes in which the relevance of evolutionary theories for society becomes clear. The first theme is evolution and disease. Evolutionary biology provides a larger (historical) perspective on the fundamental forces that shape diseases and is, therefore, widely used to determine the source of diseases and infections to combat and prevent them. The second theme is evolution and technology. Scientists of other disciplines than biology are adopting evolutionary findings into their own field. This accounts even for computer scientists and engineers. The third theme is evolution and what it means to be human. The question of how humans and other species came into being has interested people since the dawn of history. Modern evolutionary science is trying to answer those fundamental questions in a different way, providing people with new perspectives on why they are here, how they should live and what the future entails. The fourth and last theme is evolution in the public sphere. Discoveries of evolutionary science are more accessible now than ever before. Newspapers, books, and television used to dominate the media coverage of evolution. Nowadays, people can explore evolutionary science through websites, blogs, and social media. The findings that arise from scientific research are inconsistent with other narratives about the origin of our species. This results in societal tension and debates.

2.1.2 Existing research on the communication of evolutionary theories

Now that evolutionary theories have been defined, existing research about the communication of evolutionary theories can be discussed. This part describes the existing social scientific research on evolution, which includes the perception of evolutionary theories, the implementation of evolutionary theories in society, and specific content analysis research about communication of evolutionary theories. These areas of research are discussed to give an overview of how evolutionary theories are researched in the social sciences.

One level on which evolutionary theory is researched is its perception within society, among the broad public but also specifically among students. The perception of evolution someone has is often influenced by his pre-existing (religious) views. Evolutionary theories can challenge someone's worldview or values (National Academies of Sciences, Engineering, and Medicine, 2017). A cross-national survey executed by Miller et al. (2006), which asked people if they thought it was true or false that human beings developed from earlier species of animals, showed that countries like the United States and Turkey are outliers in the fact that most respondents rejected that statement.

Another area of interest for social sciences concerning evolutionary theories is education, because the implementation of evolutionary theories in educational curricula causes science-related policy debates and sometimes even to court cases (National Academy of Science and Institute of Medicine, 2008; Berkman & Plutzer, 2011; Jamieson, 2017). Because evolutionary theories are adopted in educational curricula (Next Generation Science Standards, n.d.; GOV.UK, 2015) some researchers explicitly write about widespread misconceptions and conceptual debates about evolutionary theories to improve the learning and teaching of evolutionary theories (Van Dijk & Reydon, 2009).

As a result of the controversies surrounding evolutionary theories, social scientific research that studies the reception of evolution is also focused on providing a more in-depth insight into the question why people do not accept evolutionary theories. There is, for example, a lot of research which focuses on why evolutionary science is denied or not well-understood (Anderson, 2007; Cotner, Brooks & Moore, 2010; Thagard and Findlay, 2010; Setälä & Väliverronen, 2010; Infanti and Wiles, 2014; Silva and Lowe, 2015).

Communication of evolution has also been an area of research in social sciences because people learn about scientific subjects like evolutionary theories mainly or exclusively through media (Schäfer, 2017). The research, however, accounts predominantly for other forms of science communication than news coverage. The content analyses that have been done on evolutionary theories are focused on areas of science communication like educational textbooks or the state of knowledge of students about evolution. Research shows, for example, that students who enter university can have misconceptions about science and evolution. Also, textbooks for biology cam provide over-simplified and inaccurate information (Wescott & Cunningham, 2005; Rees, 2007).

2.2 News coverage of evolutionary theories

While evolutionary theories are communicated trough all kinds of media, the focus of this research is specifically on communication of evolutionary theories in newspapers, because newspapers are a significant distributor of information about evolutionary theories (Zimmer, 2014). Therefore, from now on the theoretical framework will be narrowed down to communication through newspapers only.

Journalistic coverage of contemporary evolutionary science began in the 1970s, which was a period of renewal within evolutionary biology. The fossil record provided new insights into human

evolution, and journalists started documenting evolutionary biologists' reconstructions of natural history (Zimmer, 2014).

In discussing the communication of evolutionary theories through newspapers, the communication of science in general will first be discussed, followed by the role news media have in communicating science to the public. Second, the current media landscape will be described in general, as well as in The Netherlands specifically. Third and last, an overview will be given of existing research on news coverage about evolutionary theories.

2.2.1 Communication of science

News coverage is one of many forms to make scientific theories and findings accessible to the public (Buchi, 1998), and falls within the realm of science communication. This section is therefore used to describe different views on the communication of science.

A prominent view in the realm of science communication is the 'dissemination paradigm' of science communication (Kappel & Holmen, 2019). This model assumes that an appropriate way to communicate science is a one-way transmission from scientific experts to the public. This transmission can work in two different ways: through education in school or through (re)education by mass media.

The general goals of science communication are summarized in five points by the *National Academies of Sciences, Engineering, and Medicine* (2017). The first goal is to share recent findings and excitement for science. The second goal is to increase the appreciation of science by the public. The third goal is to increase knowledge and understanding of science. The fourth goal is to influence opinions and policy debates about science. The fifth and last goal is to facilitate a variety of perspectives about scientific subjects and issues to accelerate the search for solutions in societal problems.

Burns et al. (2003) illustrate the communication of science as mountain-climbing. In this analogy, science is depicted as an expansive mountain with multiple peaks (e.g., the large amount of different scientific fields) that need to be climbed (e.g., to grow in scientific literacy). Science communicators can be thought of as the mountain guides: they teach the skill of climbing and provide ladders (e.g., media) to climb on, and keep the climbers informed about progress and issues regarding the act of climbing.

Burns et al. (2003) also distinguish three essential tools for the process of science communication. First, personal skills of science communicators are the basis of science communication. Second, media are necessary to distribute information about science. A distinction is made between formal learning (e.g., education at universities, academic and professional conferences, science textbooks), and informal science communication (e.g., science museums, popular science books, and coverage on television or in print). Third, dialogue between scientists and the public is needed to receive feedback and local knowledge.

The second tool, the communication through media, is the main focus of this research. This research is, however, to a certain extent also related to the skills of science communicators and the dialogue between scientists and the public, because news coverage can reflect these skills and dialogues.

2.2.2 Communication of uncertainty

It is widely accepted that an understanding of scientific issues is necessary for full participation in society (Davis & Russ, 2015), therefore it is important that people receive accurate and reliable news about scientific developments and findings. It is thus important to define what it means to deliver accurate information about science, which will be done in this part.

According to Carpenter (1995), wholly accurate science communication is a description of the current state of uncertainty. Peters and Dunwoody (2016) define scientific uncertainty as epistemic uncertainty, which refers to the "uncertainty about the validity of truth claims" (p. 894). This is derived from the idea that uncertainty is inherent to the scientific method. Scientific knowledge moves in paradigmatic cycles, in which new discoveries can refute longstanding assumptions and introduce new uncertainties (Kuhn, 1970). Science can often disprove hypotheses, but to a lesser extent support hypotheses (Popper, 1959). When scientific findings and theories are portrayed in the news, they need to be accompanied by the uncertainties in order to be accurate. It is important to honestly portray these uncertainties of science, so that the public can make well-informed decisions and participate as voters (Campbell, 2011; Stocking, 2010).

Han et al. (2011) propose a three-dimensional view of the main sources of scientific uncertainty. The first is probability, which is indeterminacy of future outcomes. The second is ambiguity, which contains lack of reliability, credibility, or adequacy. The third is complexity, which points to uncertainty that arises out of aspects of the scientific phenomenon that are difficult to comprehend. Gustafson (2018) summarizes four different types of uncertainty based on a literature review of the communication of scientific uncertainty. The types of uncertainty follow from the cause of the uncertainty. The first is deficient uncertainty, which contains "emphasizing a lack of knowledge that exists because there is a lack of research on this question, or because that thing cannot ever be known, or because the problem space has expanded in a way that has exposed new unknowns" (p. 13). The second is technical uncertainty, which is "an effect of inherent complexity in a problem space, or inherent randomness in a phenomenon" (p. 14). The third is scientific uncertainty. "Statements of scientific uncertainty position uncertainty about a claim as a function and feature of the process or nature of good scientific research" (p. 15). The fourth and last is consensus uncertainty. "The (un)certainty of any particular claim can also be described in terms of the collective discord/accord that exists about it" (p. 17)

2.2.3 Existing research about news coverage of evolutionary theories

While content analysis on news coverage of science and how scientific subjects are portrayed exists (Good, 2008; Listerman, 2010; Shehata & Hopmann, 2012; Guillaume et al., 2017), there is little research specifically about news coverage of evolutionary theories. This is noteworthy, because the importance and relevance of accurate scientific communication is acknowledged by scholars (Scheufele, 2014; Kahan, 2015; Jamieson, 2017).

Even though research on evolution and news coverage is still minor, there is some research on this topic which goes back to 1987. Caudill (1987) did a content analysis of news about Darwin's evolution theory and noted that the interest of the newspapers shifted from Charles Darwin as a person, to Darwinism as a theory, between 1860 and 1925. Other examples are research on inaccuracies in Spanish news media in reporting evolutionary theories (Garabi, Anton & Villaroel, 2019), how evolutionary theories are communicated in Spanish newspaper cartoons (Dominguez & Mateu, 2012), and how evolutionary theories are framed in Finish newspapers (Setälä & Väliverronen, 2010). These studies, however, lack an analysis of large amounts of news about evolutionary theories, framing and used sources. The analysis of Setälä & Väliverronen (2010) does contain frames and sources but is limited to articles about a specific event concerning evolutionary theories and thus contains only a small dataset.

A possible reason why there is little research on news coverage of evolutionary theories is that evolutionary theory in societal scientific research is seen as a metatheory (Greenwood, 2010). Evolutionary theory is not seen as a separate scientific discipline, which could explain why it is not taken into account when researching news coverage of science (Schäfer, 2012). Schäfer (2012) found that research on news coverage of science in Western countries shows bias towards natural sciences, which contains fields like biology, medical science, physics, etc. Another example is a content analysis of BBC news by Mellor et al. (2011), in which they distinguished different fields of science like physical sciences, life sciences, and climate sciences. In both these examples, evolutionary theories play a certain role in the different fields of scientific research, but they are not considered as a specific field of research on its own. Therefore, evolutionary theories are less likely to be analyzed in research on news coverage of science.

2.3 The media landscape

Now that the communication of science and the existing research on news coverage about evolutionary theories have been discussed, the context in which news media write about evolutionary theories can be discussed. In this chapter, an overview will be given of the media landscape in which news about evolutionary theories is produced. This overview includes a specific description of the Dutch media landscape, which is the focus of this research. To conclude the theoretical framework, the research questions and hypothesis will be introduced according to three different levels of news production: the selection of news, the frames used, and the sources quoted.

News media are part of a media landscape that has been rapidly changing in the last few decades. To research news coverage about evolution within this media landscape, it is therefore necessary to review these changes and to describe the current landscape in which news coverage of evolutionary theories is produced.

In an ideal functioning of news media, scientific findings would be presented without any distortion. Traditionally the role of news media in society is determined by the contribution of news to democracy, also known as the journalism-democracy paradigm (Ryfe, 2019). The Netherlands is a representative parliamentary democracy with a multiparty political system, in which the responsibility for government policy lies with the cabinet ministers (Gutteling, 2002). A two-chambered States General serves the public through proportional representation. The ideal functioning of a representative democracy depends on the participation of an informed rational electorate (McNair, 2017). Media need to provide "information that people can trust and act upon" (Strömbäck, 2005, p. 339), because people rely on media for information about social developments.

News reports, however, are not simply mirroring reality (McQuail, 2003). News is produced in specific situations and is the result of journalistic choices. Focusing only on the theoretical ideals of how journalism should function is not adequate to describe what it is and how it functions in practice. Or, as Deuze & Witschge (2020) put it: "What journalism is and what journalists do cannot be meaningfully separated from their material context" (p. 35). News media are part of a media landscape that has been rapidly changing in the last few decades.

The communication of science in news media is affected by general changes in the media landscape. According to sociologist Manuel Castells (2000), technological changes in the last few decades lead to a new paradigm, which he calls the information age. Networks are the key element of organization in the information age, which cause a decentralization of communication (Hjarvard, 2018). This means that traditional news media are no longer the primary producer and source of information, but part of a network in which everyone can spread information. Benkler (2006) described this phenomenon as a shift in the information economy from a top-down model to a one-to-many model. The internet has made it possible for people on every level of society to produce and spread information in a system sustained by algorithms.

Schäfer (2017) states that legacy news media are under pressure in many countries around the world. The traditional business model of selling news for advertisements and subscriptions is in crisis, which in return leads to cutting of staff and a switch to online-only publication. Traditional news media are also increasingly competing with social media, which are a growing source of information for people. The business model of news media is affected by the massive migration of advertisers to digital platforms such as Google and Facebook (Waisbord, 2019). This leaves news media with a reduced amount of funding to produce news. Because news media are commercial businesses, they need to ensure their readers attention to survive. Schudson (2003) calls this phenomenon the market model of

journalism, in which “mass customization of news content to satisfy personal demand is a logical evolutionary step” (Wilbur, 2017, p. 4).

It can be concluded that news media play an important role in determining what people read about scientific research, and thus also about evolutionary theories. News media influence the communication of science in three ways: through the selection of news, the frames used and the sourced quoted. In all these areas, changes in the media landscape influence the way in which news media communicate about science.

2.3.1 The Netherlands

By focusing on Dutch newspapers, this study adds another dimension to the goal of researching news coverage about evolutionary theory from a general science communication perspective, namely the possible differences between religious and other types of newspapers. The specific relevance of studying news coverage in the Netherlands in addition to the general perspective will be discussed here.

As mentioned previously, news media can influence the public opinion about scientific topics because most people learn about these topics mainly or exclusively through these media (Schäfer, 2017). Furthermore, the public opinion is an important voice in a representative democracy (Ryfe, 2019). Therefore, it is relevant to study how news media cover certain topics because differences between newspapers could influence the public opinion.

The history of pillarization in the Netherlands makes it especially interesting to study the production of news and the possible differences between newspapers. Until the 1960s, the Netherlands was segregated into different pillars, which means that society was divided into various religious and ideological groups (Blancke et al., 2014). The Netherlands is a secularized country today, but the Dutch media landscape is still, to a certain extent, influenced by its history of pillarization. Pillarization has shaped the country’s political and educational system and led to segmentation of newspapers based on moral and religious worldviews (Spiecker & Steuter, 2001). There is, however, little research on how the history of pillarization influences news coverage in general, and specifically on possible differences in news coverage between religious and other types of newspapers today.

Evolutionary theories are suited as a starting point for analyzing possible differences between religious and other types of newspapers because evolutionary theories are surrounded by perceived conflict between science and religion and discussions about what belongs to the private and public sphere (Gonzalez, 2016). Therefore, it is possible that religious newspapers frame or select in a different way when writing about these topics because their morals and worldview differ from secular newspapers.

Now that the media landscape and its changing structures have been described, the specific levels on which news is produced can be introduced. In this research three levels of news production are being analyzed: the selection of news, the frames used, and the sources quoted. These levels form the basis for the research question and hypothesis, which will be introduced in the following chapters.

2.3.2 Selection of news

The first of three ways in which news media play a role in communicating scientific research is through the amount of attention scientific subjects receive in news coverage. The *first-level agenda-setting theory* (McCombs & Shaw, 1972; Scheufele & Tewksbury, 2006) refers to the amount of attention news media give to a certain topic. The basis of this theory is that news media can determine what is important for the public. According to Scheufele & Tewksbury (2006, p. 11), agenda-setting "refers to the idea that there is a strong correlation between the emphasis that mass media place on certain issues (e.g., based on relative placement or amount of coverage) and the importance attributed to these issues by mass audience".

A distinction can be made in The Netherlands between elite newspapers that write for audiences with a Christian background, and elite newspapers that are secularized (Bakker & Scholten, 2013). Because worldviews are a determining factor in how people think about evolutionary theories (National Academies of Sciences, Engineering, and Medicine, 2017), it is possible that religious and secular newspapers differ in news coverage about evolutionary theories because they write for different audiences. On the other hand, research suggests that news media are institutionalized, which means they report in a similar way and handle the same news values, despite the different characters they have (Cook, 2006).

The amount of news coverage about science increased in the last half of the twentieth century, because news media started to introduce specific science section and pages into their newspapers (Hijmans et al., 2003). This was also the case for news coverage of evolutionary theories (Losos et al., 2014), which was accelerated by the growth of scientific research and findings within the field of evolution at that time. Schäfer (2017) notes, however, that the growth of the amount of media coverage on science seems to have stopped recently. A long-term trend shows that popular newspapers generally report less about scientific subjects than quality newspapers (Bauer et al., 1995). According to Boukes & Vliegenthart (2017), this is also true for popular and elite newspapers in The Netherlands. Therefore, the following hypothesis and research question are formulated:

> *H1: The amount of news coverage on evolutionary theories in Dutch news media has decreased between 2008 and 2020*
>
> *RQ1: To what extent does the amount of news coverage about evolutionary theories differ between popular, elite, and religious newspapers?*

News media differ in routines and ideologies on which they base their selection of news (Shoemaker & Vos, 2009). Because evolutionary theories consist of a large variety of topics and research domains (Losos et al., 2014), the selection of news about evolution and what topics are given attention can differ between news media. In the selection of news by media, news values are used in determining what is worthy to be published. Controversy and debate are, for example, important values for increasing the

newsworthiness of stories (Friedman et al., 1999). According to Bauer et al. (2006, p. 100), "science makes the news if it is seen as novel, controversial, exciting, with images, locally relevant, personalized, and with a human touch". In today's media landscape new developments like the capability to measure audience metrics are also influencing the selection of news. (Welbers et al., 2015). For news coverage of evolutionary theories in Dutch news media multiple things can be expected. News coverage can show bias towards topics within evolutionary theories that are perceived as exciting, such as findings of new fossils or 'missing links'. On the other hand, more complex topics can be avoided. Therefore, the following research questions are formulated:

RQ2: What topics do Dutch news media associate with evolution?
RQ3: Do Dutch news media show bias towards certain topics within evolutionary theories?
RQ4: To what extent does the occurrence of topics within news coverage of evolutionary theories differ between popular, quality, and religious newspapers?

Another way of analyzing the selection of news and the news values that news media use in that process, is by looking at the events that trigger news coverage. News events are connected to news values in the sense that news values determine the extent to which an event is covered in news media (Olteanú et al., 2015). There is, however, no research yet on events triggering news coverage about evolutionary theories. Therefore, the following research questions are formulated:

RQ5: What events trigger news coverage of evolutionary theories in popular, quality, and religious newspapers?
RQ6: To what extent do the events triggering news coverage about evolutionary theories differ between popular, quality, and religious newspapers?

2.3.3 Framing

A second way in which news media are setting an agenda is through the framing of news. Entman (1993) defines framing as follows: "To frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described" (p. 52). This is the reason why "... frames are never neutral: they define an issue, identify causes, make moral judgements and shape proposed solutions" (O'Neill et al., 2015, p. 380). The assumption behind the theory of framing is thus that the way news is framed influences the way in which the public understands it. When a frame is repeatedly used by journalists, the chance increases that the public will perceive reality trough that frame. This effect of a frame becoming a common view is referred to as frame setting (Brüggemann, 2014).

A distinction can be made between generic and issue-specific frames (de Vreese, 2002; de Vreese, 2005). Generic frames are commonly used frames and apply to a multitude of topics. These frames can also be referred to as 'traditional' frames. Examples of generic frames are episodic and thematic frames. In science, news stories tend to be more episodic than thematic, which means that news articles are short stories about specific events rather than long stories with more background information (Dunwoody, 2014). Another well-known generic frame is the conflict frame (Semetko & Valkenburg, 2000), which is also used in this research. Issue-specific frames are, as the name suggests, frames that suggest interpretations in debates about specific issues.

Because there is little research on how evolutionary theories are framed in news coverage, only generic frames are used in this research. Five frames are being analyzed in total: the conflict frame and four types of uncertainty frames, which will be discussed separately below.

Conflict frame

First, the conflict frame and the relevance and expectations in relation to news coverage of evolutionary theories will be discussed. According to Semetko and Valkenburg (2000), the conflict frame "emphasizes conflict between individuals, groups, or institutions as a means of capturing audience interests" (p. 95). A more comprehensive definition of what conflict is can help to determine what conflict could mean in relation to evolutionary theories. Claire and Holden (2007) provide the following definition of a controversial issue: "In general terms a controversial issue is one in which: the subject/area is of topical interest, there are conflicting values and opinions, there are conflicting priorities and material interests, emotions can become strongly aroused and the subject/area is complex" (p. 5-6).

The conflict frame is relevant to study because it can give an insight into how newspapers choose to frame the controversies surrounding evolutionary theories. One issue concerning evolutionary theories is the creationism/evolution controversy, which is first of all a controversy in worldviews, but also reflected in policy debates about what should be adopted in educational curricula (Berkman & Plutzer, 2011). This issues reflects conflicting values and opinions, but also conflicting priorities and material interests. It is known that framing of science can be based on science-related policy-debates such as educational curricula, and that the conflict frame commonly appears in news coverage regarding these debates (Nisbet, 2009).

Science writer Carl Zimmer (2014) argues that much of the coverage about evolutionary theories addresses social conflicts, rather than the evolutionary theories themselves. This leads, according to Zimmer, to a false balance in news coverage by promoting the impression that evolutionary theories are controversial within the scientific community, rather than the foundation of biology. While it is indeed known that controversy and debate are important for increasing the newsworthiness of stories (Friedman et al., 1999), there is little to no scientific research on the presence of the conflict frame in news coverage about evolutionary theories to test the assumption of Zimmer. Based on the

common appearance of the conflict frame in news coverage about debates surrounding science, it can, however, be expected that religious newspapers frame news about evolutionary theories more from a conflict perspective than other newspapers. This is because controversies about evolutionary theories are more likely to be relevant for readers of religious newspapers, because their interests about for example education are at stake. Therefore, the following research questions and hypothesis are formulated:

RQ7: to what extent is the conflict frame present in news coverage of evolutionary theories in popular, quality, and religious newspapers and to what extent does the presence of the conflict frame differ between medium types?

H2: The conflict frame is significantly more present in religious newspapers than in popular and quality newspapers

Uncertainty frames

Besides conflict, which is only a small part within the areas of modern evolutionary science (Losos et al., 2014), uncertainty is a good starting point for researching news coverage about evolutionary theories because science is often discussed through frames of uncertainty (Gustafson, 2018, Gustafson & Rice, 2018). Researching uncertainty thus complements the analysis of framing because it provides a bigger framework for determining accuracy and balance in science communication than just conflict.

In the media, it is known that "public-facing science communicators often shy away from portraying the uncertainties of science" (Gustafson & Rice, 2019, p. 680), and that this leads to the portrayal of scientific theories and findings "as more certain than they truly are" (Gustafson & Rice, 2019, p. 680). Communicating scientific uncertainty can, for example, question the worldview of newspaper readers. This can cause confusion and can be hard to understand for the public (Gustafson & Rice, 2020). Journalists need to make stories that are understandable for readers and are judged by their editors, a process that can lead to covering the obvious implications for the readers (Stocking, 1999). In the Dutch media landscape this could mean that religious and secular newspapers show a different expression of scientific uncertainty in news coverage of evolutionary theories.

The study of uncertainty communication is relevant because of the effects it can have on the public perception of the science that is communicated. As Gustafson (2018) points out, the effects differ between the kinds of uncertainty. Communication of consensus uncertainty is most associated with undesirable effects, such as distrust in science and lower behavioral intention (Gustafson, 2018). Scientific and technical uncertainty are associated with desirable effects such as stronger belief and an increase in the perceived credibility of the science communicated. According to Gustafson (2018), there

is not enough research to determine the effects of communicating deficient uncertainty, although it resembles consensus uncertainty in the sense that there is something missing in evidence or research.

The communication of science and its uncertainties is also for a big part challenged by the content of the information itself. Scientific theories and findings are often work in progress, dependent on contexts, and accompanied by unanswered questions (National Academies of Sciences, Engineering, and Medicine, 2017). In addition to this, media organizations are racing to be the first to publish information online. The scientific process is, however, different than the news cycle of journalism. Scientific research takes years before enough data is gathered to present findings. In the past, content analyses have found that news coverage of scientific research is rarely hedged (Jensen, 2008). This means that news articles about scientific research do not contain limitations or any other indicators of scientific uncertainty. Therefore, the following research questions and hypothesis are formulated:

RQ8: To what extent are uncertainty frames present in news coverage of evolutionary theories in Dutch newspapers and to what extent does the presence of uncertainty frames differ between popular, quality, and religious newspapers?

H3: The expression of uncertainty has decreased in news coverage of evolutionary theories in Dutch newspapers

Frames and news topics

As discussed previously, evolutionary theories can be divided into multiple topics and areas of research (Losos et al., 2014). Besides use of frames in general, the production of news can cause that frames are used in news about specific topics within evolutionary theories. In other words, agenda-setting can also mean that certain topics are for example structurally more framed in terms of conflict than other topics, or that uncertainty is structurally expressed in relation to certain news topics. To give more insight into the framing of evolutionary theories, the correlation between the analyzed frames and news topics can be determined. Therefore, the following research questions are formulated:

RQ9: to what extent does the conflict frame correlate with news topics within news coverage of evolutionary theories?

RQ10: to what extent do the scientific uncertainty frames correlate with news topics within news coverage of evolutionary theories?

2.3.4 Sources

A third way in which news media are setting an agenda is through the source's media use in writing about scientific research. Journalists who write about scientific findings rely on external sources like experts and researchers for clarification and comments, which they can use in writing their articles

(Conrad, 1999). In addition to this, it is argued that the selection of news sources influences the frame-building process described above. The reason for this is that news media often adopt the frames that their sources use (Vasterman & Ruigrok, 2013).

A general trend in news coverage of science is that journalists who write about science are more source-dependent than other journalists, which leads to a "source-driven reportage of science" (Bauer & Gregory, 2007, p. 33). According to Schäfer (2017) the literature on science news coverage shows that journalists tend to rely on a small number of influential scientific journals as primary sources for their articles.

Stocking (1999) argued that journalists relied on too few sources in the coverage of scientific research. By neglecting a variety of sources science is made more certain than it is. A large variety and diversity of sources are important for news media to fulfill their role in democracy (Tiffen et al., 2013). Therefore, the following research questions and hypothesis are formulated:

> *RQ11: Which sources are used by Dutch newspapers in news coverage of evolutionary theories?*
>
> *RQ12: To what extent do popular, quality, and religious newspapers differ in use of sources in news coverage of evolutionary theories?*
>
> *H4: Scientific sources are significantly more used in quality newspapers than in popular and religious newspapers*

The theoretical framework was used to describe all the relevant concepts and theories needed to answer the mean research question: *in what way and to what extent are evolutionary theories covered in Dutch newspapers?* In the next chapter, the methods that are used to answer this question will be described and explained.

3. Method

In this section, the methods used to conduct this study are described and explained. This section includes information about how the data is collected, which methods have been used to analyze the data and how the variables were operationalized to answer the research questions and test the hypotheses.

3.1 Data collection

This research is focused on giving an overview of the news coverage of evolutionary theories in Dutch newspapers, by analyzing the selection of news, the frames used, and the sources quoted. The analysis consisted of an automatic and a manual content analysis. To give this overview, news articles of seven Dutch newspapers were used within a timespan of thirteen years. This timespan and these newspapers were used for all analyses.

The newspapers used in this research are *De Telegraaf, Algemeen Dagblad, de Volkskrant, NRC Handelsblad, Trouw, Nederlands Dagblad,* and *Reformatorisch Dagblad*. All seven newspapers are national newspapers. Bakker and Scholten (2013) distinguish De *Telegraaf* and *Algemeen Dagblad* as popular newspapers and *De Volkskrant, NRC Handelsblad* and *Trouw* as quality newspapers. According to Bakker and Scholten (2019), readers of popular newspapers represent the whole population, while people with higher educational and income levels are overrepresented in the reader population of quality newspapers. *Nederlands Dagblad* and *Reformatorisch Dagblad* are two smaller newspapers with a protestant-Christian signature. These newspapers were chosen because they represent a big part of the Dutch newspaper landscape and allow for analyzing differences between different kind of newspapers.

Because of the minor research on news coverage about evolution, the choice for longitudinal research has been made. This means that a longer period of time was analyzed, by which an overview can be given of news coverage of evolution over the years. For this research, news articles were analyzed within a timespan of thirteen years, between 2007 and 2020. This sample was used for both the automatic and the manual analysis. The year 2007 is a relevant starting point because it was the first year since the current educational curriculum was used in the Netherlands (Curriculum.nu, 2020; Rijksoverheid, n.d.). This refers to the societal relevance of this research as previously discussed in the theoretical framework.

The news articles were collected using AmCAT and NexusUni. AmCAT is an online infrastructure that can be used as a tool for automatic and manual content analysis (Van Atteveldt, 2008). To find relevant articles, a search string was used (see appendix A). The search string is based on the topical overview of evolutionary science provided by *The Princeton Guide to Evolution* (Losos et al., 2014) (see appendix A and E), as previously discussed in the theoretical framework. To measure the validity of the search string a *precision* and *recall* were performed. The precision measures whether the articles are justly recognized as being relevant, the recall measures whether all relevant articles are found (Van Atteveldt, 2008). The values of the precision and recall were .86 and 0.88. These values show that the search string resulted in a dataset consisting for the biggest part of articles that are actually

containing information about evolutionary theories. Using this search string, a total of 3242 articles were selected between the years 2007 and 2020, which were used in this research. The distribution of the articles per newspapers and medium type is described in Table 3.1.

Table 3.1. Distribution of news articles per medium type

Medium type	**Newspaper**	**Number of articles**	**Number of articles per medium type**
Popular newspapers	Algemeen Dagblad	76	251
	De Telegraaf	175	
Elite newspapers	Trouw	409	1850
	NRC Handelsblad	878	
	De Volkskrant	563	
Religious newspapers	Nederlands Dagblad	540	1141
	Reformatorisch Dagblad	601	
Total			3242

3.2 Research method

This research was executed using multiple quantitative content analyses. According to Krippendorff (2004, p. 18), a quantitative content analysis is "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use." A quantitative content analysis is suitable for this research because it enables the researcher to analyze a large amount of data. The results are generalizable and can be linked to theoretical concepts. In this research, both an automatic and a manual content analysis were used to answer the research questions.

Scharkow (2017, p. 1) defines automatic content analysis as "a technique for coding messages with the help of computer algorithms." The automatic content analysis was used for analyzing the total dataset. The amount of news coverage over time as well as the topics newspapers associate with evolution was measured using automatic content analysis. The latter was done using a technique called *topic modelling*. According to Jacobi et al. (2015) topic models are "computer algorithms that identify latent patterns of word occurrence using the distribution of words in a collection of documents" (p. 2). The output of a topic model is "a set of topics consisting of clusters of words that co-occur in these documents according to certain patterns." (Jacobi et al., 2015, p. 2). *Topic modeling* can thus be used to find correlations between topics within a large collection of news articles. Using *topic modeling* was relevant in this study about news coverage of evolutionary theories because this kind of analysis can identify to what extent the different areas of evolutionary science, as discussed in the theoretical framework, are covered in Dutch newspapers.

The biggest difference between an automatic and a manual content analysis is that the former is executed by a computer, and the latter by a human coder. The benefit of automatic analysis is that a

large dataset can be analyzed, but the disadvantage is the lack of ability to find latent meanings. The manual analysis was, therefore, performed on a sample of the dataset and is useful for finding latent meanings (Krippendorff, 2004). The manual analysis was in this research used to analyze the news events triggering news coverage, the frames used, and the sources quoted. The automatic and manual content analyses thus complement each other and are both necessary to give a complete overview of news coverage about evolutionary theories.

To analyze the data derived from the automatic and manual analysis, the open-source program *R Studio* was used. R Studio can be used for calculations and visualization of the data, which was used for answering the research questions and testing the hypotheses. R Studio also made it possible to analyze how different aspects of this research correlate with each other. It was, for example, possible to calculate and visualize the correlation between the presence of the conflict frame in different news topics.

3.3 Operationalization

The news coverage of evolution in Dutch newspapers was analyzed in three different ways: the selection of news, the frames used, and the sources quoted. In the following part the operationalization of the different variables that were used in this research are described.

3.3.1 Selection of news

The selection of news was studied in different ways. The automatic analysis was used to study the amount of news coverage of popular, quality, and religious newspapers within the time span of 2007 till 2020. By using the total dataset, differences between medium types and time periods were analyzed. The selection of news was also analyzed through *topic modeling,* a technique that, as explained in the research method section, can show what topics newspapers associate with evolution and which news topic are more prominently present than others, as well as the differences between medium types in the selection of news topics.

The *topic modeling* technique was carried out in four steps. The first step was tokenization, which means that the texts of news articles were split into a list of words. The second step was lemmatization, which means that words were reduced to their lemma. Third, the *topic modelling* technique calculated to what extent words appeared together, and correlating words formed clusters of words which can be described as topics. Fourth and last, the researcher manually linked news topics to the clusters after the clusters of words were formed. How many clusters the topic model produces, was determined beforehand. According to Jacobi et al. (2015, p. 5) “there is no default or simple rule of thumb for this parameter. The trade-off is comparable to factor analysis: the goal is to describe the data with fewer dimensions (topics) than are actually present.” This means that the researcher had to discover manually through trial and error how many topics were to be in the list, while losing as little relevant information as possible. For this research, 17 topics have been chosen, based on the 3242 articles. Eventually, some topics were merged because they had a lot of similarities. There are also irrelevant

topics, which can be explained by the fact that the dataset contained articles that mention evolution only sideways. These articles were considered by the topic model and resulted in the irrelevant topics. Eventually, 9 news topics were selected based on the 17 topics that were determined in the topic model. The automatic analysis was used to analyze the amount of news and the news topics.

The last way in which the selection of news was studied, was through manual coding of news events. By performing a manual analysis, the coder searched for latent meanings according to a coding instruction (see appendix C). To test if this instruction was reliable, a sample of 60 articles was coded by two different coders. The extent to which the coders agreed was calculated, which is expressed in Cohen's Kappa and can be found in paragraph 3.3. Cohen's Kappa measures whether the amount of agreement is higher than it is expected to be by chance (Sun, 2011). A value of .60 or higher is seen as reasonably reliable, a value of .80 or higher is very reliable. The manual analysis was used to analyze the news events, the frames, and the sources. Per medium type, a total of 150 articles were manually coded. This means that overall, 450 articles were manually coded.

The event that triggered the news coverage about evolutionary theories was determined per article. The variable determining the news event that triggered the news coverage has a high reliability ($\kappa = 0.8$). In Table 3.2, the different news events are described, which could be coded as triggering the news coverage.

Table 3.2. Description of news events

Launch of books/movies/games/etc.	Discussion of books/movies/games/etc. about evolution.
Science policies	Events concerning policy making or the implementation of science in society: e.g., the implementation of evolutionary theories in education
Societal events	Events in society concerning evolution: e.g., museum exhibitions or the year of Darwin.
New discoveries	Scientific discoveries prior to research (e.g., the discovery of a new fossil).
Research	Ongoing or completed scientific research (e.g., the publication of a research paper).
Natural events/accidents	Uncontrolled events that involve disaster or accidents (e.g., the death of a famous person or a natural disaster).
New technologies	Events concerning the development or discussion of a new technology.
Media items	Items in media concerning evolution (e.g., other news articles about evolution or statements by media celebrities about evolution covered by media).
Other	Events that are not covered by the news events mentioned above.

3.3.2 Frames

A total of 450 articles were manually coded to measure the presence of the different frames that were analyzed in this research. To ensure the relevance of the coded articles, the requirement that words had to occur at least two times in an article was added to the search string. The frames were measured by

answering one or more questions with yes or no. The frames were coded on article level, which means that multiple frames could occur in a single article. The reliability of the frames is expressed in Cohen's kappa (κ).

Conflict frame ($\kappa_{gem} = 0.80$)

The conflict frame is based on research of Semetko and Valkenburg (2000). The operationalization of the conflict frame is taken from this research, but the questions are slightly modified to fit the topic of this thesis. The conflict frame can be measured by answering the following questions with yes or no:

- *Does the article reflect disagreement between individuals, groups or worldviews when spoken about evolution?* (κ = 0.71).
- *Does the story refer to two sides or to more than two sides of a problem or issue about evolution?* (κ = 0.69).
- *Does the article refer to winners and losers when spoken about evolution?* (κ = 1.00).

Uncertainty frames

The uncertainty frames are based on the typology of uncertainty frames created by Gustafson (2018), which are based in an extensive overview of the literature on communication of uncertainty. The questions that were used for measuring the frames are based in this typology. A description of his typology is shown in Table 3.3.

Table 3.3. Four uncertainty types according to Gustafson (2018).

	Deficient	**Technical**	**Consensus**	**Scientific**
Exemplar phrasing	"Scientists' knowledge in ____ remains limited because most of the research needed to prove or disprove these ideas has not yet been conducted."	"Scientists' best estimate is that the total increase in ___ could be as low as 6% or as high as 24%."	"Scientists remain divided on ____, with each side receiving strong support from leading scientists and research groups."	"Scientists are always striving to develop a better understanding of ___, so scientists fully expect to adjust their opinions about this issue as future research is conducted."
Defining properties	Uncertainty caused by a lack of study, a lack of available evidence, or fundamental "unknowable" nature of the question.	Uncertainty caused by the known properties of precise, quantified estimates; often derived from evidence or study.	Uncertainty caused by disagreement, controversy, or discrepancy across expert opinion or across evidence.	Uncertainty caused by the perpetual potential for future research to reform or reject the current assumptions or body of evidence.

The frames were operationalized as follows:

Deficient uncertainty frame (κ_{gem} = 0.82)

A frame of *deficient uncertainty* emphasizes a known lack of scientific knowledge. This can be caused by a lack of study, a lack of evidence, or the fundamental unknowable nature of the phenomenon in question. The deficient uncertainty frame can thus be measured by answering the following question with yes or no:

- *Does the article mention a lack of study and/or available evidence?* (κ = 0.70)
- *Does the article mention the fundamental unknowable nature of the phenomenon in question?* (κ = 0.94)

Technical uncertainty frame

Many scientific claims are limited by measurement error, modeling approximations, and other methodological imprecisions. Thus, science communication often includes information about projected ranges, confidence intervals, and probabilities. The technical uncertainty frame can thus be measured by answering the following question with yes or no:

- *Does the article mention quantifiable limits of scientific research?* (κ = 1)

Consensus uncertainty frame

Consensus uncertainty is uncertainty caused by disagreement, controversy, or discrepancy between experts or across evidence. The consensus uncertainty frame can thus be measured by answering the following question with yes or no:

- *Does the article reflect disagreement or controversy between experts or evidence?* (κ = 1)

Scientific uncertainty frame (κ_{gem} = 0.76)

Scientific uncertainty is, to a certain extent, similar but distinct from deficient uncertainty in the sense that the latter is a known, identifiable shortcoming in a specific area while the former is a general epistemological philosophy of unknown unknowns that can be applied to all knowledge. The scientific uncertainty frame can thus be measured by answering the following questions with yes or no:

- *Does the article suggest that further research is needed?* (κ = 0.85)
- *Does the article refer to the nature of scientific research as being continuously in motion and never settled?* (κ = 0.66)

3.3.3 Sources

In this research, a source was coded as a source when it was quoted or paraphrased. The sources were coded on article level, which means that the coder had to select all sources that were quoted or

paraphrased in one article. For the relevance of this research, a distinction was made between scientists and theologians, even though theologians can be seen as scientists. If no source was quoted or paraphrased, the journalist was coded as the source of the article. The reliability for the sources is expressed in Cohen's Kappa (κ).

Table 3.4. Description of sources and their reliability.

Source	Description	κ
Scientists	Statements of persons or institutes with a scientific background, like professors, researchers etc.	0.96
Theologians	Statements of persons or institutes with a theological background.	1
Religious figure	Statements of persons who are not theologians, but fulfill a religious function like pastors etc.	1
Politician	Statements of politicians on all levels of society.	1
Writer	Statements of writers that are not scientists or philosophers.	1
Philosopher	Statements of people who are described as philosophers.	1
Science journals	Statements of scientific journals or magazines like Nature, Science etc.	1
Other media	Statements of media that are not scientific journals or magazines.	0.66
Citizen	Statements of people that do not account for one of the functions mentioned above.	1
Journalist	Statements of journalists who express their own view in, for example, opinion articles.	1

The method section was used to describe the different research methods that were used, the reliability of the coding instruction, and the operationalization of the variables that were analyzed. In the next chapter, the results of the quantitative content analyses will be discussed.

4. Results

In this chapter, the results are presented according to the different areas that were analyzed in this research: the selection of news, the frames used, and the sources quoted. The results within each section are described according to the three hypotheses and thirteen research question as stated in the theoretical framework. Automatic and manual analyses were used and combined to answer the main research question: *in what way and to what extent is the theory of evolution covered in Dutch news media?*

4.1 Selection of news

The first way in which news coverage of evolutionary was studied, was by analyzing the selection of news. This included the amount of news about evolutionary theories between 2008 and 2020, the news topics associated with evolutionary theories and the events triggering news coverage about evolutionary theories.

4.1.1 Amount of news

The selection of news was first analyzed based on the amount of news about evolutionary theories. This analysis gives an insight into the development of the amount of news about evolutionary theories, which increased in the last half of the twentieth century (Hijmans et al., 2003; Losos et al., 2014). The first hypothesis, however, was the expectation that the total amount of news coverage about evolutionary theories had decreased between 2008 and 2020, due to the financial problem's media outlets face. This could possibly lead to a decrease in scientific news, since scientific news is regarded as expendable and a luxury compared to other types of news, which are cheaper to produce and more popular with audiences (Schäfer, 2017). Table 4.1 shows that the number of articles about evolutionary theories has nearly stayed the same in the years 2008 and 2020. 2008 is used as the first year in this calculation because the year 2007 only consists of the months June till December, which makes 2008 the first full year in the dataset and thus a better year in this comparison. A t-test confirmed that the number of articles about evolutionary theories has not changed significantly between 2008 (M = 0.11, SD = 0.05) and 2020 (M = 0.12, SD = 0.03), $t(22) = -0.69$, $P = .496$. Therefore, hypothesis 1 is not accepted, the amount of news about evolutionary theories has not decreased between 2008 and 2020.

Table 4.1 Relative number of articles about evolutionary theories in 2008 and 2020

Year	Number of articles about evolution	Total amount of articles	Percentage of total amount
2008	169	159420	0.11%
2020	248	209073	0.12%

This finding is not in accordance with the literature about the amount of scientific news and its expected decrease in the last decades. This can be explained partly by the fact that news about evolutionary science sometimes balances on the border of scientific news and other types of news.

That the amount of news about evolutionary theories has roughly stayed the same can also be seen in Figure 4.1, which shows the total number of articles about evolutionary theories per medium type and is used the answer the question to what extent the amount of news differs between popular, quality, and religious newspapers. A series of t-tests was conducted to test the differences between media types. Two big differences were clearly noticed. First, quality newspapers (M = 0.23, SD = 0.05) write significantly more about evolutionary theories than popular newspapers (M = 0.02, SD = 0.01) on average per year, $t(34) = 20.63$, $p < .001$. This is in line with the long-term trend that popular newspapers generally report less about scientific subjects than quality newspapers (Bauer et al., 1995; Boukes & Vliegenthart, 2017). Second, religious newspapers (M = 0.17, SD = 0.07) also write significantly more about evolutionary theories than popular newspapers (M = 0.02, SD = 0.01) on average per year, $t(34) = 14.05$, $P < .001$. Quality newspapers (M = 0.23, SD = 0.05) write significantly more about evolutionary theories than religious newspapers (M = 0.17, SD = 0.07) on average per year, t(34) = -6.58, $P = 0.012$.

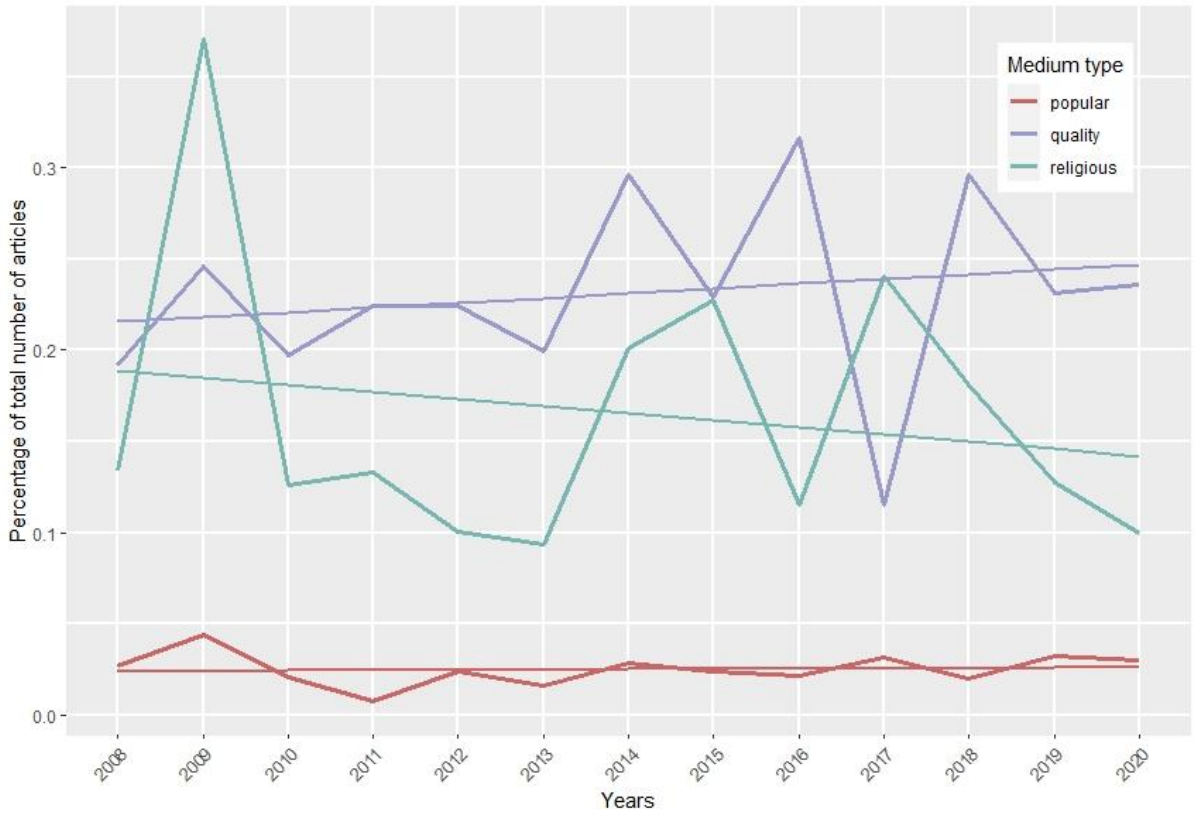

Figure 4.1. Relative number of articles about evolutionary theories between 2008 and 2020 in popular, quality, and religious newspapers.

The peak moment of news coverage was in the year 2009. This can be explained by the fact that 2009 was the 'Year of Darwin', which was a celebration of the 150th anniversary of Darwin's *On the Origin of Species*, exclaimed by the *International Union of Biological Sciences*. On top of that, the Dutch media company *Evangelische Omroep* used this event to publicly renounce their belief in a literal reading of

the Genesis story in the Bible. This caused extra media attention on top of the attention for the year of Darwin (Dros, 2009).

4.1.3 News topics

The second way in which the selection of news was analyzed, was by looking at the news topics within news coverage about evolutionary theories. As discussed in the theoretical framework, the combination of the different routines and ideologies of newspapers (Shoemaker & Vos, 2009) and the large variety of topics within modern evolutionary science (Losos et al., 2014) can cause differences between medium types. The news topics were analyzed with a technique called *structural topic modeling*, which is an automatic content analysis focused on discovering patterns in which words frequently appear together in news articles (Jacobi et al., 2015) (see paragraph 3.2). This technique was used to answer the research questions about news topics in news coverage of evolutionary theories.

The first two research questions concerning news topics asked what topics Dutch newspapers associate with evolutionary theories, and if Dutch newspapers show bias towards certain topics within evolutionary theories. Figure 4.2 shows the frequency of news topics in the total dataset and is used to answer these research questions.

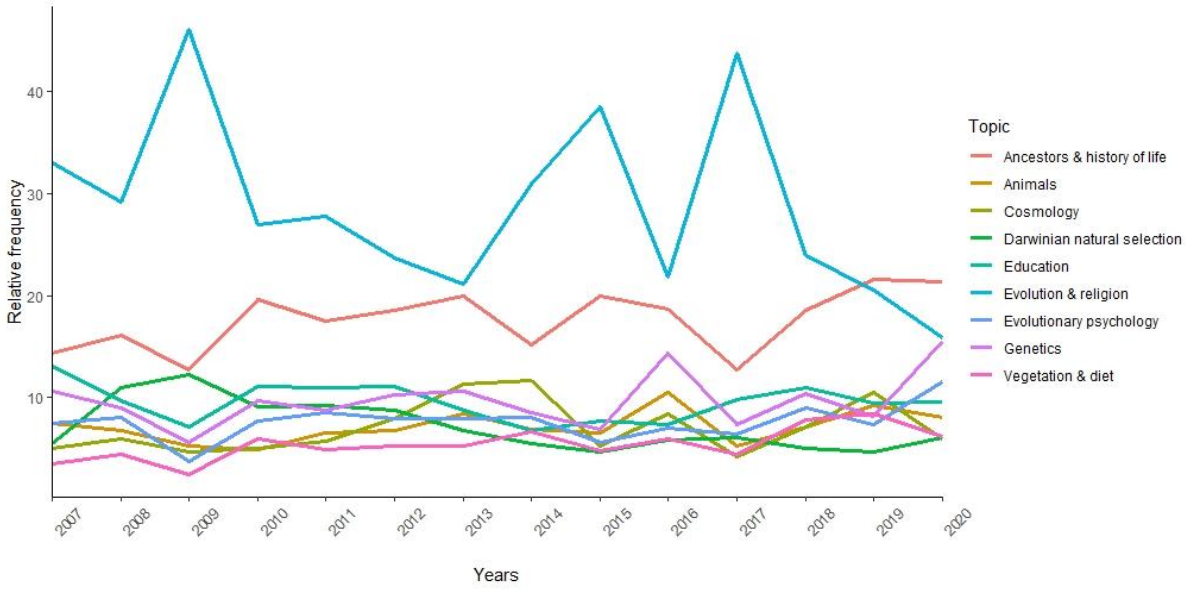

Figure 4.2 Relative frequency of news topics in the total dataset of news coverage about evolutionary theories.

Figure 4.2 shows that there is a variety of topics present in news coverage about evolutionary theories, but that two topics appear the most: *Evolution & religion* and *Ancestors & history of life*. The most frequent topic was *Evolution & religion*. This topic is characterized by words such as creation, faith, science, Genesis, God etc. An explanation for the relative high frequency of this topic can be that the topic is surrounded by a lot of controversies, which are known to be commonly used news values (Nisbet, 2009; Semetko & Valkenburg, 2000). The second most frequent topic was *Ancestor & history*

of life. This topic is characterized by words such as fossil, find, neanderthal, bone, ancestor. This topic consists of new discoveries about the origin of life and is therefore an exciting part of evolutionary science. One of the causes for science to make the news is that it is seen as exciting (Bauer et al., 2006), which explains the relatively high frequency of this topic compared to other topics.

The third research question considering news topics asked to what extent the presence of news topics differed between medium types. Figure 4.3 shows the frequency of news topics per medium type and is used to give an insight into these differences. The most important ones are discussed below.

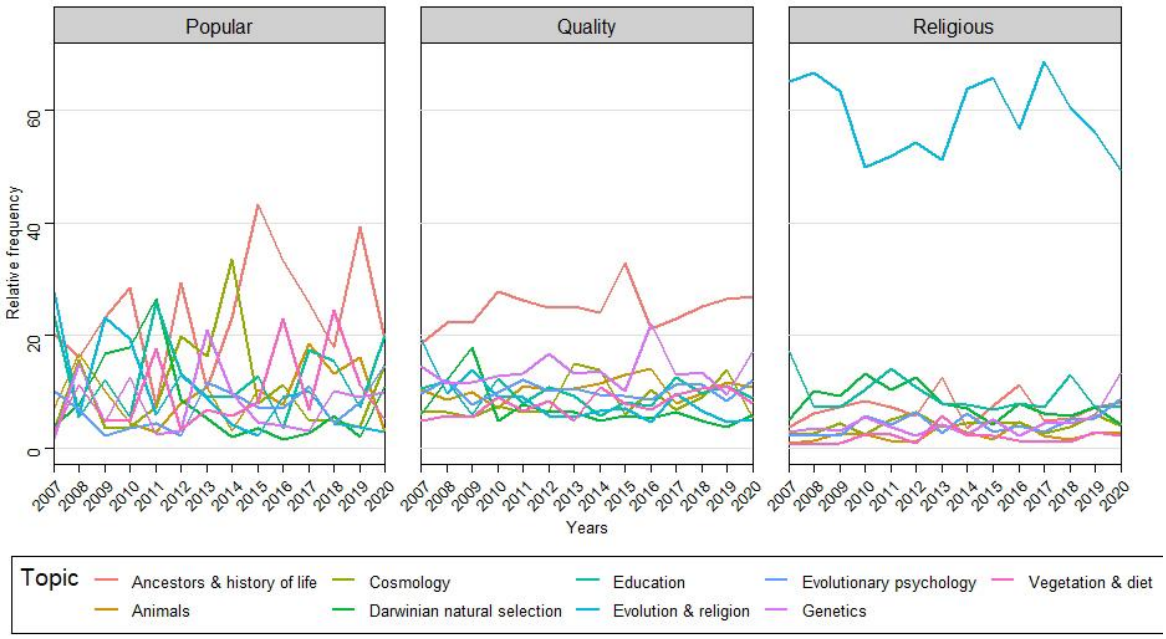

Figure 4.3. Relative frequency of news topics in news coverage about evolutionary theories per medium type.

The finding that stands out is the frequency of the news topic *Evolution & religion* in religious newspapers. The graph shows that the topic is consequently more present in news about evolutionary theories in religious newspapers than in other newspapers. The t-test, as shown in Table 4.2, confirms the significant difference between religious and popular, and religious and quality newspapers concerning this topic. An explanation for the relative high frequency of this topic in religious newspapers can be that the controversies about evolutionary theories are especially relevant for Christian readers. Controversies in the context of evolution and religion consist of, for example, discussions between experts about how to read the Bible or to what extent Christians should accept and adopt theories of evolution.

Besides the topic Evolution & religion, a series of t-tests were used on all news topics to measure the differences between medium types, which are displayed in table 4.2 and 4.3.

Table 4.2. Average frequency of news topics in popular, quality, and religious newspapers.

Topic	Popular-quality			Popular-religious			Quality-religious		
	t	*df*	*P*	*t*	*df*	*P*	*t*	*df*	*P*
Ancestors	-0.04	3240	.997	-4.96	3240	<.001***	-4.92	3240	<.001***
Animals	0.79	3240	.418	-3.94	3240	<.001***	-4.73	3240	<.001***
Cosmology	-1.74	3240	.158	-3.78	3240	<.001***	-2.05	3240	<.001***
Darwinian	-0.24	3240	.934	2.04	3240	.013*	2.28	3240	<.001***
Education	0.00	3240	.134	0.00	3240	.999	0.00	3240	.001**
Religion	-0.27	3240	.854	14.71	3240	<.001***	14.98	3240	<.001***
Psychology	1.83	3240	.047*	-1.29	3240	.246	-3.13	3240	<.001***
Genetics	3.87	3240	<.001***	-1.35	3240	.390	-5.22	3240	<.001***
Vegetation	-0.14	3240	.976	-3.74	3240	<.001***	-3.60	3240	<.001***

*Significance levels: * p<0.5 ** p<.01 *** p<.001*

Table 4.3 Average means and standard deviations of news topics per medium type.

Topic	Popular (N = 251)		Quality (N = 1850)		Religious (N = 1141)	
	M	SD	M	SD	M	SD
Ancestors	7.77	17.72	7.72	17.49	2.81	10.44
Animals	5.79	9.90	6.58	11.08	1.85	5.35
Cosmology	7.12	18.24	5.38	15.58	3.32	9.96
Darwinian	4.53	10.76	4.29	9.51	6.57	11.41
Education	7.34	11.91	5.84	11.27	7.35	12.29
Religion	2.00	7.20	1.72	6.32	16.70	20.23
Psychology	4.51	11.21	6.35	12.71	3.22	9.48
Genetics	4.76	12.28	8.62	17.33	3.40	10.12
Vegetation	5.11	12.11	4.97	17.33	1.37	5.48

Between religious and quality newspapers, all news topics were significantly different, which in this case means that most topics, except *Evolution & religion*, *Darwinian natural selection,* and *Education,* were more present in quality newspapers. These three topics were subsequently more worthy to write about for religious newspapers. The relatively high presence of the topic *Darwinian natural selection* in religious newspapers can be explained by looking at the peak of news coverage in religious newspapers as shown in Figure 4.1. 2009 was the national year of Darwin and explains the amount of news about Darwin and his theory of natural selection.

The differences in frequency of topics between popular and quality newspapers were minor. What stands out from Figure 4.3 is that the frequency of topics in popular newspapers had a lot more peaks than in quality newspapers, while the frequency in quality newspapers was more consistent. This can be explained by the fact that quality newspapers have specific sections dedicated to scientific news, while popular newspapers are more reliant on events for writing about evolutionary theories. This can

also be seen in the analysis of the events triggering news coverage, which is discussed in paragraph 4.1.3.

To summarize, compared to the areas as provided by *The Princeton Guide to Evolution* (Losos et al., 2014, see paragraph 2.1) Dutch newspapers cover roughly all areas within modern evolutionary science. They do not cover it in all details, but it is questionable whether that could be expected from newspapers, since news about science is not a high priority. Quality and popular newspapers give a relatively balanced view of evolutionary theories considering these areas, with both a small bias towards the topic *Ancestors & history of life*. Religious newspapers show, as discussed above, a bias towards certain topics but also cover roughly all areas of modern evolutionary science.

4.1.3 News events

The third and last way in which the selection of news was researched, was by analyzing the events triggering the news coverage about evolutionary theories. News events were analyzed to give additional insight into the news values newspapers use in producing and selecting news coverage about evolutionary theories. Two research questions were formulated regarding the news events. The first was the question which events trigger news coverage of evolutionary theories. The second question was to what extent the events differed between the different kinds of newspapers. While the amount of news and the news topics were automatically analyzed, the news events were analyzed by coding 450 articles manually. Figure 4.4 shows the events that triggered the analyzed news coverage per medium type.

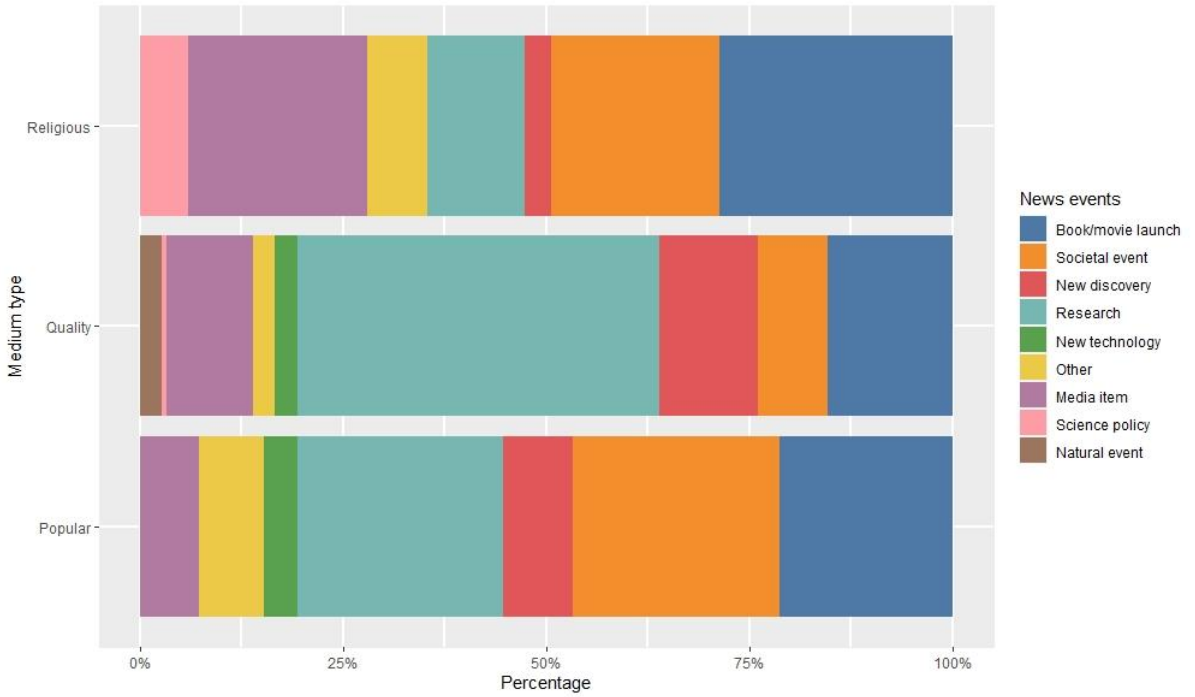

Figure 4.4. Relative distribution of events triggering news coverage per medium type.

A chi-square test of independence was used to analyze differences between medium types regarding the news events triggering the news coverage about evolutionary theories. Table 4.3 shows multiple significant differences, which are discussed below.

Table 4.4. Differences in events triggering news coverage between medium types.

	N	*df*	χ^2	*P*
Research	450	2	40.747	<.001***
Book/movie launch	450	2	7.853	.020*
Science policy	450	2	14.932	<.001***
Societal event	450	2	14.883	<.001***
New discovery	450	2	7.790	.020*
Natural event	450	2	8.072	.018*
New technology	450	2	5.723	.057
Media item	450	2	15.346	<.001***
Other	450	2	4.492	.106

*Significance levels: * p<0.5 ** p<.01 *** p<.001*

The biggest contrast that can be seen between medium types is scientific research as a basis for news coverage. Quality newspapers base their news about evolutionary theories for 45% on scientific research, like publications of science journals. For popular newspapers this is only 25%, and for religious newspapers even less with 12%. Religious newspapers base their news about evolutionary theories more on media items than popular and quality newspapers, with 22% versus 7% and 11%. The use of media items for news coverage in religious newspapers can be explained by the fact that articles about evolutionary theories in religious newspapers are often based on earlier articles from the same newspapers, which suggests that news about evolutionary theories in religious newspapers consists more of an internal discussion compared to other newspapers. Popular and religious newspapers rely more on societal events, like for example museum exhibitions and events about Charles Darwin, than quality newspapers for their news about evolutionary theories.

4.1.4 Summary of selection of news

A few things can be concluded so far. In contrast to expectations based on earlier research, news coverage about evolutionary theories did not decrease over time. Rather, the results show a steady line in the amount of news about evolutionary theories.

In line with earlier research on the amount of scientific news and the differences between newspapers, the analysis on the amount of news compared between newspapers shows that religious and quality newspapers report significantly more about evolutionary theories than popular newspapers.

The analysis of the news topics shows a bias in religious newspapers towards the topic *Evolution & religion*, whereas quality and popular newspapers report mostly about *Ancestors & the history of life*. The analysis of the news events shows that religious newspapers base their news about evolutionary theories the least on scientific research, and quality newspapers the most. The combination of the analyses shows that the use of evolutionary theories in education, which was a relevant starting point for this research, is not significantly more newsworthy than other topics in all newspapers.

As previously discussed in the theoretical framework, news events can give insight into the news values newspaper use in writing about evolutionary theories. From this perspective, a couple of things can be concluded. Quality newspapers value scientific research, like publications of science journals, the most. Popular newspapers value societal events the most. Religious newspapers value book or movie launches the most, but also media items which are often based on earlier news articles of the same newspaper.

Now that the selection of news in relation to evolutionary theories has been discussed, the second part of the results will discuss how evolutionary theories are framed in Dutch newspapers.

4.2 Frames

The second way in which news coverage of evolutionary theories was analyzed, was through measuring different frames. These included the conflict frame and four different types of uncertainty frames. The frames were analyzed by coding 450 articles manually. The results are presented with statistical tests, graphs and a correlation matrix between frames and news topics. The frames are discussed separately, which means that the part about the conflict frame is relatively short compared to the uncertainty frames, because there are four uncertainty frames to be discussed. Examples of articles that contain the coded frames are integrated in the results to illustrate the different frames.

4.2.1 Conflict frame

The first frame that was analyzed is the conflict frame. The conflict frame in this research was specifically focused on conflict between individuals, groups or worldviews when spoken about evolutionary theories. Because of little research on conflict framing and news coverage of evolutionary theories, a research question was formulated that asked to what extent the conflict frame is present and to what extent this presence differs between medium types. An example of how the conflict frame is expressed is how the Christian newspaper *Reformatorisch Dagblad* speaks about the issue of creation and evolution: "We have a problem. The Bible speaks about creation, science about evolution. The Bible covers all life, just as science. How should we proceed?[1]" (Reformatorisch Dagblad, 2014). The way in which this newspaper uses conflict in news coverage about evolutionary theories is in accordance with the finding of Setälä & Väliverronen (2010), who performed a small-scale content analysis on news coverage about evolutionary theories in Finland and found a reflected conflict between secular and religious worldviews. Figure 4.5 shows the relative presence of the conflict frame per medium type in this study.

[1] Original Dutch translation: We hebben een probleem. De Bijbel spreekt over schepping, de wetenschap over evolutie. De Bijbel gaat over het hele leven, de wetenschap ook. Hoe nu verder.

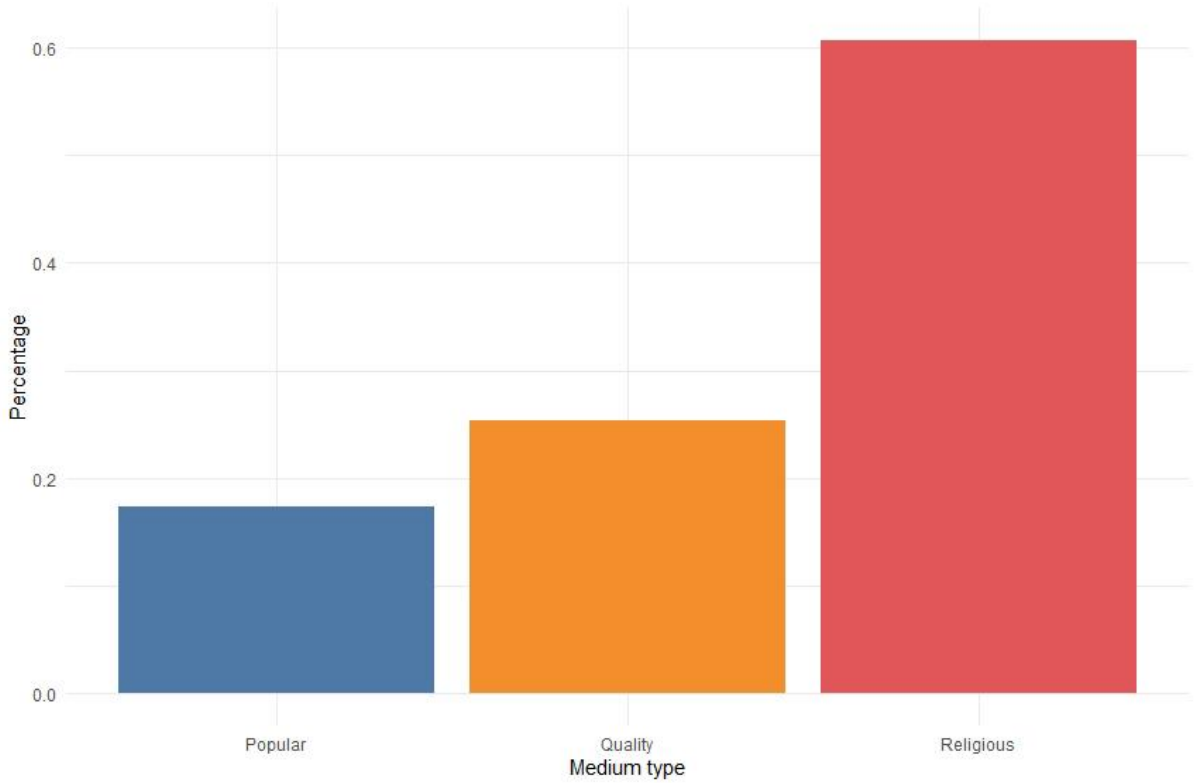

Figure 4.5. Relative presence of conflict frame per medium type.

The figure shows that there is a big difference between religious newspapers and other medium types in the relative presence of the conflict frame. A t-test confirms that the conflict frame was significantly more present in religious newspapers (M = 60.7, SD = 20.02) than in popular newspapers (M = 17.3, SD = 17.94), $t(2) = 43.33$, $p < .001$. The presence of the conflict frame in religious newspapers (M = 60.7, SD = 20.02) was also significantly higher than in quality newspapers (M = 25.3, SD = 17.31), $t(2) = 35.33$, $p < .001$. There was no significant difference between quality newspapers (M = 25.3, SD = 17.31) and popular newspapers (M = 17.3, SD = 17.94), $t(2) = 8.00$, $p = .374$.

These results were used to test the hypothesis about the conflict frame, which stated that the conflict frame is significantly more present in religious newspapers than in other medium types. This was expected because the controversies surrounding evolutionary theories were more likely relevant to readers of religious newspapers, as previously discussed in the theoretical framework. The t-tests confirmed that the conflict frame was significantly more present in religious newspapers. Therefore, hypothesis 2 is accepted.

The results of the analysis of the conflict frame show that conflict is present in more than half of the news coverage of religious newspapers about evolutionary theories. It is interesting to analyze if and to what extent the conflict frame correlates with the news topics that were discussed earlier. This is discussed after the presentation of the uncertainty frames, in paragraph 4.2.6.

4.2.2 Scientific uncertainty frames

Beside the conflict frame, four types of uncertainty frames were analyzed. These frames were analyzed to study the extent to which uncertainty was communicated in news coverage about evolutionary theories, derived from the idea that uncertainty is inherent to science and that science news coverage thus must portray these uncertainties to be accurate. The average presence of the frames is discussed, as well as the presence of the frames separately.

4.2.3 Total presence of uncertainty frames

First, the total average of the frames per medium type is discussed. The average presence of uncertainty frames answers the question to what extent uncertainty frames are present in news coverage of evolutionary theories. Figure 4.6 shows the relative average presence of the uncertainty frames per medium type.

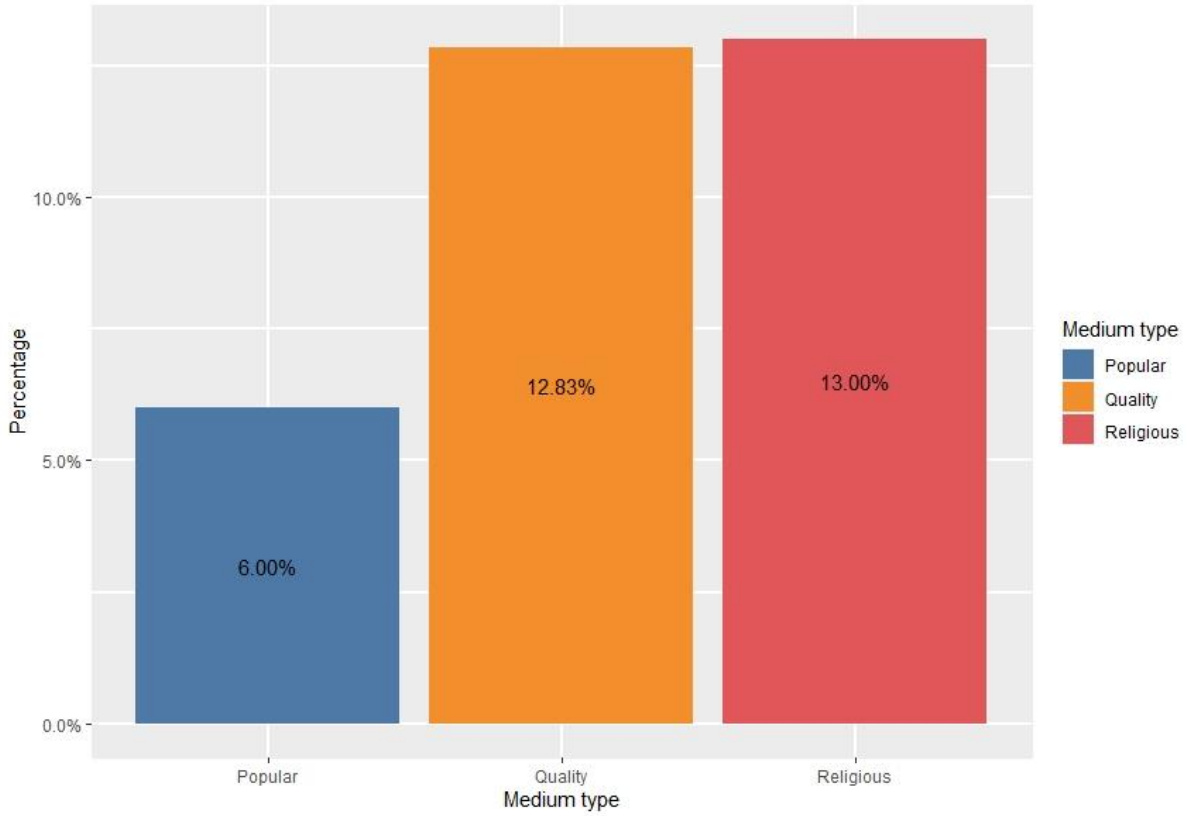

Figure 4.6. Relative average presence of uncertainty frames per medium type.

The figure shows that uncertainty frames on average were only for a small part present in news articles about evolutionary theories. This accounts for all medium types. While there were some small differences between medium types, a series of t-tests showed that these differences were not significant. The average presence of uncertainty frames in religious newspapers (M = 13.00, SD = 11.78) was a bit higher than in popular newspapers (M = 6.00, SD = 3.31), $t(2) = 7.00$, $p = .487$. The average presence of uncertainty frames in quality newspapers (M = 12.83, SD = 7.59) was also a bit higher than in popular newspapers (M = 6.00, SD = 3.31), $t(2) = 6.83$, $p = .503$. The difference between religious newspapers

(M = 13.00, SD = 11.78) and quality newspapers (M = 12.83, SD = 7.59) was minor, $t(2) = 0.17$, $p = .999$.

Uncertainty frames were thus only for a small part present in news coverage of evolutionary theories in Dutch newspapers, which confirms earlier research about uncertainty in news coverage of science that suggests a lack of uncertainty communication (Stocking, 1999; Jensen, 2008; Gustafson & Rice, 2019; Gustafson & Rice, 2020). According to these researchers, uncertainty is often excluded in communication of science to the public because it can be hard to understand or because the production of news is vastly different than the production of scientific research.

4.2.4 Presence of uncertainty frames over time

While uncertainty frames were only for a small part present in news coverage of evolutionary theories, it is interesting to see whether the presence has changed over the years. This data was used to test hypothesis 3, which stated that the expression of uncertainty has decreased between 2008 and 2020. The hypothesis is based on the description of Schäfer (2017) about how changing media structures are influencing science news coverage, and in this case specifically the expression of uncertainty. The decrease in specialized science journalists and dedicated science sections creates the expectation that uncertainty is expressed to a lesser extent.

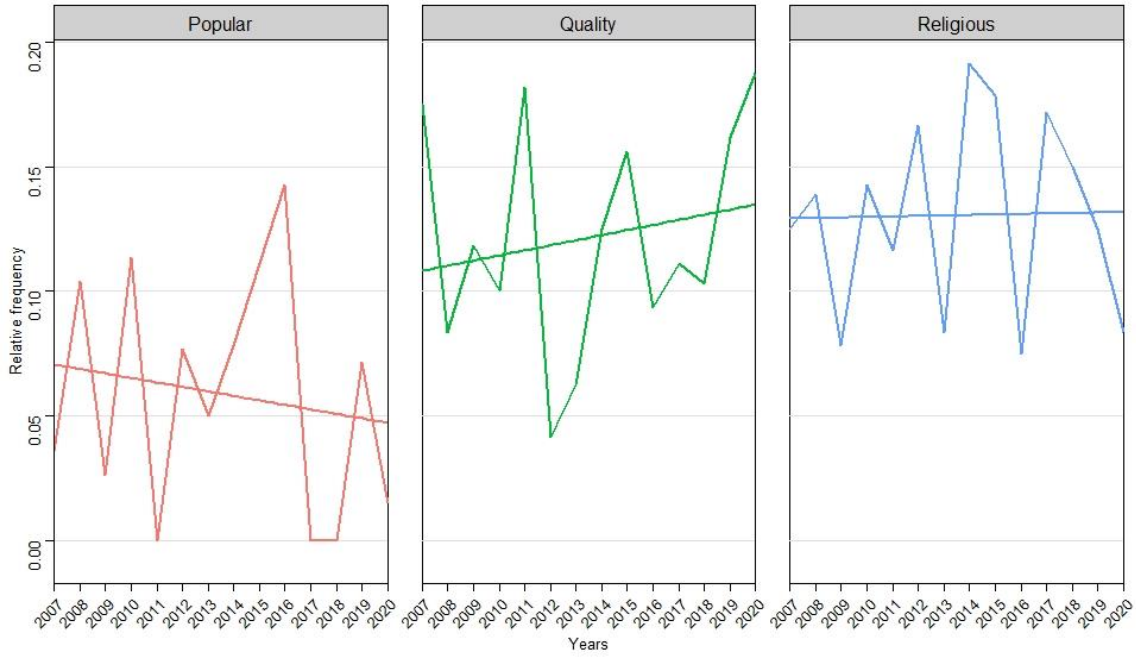

Figure 4.7. Relative presence of uncertainty frames between 2007 and 2020 per mediumtype.

Figure 4.7 shows the relative presence of uncertainty frames between 2007 and 2020 per medium type. In popular newspapers, a t-test confirmed that there was no significant difference in the presence of uncertainty frames between the years 2008 ($M = 7.23$, $SD = 13.68$) and 2020 ($M = 1.25$, $SD = 3.95$), $t(16) = 1.34$, $p = .199$. In quality newspapers, a t-test also confirmed that there was no significant

difference in the presence of uncertainty frames between the years 2008 (M = 4.17, SD = 8.33) and 2020 (M = 17.19, SD = 17.60), $t(10) = -1.38$, $p = .198$. In religious newspapers, a t-test also confirmed that there was no significant difference in the presence of uncertainty frames between the years 2008 (M = 9.38, SD = 11.97) and 2020 (M = 10.00, SD = 22.36), $t(7) = -0.05$, $p = .962$. Therefore, hypothesis 2 is not accepted: there is no visible decrease in the expression of uncertainty in news coverage of evolutionary theories.

4.2.5 Presence of uncertainty frames separately

While there were no significant differences between the average presence of the uncertainty frames between different medium types and over the years, there were differences between the four kinds of uncertainty frames and their presence in the newspapers that were analyzed. The four types of uncertainty frames are based on the different causes of uncertainty in science, as described by Gustafson (2018): the deficient, technical, consensus and scientific uncertainty frame.

Because newspapers use different routines and journalists tend to cover the obvious implications for their readers (Stocking, 1999), the question was asked to what extent the different uncertainty frames are present and to what extent this differs between medium types. Figure 4.8 shows the relative presence of the different types of uncertainty frames per medium type.

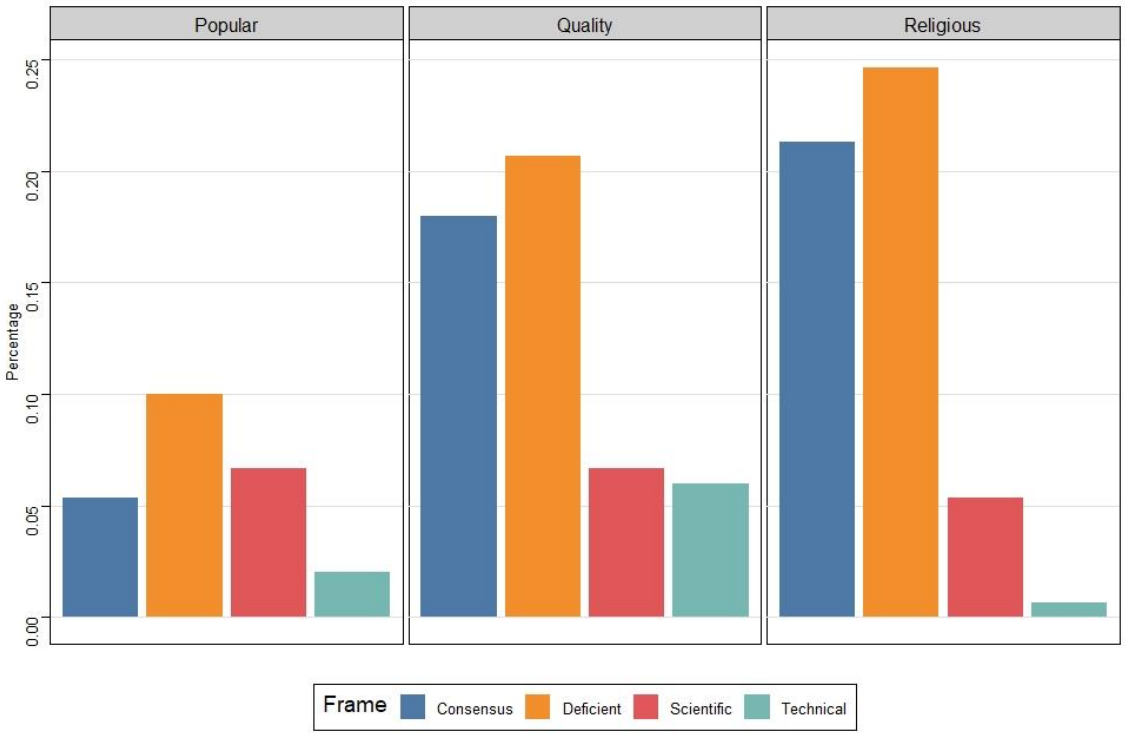

Figure 4.8. Relative presence of four uncertainty frames per medium type.

The first frame that showed a relatively large difference was the consensus uncertainty frame. The consensus uncertainty frame describes disagreement between experts or across evidence as a cause of uncertainty. An example of this frame can be derived from the earlier mentioned article of *NRC*

Handelsblad (2020) about archeological research, which mentions critical reactions coming out of the scientific community and controversial archeological cases that are being bombarded with criticism. A t-test showed that there was a significant difference between popular newspapers (M = 5.33, SD = 6.54) and quality newspapers (M = 18.00, SD = 13.90), $t(2) = 12.67$, $p = .005$. There was also a significant difference between popular newspapers (M = 5.33, SD = 6.54) and religious newspapers (M = 21.30, SD = 9.79), $t(2) = 16.00$, $p < .001$. The difference between quality newspapers (M = 18.00, SD = 13.90) and religious newspapers (M = 21.30, SD = 9.79) was not significant, $t(2) = 3.33$, $p = .69$. That the consensus uncertainty frame was most present in religious newspapers can be explained by the relative high presence of the conflict frame as discussed above in paragraph 4.2.1. Disagreement between experts or across evidence can overlap with conflict between worldviews or people.

The second uncertainty frame is the deficient uncertainty frame, which describes uncertainty caused by a lack of study/evidence or the fundamental unknowable nature of a phenomenon. An example of this is how a researcher is paraphrased in the newspaper *NRC Handelsblad* (2020), as being disappointed by the lack of cutting marks or other modifications on bones that were dug up in archeological research, which caused uncertainty about how earlier humans lived. The deficient uncertainty frame followed roughly the same pattern as the consensus uncertainty frame in its presence. A t-test showed no significant difference between popular newspapers (M = 10.00, SD = 10.42) and quality newspapers (M = 20.67, SD = 9.93), $t(2) = 10.67$, $p = .06$. There was a significant difference between popular newspapers (M = 10.00, SD = 10.42) and religious newspapers (M = 24.67, SD = 11.92), $t(2) = 14.67$, $p = .006$. The difference between quality newspapers (M = 20.67, SD = 9.93) and religious newspapers (M = 24.67, SD = 11.92) was not significant, $t(2) = 4.00$, $p = .69$. That the presence of the deficient uncertainty frame was the highest in religious newspapers could point towards ideological motives to write about flaws in evolutionary theories, but the fact that religious and quality newspapers did not differ significantly at this point makes this too ambiguous to determine in this study.

A third frame, the technical uncertainty frame, describes uncertainty caused by quantifiable limits of scientific research. An example of this is how a team of researchers is paraphrased in an article of *De Volkskrant* (2019), in which they speak about a reconstruction of ancestor-DNA and the estimation that their reconstructions are correct 5 out of 6 times. The technical uncertainty frame was most present in quality newspapers, but the differences were not significant. A t-test showed that there was no significant difference between popular newspapers (M = 2.00, SD = 3.38) and quality newspapers (M = 6.39, SD = 6.39), $t(2) = 4.00$, $p = .09$. There was also no significant difference between popular newspapers (M = 2.00, SD = 3.38) and religious newspapers (M = 0.67, SD = 1.87), $t(2) = -1.33$, $p = .77$. The difference between quality newspapers (M = 6.39, SD = 6.39) and religious newspapers (M = 0.67, SD = 1.87) was significant, $t(2) = -5.33$, $p = .02$. This frame was the least present of all uncertainty frames and this could be explained by the level of complexity of this frame compared to the other frames.

The fourth and last uncertainty frame is the scientific uncertainty frame, which describes uncertainty caused by the general nature of scientific research. An article of *NRC Handelsblad* (2013) expresses this frame by stating that in scientific research, big questions are always present. The presence of the scientific uncertainty frame was relatively equal in all medium types. A t-test showed that there was no significant difference between popular newspapers (M = 6.67, SD = 6.92) and quality newspapers (M = 6.67, SD = 7.12), $t(2) = 0.07$, $p = .50$. There was also no significant difference between popular newspapers (M = 6.67, SD = 6.92) and religious newspapers (M = 5.33, SD = 6.64), $t(2) = 0.07$, $p = .49$. The difference between quality newspapers (M = 6.67, SD = 7.12) and religious newspapers (M = 5.33, SD = 6.64) was also non-significant, $t(2) = 0.00$, $p = .10$.

4.2.6 Correlation between frames and news topics

Having analyzed the different frames, the last two research questions concerning the framing of evolutionary theories were whether and to what extent the frames correlated with the news topics discussed in paragraph 4.1.3. Analyzing correlations between frames and news topics gives more insight into what areas of evolutionary theories conflict and uncertainty are expressed. The correlation matrix in Figure 4.9 displays the correlations between the frames and news topics. The correlations are expressed in Pearson's correlation coefficient.

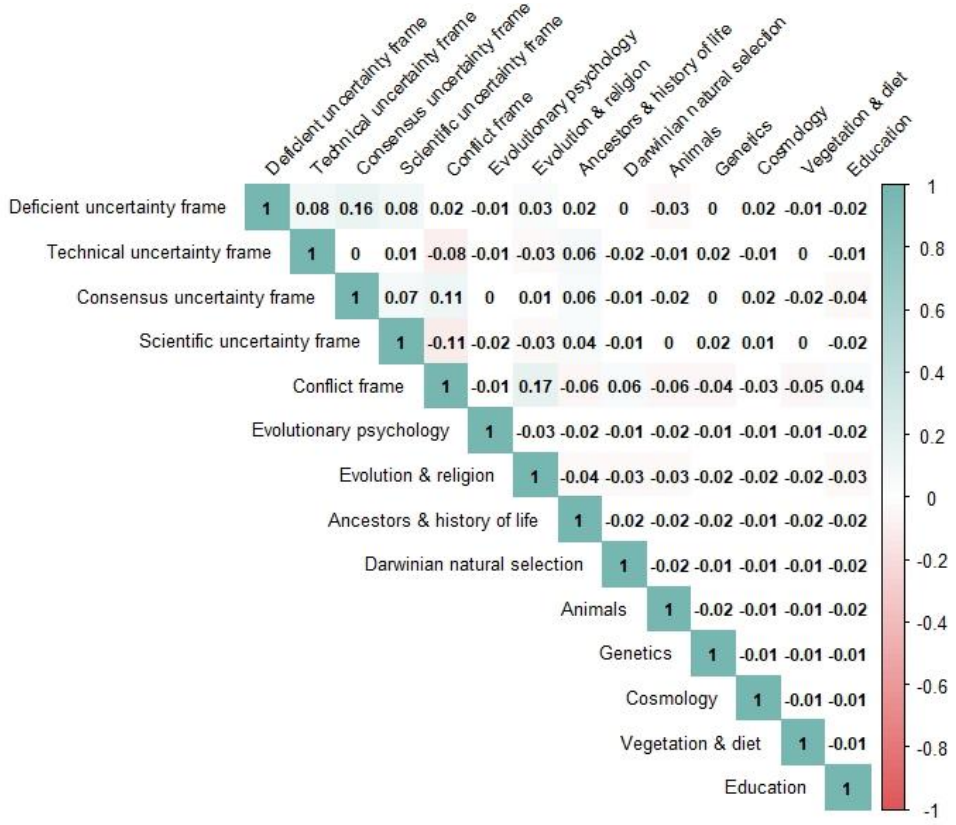

Figure 4.9. Correlation between frames and news topics.

First, the correlation between the conflict frame and the news topics was analyzed. The biggest and only significant correlation was visible between the conflict frame and the news topic *Evolution & religion*, $r(540) = 0.17$, $p < .001$. This correlation can be explained by the framing of the relationship between evolutionary theories and perspectives on the origin and development of life. Religious newspapers tend to frame these relationships as conflicts between different areas of research, like science and theology, or as conflicts between worldviews. That the correlation is especially applicable to religious newspapers can be supported by earlier findings of this results section. Namely, that the topic *Evolution & religion* was highly present in news coverage of religious newspapers, and that the conflict frame was also highly present in news coverage of religious newspapers.

Second, the correlations between the uncertainty frames and the news topics were analyzed. Figure 4.9 shows that there are no noteworthy correlations between news topics and uncertainty frames. This can partly be explained by the small presence of the uncertainty frames, and the small presence of most news topics.

Besides the correlations between the frames and the news topics, two significant correlations were found between different frames. The first significant was between two uncertainty frames, the consensus uncertainty and the deficient uncertainty frame, $r(540) = 0.16$, $p < .001$. This correlation can be explained by the fact that when scientific research is deficient of certain evidence of studies, there is more room for discussion and debate among researchers and experts. Another explanation is that, as previously discussed in the theoretical framework, deficient uncertainty resembles consensus uncertainty in the sense that they both point towards the state of scientific research as being incomplete (Gustafson, 2018). The second significant correlation was between the conflict frame and the consensus uncertainty frame, $r(540) = 0.17$, $p < .001$. This can be explained by the nature of both frames. The conflict frame is focused on disagreement between people or worldviews, whereas the consensus uncertainty frame is also focused on disagreement but specifically on disagreement between scientific experts or across scientific evidence.

4.2.7 Summary of frames

The conflict frame was found to be significantly more present in religious newspapers than in other newspapers. The correlation between topic *Evolution & religion* and the conflict frame supports the suggestion that religious newspapers frame this topic as a conflict between people or worldviews.

The scientific uncertainty frames were to a small extent present in all newspapers. This has, contrary to the expectations, not changed over time. The deficient and consensus uncertainty frames were most commonly present compared to the scientific and the technical uncertainty frame. The frames that were most commonly present in news coverage of evolutionary theories, were also the frames that were most associated with negative outcomes (Gustafson, 2018).

4.3 Sources

In addition to the first part about the selection of news, and the second part about the frames used, the third part about the sources that are quoted give a more complete overview of how evolutionary theories are covered by Dutch newspapers. Sources influence the framing of news because news media often adopt the frames that their sources use (Vasterman & Ruigrok, 2013). This is especially relevant for news about scientific subjects because journalists who write about science are more source-dependent than other journalists (Bauer & Gregory, 2007). Figure 4.10 gives an overview of the sources that were quoted per medium type, the differences expressed in chi-square tests can be found in Table 4.5. This data was used to answer research questions 11 and 12, and to test hypothesis 3.

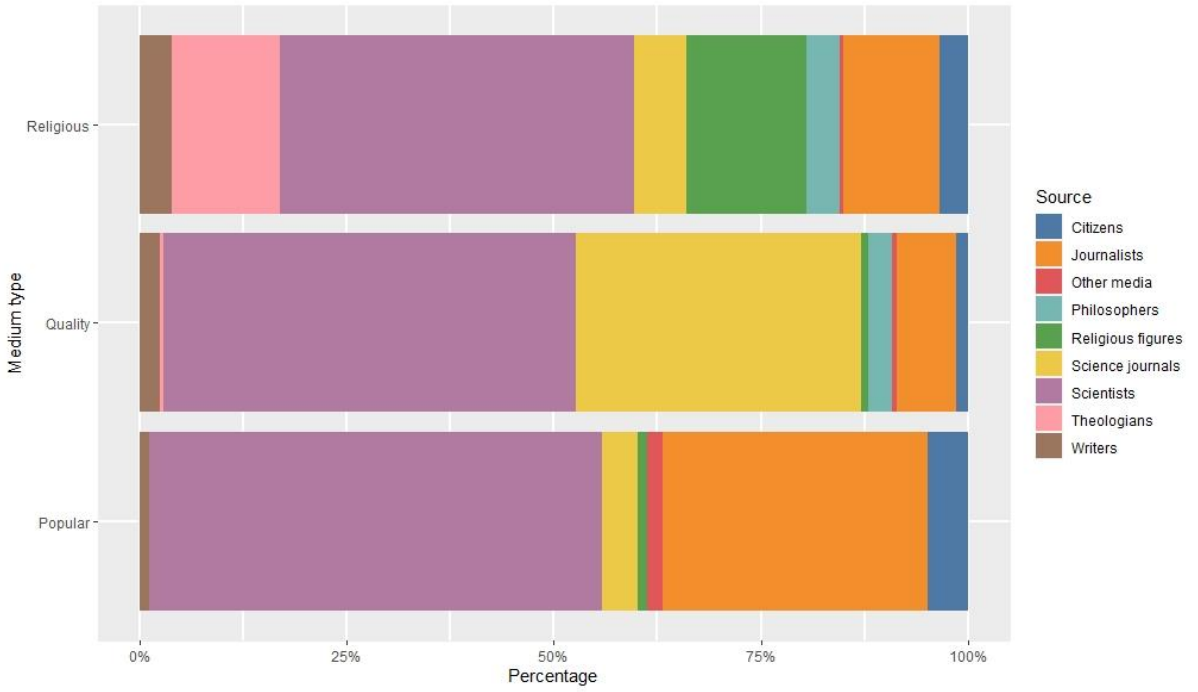

Figure 4.10. Distribution of sources per medium type.

The two research questions concerning sources, namely what sources are used by newspaper in news coverage about evolutionary theories and to what extent the use of sources differs between medium types, are answered first. First, the use of scientists as a source was roughly the same in all medium types. This is no surprise since evolutionary theories are scientific subjects. Scientists were roughly half of the sources that were quoted in all newspapers. In the other half of the sources, there were some significant differences between medium types. Quality newspapers relied for 34% on science journals for their news about evolutionary theories. This is in line with the literature on science news coverage which suggests that journalists tend to rely on a small number of scientific journals as primary sources (Schäfer, 2017). This means that quality newspapers relied for 84% on scientists and science journals. This differs significantly with popular newspapers (59%) and religious newspapers (49%).

This data was used to partly accept hypothesis 4, which stated that quality newspapers make significantly more use of scientific sources than other medium types. There was no significant

difference in the use of scientists, but science journals were significantly more used by quality newspapers. The use of science journals and scientists in quality newspapers can be explained by the public whom they write for, which consists of people with higher educational levels than for example the audience of popular newspapers (Bakker & Scholten, 2013).

Table 4.5. Differences in quotation of sources between medium types.

	N	*df*	χ^2	*P*
Scientists	450	2	4.567	.102
Theologians	450	2	53.546	< .001***
Religious figures	450	2	49.887	< .001***
Politicians	450	2	5.379	.068
Writers	450	2	3.724	.155
Philosophers	450	2	7.667	.022*
Science journals	450	2	105.78	< .001***
Citizens	450	2	2.431	.297
Journalists	450	2	30.772	< .001***

*Significance levels: * p<0.5 ** p<.01 *** p<.001*

Popular newspapers relied more heavily on journalists as sources (32%) than quality newspapers (7%) and religious newspapers (12%). This means that either news about evolutionary theories appeared in opinion articles, or that no sources were mentioned at all. The use of science journals (4%) was significantly lower than in quality newspapers (34%). It could be that these journals were sometimes used as sources, but that they were not mentioned in the news articles.

The use of sources in religious newspapers showed the largest variety of all medium types. The biggest differences were found in the use of theologians (13%) and religious figures (15%) as sources for news about evolutionary theories. This is noteworthy because news media often adopt the frames that their sources use. Since theologians and religious figures can have different perspectives on evolutionary theories than, for example, science journals and scientists, which are prominently present in quality newspapers, it could be possible that readers of different kind of newspapers receive different perspectives on evolutionary theories. The large variety of sources, which is useful and important for news media to fulfill their role in democracy (Tiffen et al., 2013), is lacking in these findings.

4.3.2 Summary of sources

The analysis of the sources showed that all newspapers relied for the biggest part on scientists for their quotes and paraphrases in news articles about evolutionary theories. Quality newspapers relied more heavily on science journals than other types of newspapers. Popular newspapers relied more heavily on journalists than other types of newspapers. Religious newspapers quoted and paraphrased more theologians and religious figures. The results thus showed that when analyzing the use of sources, the different types of newspapers adopt to a certain extent different perspective in news coverage about evolutionary theories.

The results section was used to answer the research questions and test the hypotheses that were formulated in the theoretical framework. In the following chapter, these results will be discussed and interpreted in light of the main research question.

5. Conclusion

The goal of this research was to give an overview of how and to what extent theories of evolution are covered by Dutch newspapers. Three aspects of news coverage were analyzed: the selection of news, the frames used, and the sources quoted. In this section, the results are interpreted and discussed from the perspective of the concepts and theories described in the theoretical framework. This discussion is used to answer the main research question: *in what way and to what extent are evolutionary theories covered in Dutch newspapers?* The limitations of this research are also discussed, as well as suggestions for further research.

5.1 Selection of news

The selection of news was analyzed in three different ways: the amount of news about evolutionary theories, the news topics associated with evolutionary theories, and the events triggering news coverage about evolutionary theories.

The results showed that the amount of news about evolutionary theories on average stayed nearly the same throughout the years. This finding contrasts the expectation that news coverage about evolutionary theories would have decreased due to financial challenges of news outlets. The results also showed that quality and religious newspapers write significantly more about evolutionary theories than popular newspapers, which means that readers of quality and religious newspapers get to read more about evolutionary theories than readers of popular newspapers throughout the whole period that was analyzed.

While quality and religious newspapers reported almost as much on evolutionary theories over the years, the content of the news differed on two levels. This was first analyzed by looking at the news topics within news coverage about evolutionary theories. The results showed that religious newspapers associate evolutionary theories mainly with the topic *Evolution & religion.* This contrasted the topic that was most present in quality as well as popular newspapers, which was *Ancestors & history of life*. These findings suggest that there is a certain amount of pillarization present in news coverage about evolutionary theories in Dutch newspapers. This means that when readers of religious newspapers read about evolutionary theories, it is for a bigger part brought in relationship with religious topics than in popular and quality newspaper. The frequency of topics in popular and quality newspapers contrasted with religious newspapers and were more evenly distributed.

The events triggering news coverage about evolutionary theories showed, to a lesser degree, also differences between newspapers. Quality newspapers based their news about evolutionary theories for the biggest part on scientific research, which suggests that they still have specific sections dedicated to science news. Religious and popular newspapers based their news about evolutionary theories more on book launches and societal events.

5.2 Frames

The framing of news about evolutionary theories was analyzed in two ways: by measuring presence of conflict and uncertainty. This resulted in a total of five frames: one conflict frame and four types of uncertainty frames.

The results showed that religious newspapers write significantly more from a conflict perspective in news coverage about evolutionary theories than popular and quality newspapers. This can partly be explained by the fact that conflict is, in general, an important news value. The correlation between the conflict frame and the news topic Evolution & religion can explain why the presence of the conflict frame was so high in religious newspapers compared to popular and quality newspapers, because this topic is inherently perceived as a conflict.

The uncertainty frames were, on average, only to a small extent present in news coverage about evolutionary theories. This finding is in accordance with previous research about the communication of uncertainty in Dutch science news (Hijmans et al., 2003). The results also showed that the amount of uncertainty expressed in news coverage about evolutionary theories did not change significantly over time. This was contrary to the expectation that communication of uncertainty would have decreased over time. This can, however, possibly be explained by the fact that uncertainty overall was only present to a small extent, which also minimizes the change that the amount of uncertainty will decrease because there was almost none to begin with.

As discussed in the theoretical framework, consensus and deficient uncertainty were mostly associated with undesirable effects such as distrust in science. These are also the kinds of uncertainty that are expressed the most in news coverage about evolutionary theories.

5.3 Sources

The third and last aspect of news coverage that was analyzed, was the use of sources. The sources were analyzed because sources can influence framing of news, which happens because journalists often adopt the frames that their sources use.

The results showed that in all newspapers, scientists were the most used sources. This was to be expected since evolutionary theories are scientific topics. Scientists covered roughly half of the sources that were used for all newspapers.

For the other sources, differences were found between the medium types. Theologians and religious figures were quoted in religious newspapers, but barely in quality and popular newspapers. Quality newspapers quoted science journals the most, whereas popular newspapers quoted journalists the most. This could mean that journalists of popular newspapers use less sources and depend upon their own knowledge, or that the sources were not mentioned in news coverage.

5.4 Main research question

The results of the selection of news, the frames used, and the sources quoted can be used to answer the main research question of this research: *in what way and to what extent are evolutionary theories covered in Dutch newspapers?*

In asking this question, a couple of general characteristics and developments in the media landscape were taken into consideration. The first was the amount of news about scientific topics, in this case evolutionary theories. The results showed that evolutionary theories are only a small part of the total news between 2007 and 2020, which was to be expected. The amount of news had, contrary to earlier research about science news, not decreased. This means that the newsworthiness of evolutionary theories has not changed over the years. The expectation that religious and quality newspapers write more about evolutionary theories than popular newspapers, based on the long-term trend that popular newspapers report less about scientific topics than other types of newspapers, was confirmed.

The research question can also be answered from a science communication perspective. As discussed in the theoretical framework, it is important for the public to receive balanced and accurate news about scientific topics like evolutionary theories. Balanced and accurate news coverage concerning evolutionary theories in this research meant a balanced distribution of news topics, communication of uncertainties and a balanced use of sources. Differences between newspapers are a possible threat to balanced and accurate news and were therefore taken into consideration.

The first part, balanced news coverage, is found in some aspects of news about evolutionary theories in Dutch newspapers. The news topics show that roughly all areas within modern evolutionary science, as described by *The Princeton Guide to Evolution* (Losos et al., 2014), are covered. The frequency of the news topics is, however, less balanced in religious newspapers than in popular and quality newspapers. This research confirms the assumption that news coverage about evolutionary theories is falsely balanced towards conflict partly (Zimmer, 2014), because this was only found in religious newspapers. The difference in attention for news topics suggests that newspapers have different news values in writing about evolutionary theories, which can possibly be traced back to underlying ideologies and preferences of readers.

The second part, accurate news coverage, means from a science communication perspective that uncertainties about science are communicated through news. The results showed that uncertainty is to a small extent communicated in news coverage about evolutionary theories. This indicates that journalists do shy away from portraying the uncertainties in science news, as expected from earlier research. Neglecting a variety of sources can also be a sign of inaccurate science communication, because multiple perspectives are needed to give an accurate portrayal of scientific theories. This was, to a certain extent, applicable to Dutch newspapers in writing about evolutionary theories because of the differences that were found.

Overall, it can be concluded that an accurate and balanced portrayal of evolutionary theories is found in some aspects of news production in Dutch newspapers, but that news coverage of evolutionary

theories is also inaccurate and out of balance in multiple ways. The differences between newspapers in the selection of news, the frames used, and the sources quoted, suggest that the Dutch media landscape is to a certain extent pillarized in news coverage about evolutionary theories. This research can be used as a starting point or reference to gain more knowledge and understanding about the specific ways in which this happens.

5.5 Limitations

When discussing the implications of this research, a couple limitations should be taken into consideration.

The research method of this thesis was a quantitative content analysis. While this method is useful for analyzing large amounts of data, it is less useful for finding latent meanings. Hereby must also be taken into consideration that, while the search string to find articles about evolutionary theories was formulated based on scientific terms, the dataset still consisted partly of articles that were only to a small extent dedicated to science news about evolutionary theories. It is inevitable that this influences the analyses to a certain extent.

Because the number of topics in the structural topic model needed to be determined by the researcher arbitrarily, the outcome of the structural topic model is affected in the sense that other topics would have possibly arisen if a different number of topics was chosen.

Another limitation was the use of only newspapers in analyzing communication of evolutionary theories. While newspapers are an important distributor of information about evolutionary theories, online-only media and science blogs are also relevant to analyze.

The use of five frames was limiting because much more frames could be analyzed in researching news coverage about evolutionary theories. A specific limitation of analyzing uncertainty frames was the lack of a clear standard that determines what is a good amount of uncertainty in news coverage. This research does also not give insights into the question why certain frames are present or not present.

In the analysis of the sources, a limitation was the general division of groups like scientists and science journals. Within those groups a large variety of science-areas and journals exists, which were not taken into consideration in the manual analysis.

5.6 Suggestions for further research

The limitations point out the aspects that ask for more research. Further research could include qualitative research besides quantitative research. Qualitative research on the role identities of science journalists who write about evolutionary theories could give more insight into the routines and news values, and into possible differences between newspapers. The changing media landscape affects the journalistic profession in many ways and because of that, also the news that is produced. Besides the three ways in which news media build agenda, as described before, journalists themselves are affected by the material context in which news is produced. Research on the coverage of scientific research in

Dutch Newspapers by Hijmans et al. (2003), which includes interviews with science journalists, suggests that complex scientific information is avoided and that it lacks a critical approach. These are interesting findings in the light of studying science news coverage. This study dates, however, back to 2003 and since then a lot has changed in the media landscape, as discussed previously. It is thus relatively unknown how the selection of news, the framing of news, and the use of sources are dealt with by Dutch journalists who write about scientific topics such as evolutionary theories. Another interesting aspect of interviewing journalists who write about evolutionary theories is the different role identities they can have. Fahy & Nisbet (2011) have made a list of different roles regarding science journalism in an online media landscape. An example of this is the advocate role, which means that the journalist reports and writes while being driven by a specific worldview or on behalf of a specific issue or idea.

In the theoretical framework, a distinction was made between general and issue-specific frames. Further research on news coverage of evolutionary theories could focus on issue-specific frames, to gain more insight into how specific issues are framed. The correlation between the conflict frame and the topic *Evolution & religion* gives, for example, the suggestion that evolutionary theories are framed in terms of conflict in religious newspapers, but this research gives no insight into the kind of conflicts that are expressed. This could for example include conflict concerning evolutionary theories and education, which was mentioned in the introduction. More research could be done on how education is framed concerning evolutionary theories. Qualitative research could also be added to find more latent meanings.

In addition to qualitative research, more medium types could be included in research about communication of evolutionary theories through news media. This study only included newspapers, but media like online-only news outlets and blogs are becoming important places for people to find information about scientific topics as well. A more complete overview could be given this way.

As mentioned in the limitations section, it is ambiguous to determine the right amount of uncertainty communication in science news. More research is needed to set standards for the communication of uncertainty, in order to make better reflections on science news coverage.

Further research could also be conducted on what kind of frames the different sources use to gain more insight into possible differences between newspapers. If quality newspapers, for example, rely for a big part on science journals, it would be interesting to analyze how science journals frame evolutionary theories. The same accounts for theologians and religious figures in religious newspapers. This could gain more insight into how differences in ideologies are reflected in news coverage.

The goal of this research was to contribute to knowledge about the communication of evolutionary theories in Dutch newspapers and the communication of science in general. The findings of this research can be used as a basis for further research in other countries and other time periods.

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Appendix

A. Search string for dataset about evolutionary theories

Theme	Search string
Evolutionary theories (precision)	("charles darwin" AND evolutie) OR abiogenese OR (evolutie AND wetenschap) OR (C14 AND dat*) OR (koolstofdatering AND evolutie) OR (koolstofdatering AND dna) OR radiometrisch OR ouderdomsbepaling OR (neanderthaler AND evolutie) OR (neanderthaler AND dna) OR ("homo erectus" AND evolutie) OR ("homo sapiens" AND evolutie) OR (primaten AND evolutie) OR australopithecus OR ardipithecus OR kenyanthropus OR paranthropus OR (“survival of the fittest” AND evolutie) OR uniformitarianis* OR actualiteitsprincipe OR ("charles lyell" AND evolutie) OR ("richard dawkins" AND evolutie) OR (paleonto* AND evolutie) OR (biologi* AND evolutie) OR ("jagers en verzamelaars" AND evolutie) OR (steentijd AND evolutie) OR paleolithicum OR ("origin of species" AND evolutie) OR ("13,7 miljard jaar" AND oerknal) OR ("13,8 miljard jaar" AND oerknal) OR ("big bang" AND evolutie) OR ("stephen jay gould" AND evolutie) OR "adam of aap" OR (lucy AND evolutie) OR (dinosau* AND evolutie) OR (“100 miljoen jaar” AND evolutie) OR (“miljoenen jaren” AND evolutie) OR (“miljoen jaar” AND evolutie) OR (lamarck* AND evolutie) OR symbiogenese OR (fylogen* AND darwin) OR (fylogen* AND evolutie) OR biogeografi* OR prokaryot* OR eukaryot* OR ("natuurlijke selectie" AND evolutie) OR ("ecologische niche" AND evolutie) OR (biotoop AND evolutie) OR fenotyp* OR (genotyp* AND evolutie) OR "genetische drift" OR (genetica AND evolutie) OR (biochemi* AND evolutie) OR (inteelt AND evolutie) OR (genoom AND evolutie) OR (epigeneti* AND evolutie) OR (dna AND evolutie) OR (soortvorming AND evolutie) OR ("seksuele selectie" AND evolutie) OR "gene flow" OR "adaptieve radiatie" OR (uitsterv* AND voorouder* AND evolutie) OR (speltheorie AND evolutie) OR (gedragsecologi* AND evolutie) OR (eusocial* AND evolutie) OR (cogniti* AND evolutie) OR (biologi* AND evolutie) OR (mensachtig* AND evolutie) OR (aapachtig* AND evolutie)
Evolutionary theories (recall)	NOT (("charles darwin" AND evolutie) OR abiogenese OR (evolutie AND wetenschap) OR (C14 AND dat*) OR (koolstofdatering AND evolutie) OR (koolstofdatering AND dna) OR radiometrisch OR ouderdomsbepaling OR (neanderthaler AND evolutie) OR (neanderthaler AND dna) OR ("homo erectus" AND evolutie) OR ("homo sapiens" AND evolutie) OR (primaten AND evolutie) OR australopithecus OR ardipithecus OR kenyanthropus OR paranthropus OR (“survival of the fittest” AND evolutie) OR uniformitarianis* OR actualiteitsprincipe OR ("charles lyell" AND evolutie) OR ("richard dawkins" AND evolutie) OR (paleonto* AND evolutie) OR (biologi* AND evolutie) OR ("jagers en verzamelaars" AND evolutie) OR (steentijd AND evolutie) OR paleolithicum OR ("origin of species" AND evolutie) OR ("13,7 miljard jaar" AND oerknal) OR ("13,8 miljard jaar" AND oerknal) OR ("big bang" AND evolutie) OR ("stephen jay gould" AND evolutie) OR "adam of aap" OR (lucy AND evolutie) OR (dinosau* AND evolutie) OR (“100 miljoen jaar” AND evolutie) OR (“miljoenen jaren” AND evolutie) OR (“miljoen jaar” AND evolutie) OR (lamarck* AND evolutie) OR symbiogenese OR (fylogen* AND darwin) OR (fylogen* AND evolutie) OR biogeografi* OR prokaryot* OR eukaryot* OR ("natuurlijke selectie" AND evolutie) OR ("ecologische niche" AND evolutie) OR (biotoop AND evolutie) OR fenotyp* OR (genotyp* AND evolutie) OR "genetische drift" OR (genetica AND evolutie) OR (biochemi* AND evolutie) OR (inteelt AND evolutie) OR (genoom AND evolutie) OR (epigeneti* AND evolutie) OR (dna AND evolutie) OR (soortvorming AND evolutie) OR ("seksuele selectie" AND evolutie) OR "gene flow" OR "adaptieve radiatie" OR (uitsterv* AND voorouder* AND evolutie) OR (speltheorie AND evolutie) OR (gedragsecologi* AND evolutie) OR (eusocial* AND evolutie) OR (cogniti* AND evolutie) OR

	(biologi* AND evolutie) OR (mensachtig* AND evolutie) OR (aapachtig* AND evolutie))

B. Precision and recall for dataset about evolutionary theories

Sample		**Relevant**		
		Yes	**No**	**Total**
Found	**Yes**	43	7	50
	No	3	47	50

Percentages		**Relevant**		
		Yes	**No**	**Total**
Found	**Yes**	43 / 50 = 0.86	7 / 50 = 0.14	100%
	No	3 / 50 = 0.06	47 / 50 = 0.94	100%

Whole population		**Relevant**		
		Yes	**No**	**Total**
Found	**Yes**	0.86 x 3242 = 2788.12	0.14 x 3242 = 453.88	3242
	No	0.06 x 6178 = 370.68	0.94 x 6178 = 59242.56	6178

Precision = true positive / (true positive + false positive) = 43 / (43+7) = 0.86.

Recall = true positive / (true positive + false negatives) = 2788.12 / (2788.12 + 370.68) = 0.88.

C. Codebook manual analysis

Codebook

In this thesis, the news coverage of evolution is researched in three ways: the event that triggered the news coverage, the frames used and the sources quoted. These areas of research are all coded manually. Despite the selection that has been made to find articles about evolution, it is possible for irrelevant articles to occur in the dataset. It is important that only relevant articles are coded, which means articles that are written by a journalist and are containing information about evolution. This means that at last one paragraph has to be dedicated to a topic about evolution. In the appendix of this codebook the coders can find a table that gives a topical overview of what falls within 'evolution', which is also used in searching for relevant articles. Irrelevant articles are:

- Articles where evolution or terms related with evolution are only mentioned sideways, but are not specifically about evolution. Examples are the use of the word evolution like 'the evolution of a company' or the phrase 'survival of the fittest' that is not used to describe the mechanism of natural selection, but is used in for example economical terms.
- Advertisements, puzzles, sent-in letters, tv-guides, etcetera.
- Double articles.

To determine which event caused the news coverage, the coder fills in the appropriate abbreviation. Every question about whether a frame is used in an article can be answered with yes (=1) or no (=0). The question about which sources are used can be answered by choosing from predefined answer categories.

News events

Every article is coded as having one event that caused the news coverage. It is possible that multiple events can be derived from an article, when this is the case the coder asks himself which event is most prominently discussed in the article. When this is to ambiguous to determine, the coder looks in a chronological way at the article and asks himself what the first event is of all the events that are mentioned. The following events can be chosen:

Launch of books/movies/games/etc.	Discussion of books/movies/games/etc. about evolution
Science policies	Events concerning policy making or the implementation of science in society: e.g., the implementation of evolutionary theories in education
Societal events	Events in society concerning evolution: e.g., museum exhibitions or the year of Darwin.
New discoveries	Scientific discoveries prior to research: e.g., the discovery of a new fossil.
Research	Ongoing or completed scientific research: e.g., the publication of a research paper.

Natural events/accidents	Uncontrolled events that involve disaster or accidents: e.g., the death of a famous person or a natural disaster.
New technologies	Events concerning the development or discussion of a new technology/
Media items	Items in media concerning evolution: e.g., other news articles about evolution or statements by media celebrities about evolution covered by media.
Other	Events that are not covered by the news events mentioned above.

Frames

The frames are all coded on article-level. This means that multiple frames can be present in one article. Every frame is coded by answering one or more questions with yes (=1) or no (=0).

Conflict frame

The conflict frame emphasizes "conflict between individuals, groups, or institutions as a means of capturing audience interest" (Semetko & Valkenburg, 2000, p. 95). In case of evolution this can mean for example that news coverage emphasizes conflicting beliefs about evolution or controversy it causes in society. To determine whether the conflict frame is present or not, the following questions can be answered with yes (=1) or no (=0):

- *Does the article reflect disagreement between individuals, groups or worldviews when spoken about evolution?*
- *Does the story refer to two sides or to more than two sides of a problem or issue about evolution?*
- *Does the article refer to winners and losers when spoken about evolution?*

Uncertainty frames

Uncertainty is inherent to science and can be divided into four types, as described by Gustafson (2018): deficient, technical, consensus and scientific uncertainty. Table 1 displays an overview of these four types, including exemplar phrases.

Table 1. Four uncertainty types according to Gustafson (2018, p. 14).

	Deficient	*Technical*	*Consensus*	*Scientific*
Exemplar phrasing	"Scientists' knowledge in ____ remains limited because most of the research needed to prove or disprove these ideas has not yet been conducted."	"Scientists' best estimate is that the total increase in ___ could be as low as 6% or as high as 24%."	"Scientists remain divided on ____, with each side receiving strong support from leading scientists and research groups."	"Scientists are always striving to develop a better understanding of ___, so scientists fully expect to adjust their opinions about this issue as future research is conducted."

Defining properties	Uncertainty caused by a lack of study, a lack of available evidence, or fundamental "unknowable" nature of the question.	Uncertainty caused by the known properties of precise, quantified estimates; often derived from evidence or study.	Uncertainty caused by disagreement, controversy, or discrepancy across expert opinion or across evidence.	Uncertainty caused by the perpetual potential for future research to reform or reject the current assumptions or body of evidence.

Deficient uncertainty frame

Deficient uncertainty is uncertainty caused by "a lack of study, a lack of available evidence, or fundamental "unknowable" nature of the question" (Gustafson, 2018, p. 14). To determine whether the deficient uncertainty frame is present or not, the following questions can be answered with yes (=1) or no (=0):

- *Does the article mention a lack of study and/or available evidence when spoken about evolution?*
- *Does the articles mention the unknowable nature of the phenomenon in question?*

Technical uncertainty frame

Technical uncertainty is uncertainty caused by "the known properties of precise, quantified estimates; often derived from evidence or study" (Gustafson, 2018, p. 14). To determine whether the technical uncertainty frame is present or not, the following question can be answered with yes (=1) or no (=0):

- *Does the article mention quantifiable limits of scientific research?*

Consensus uncertainty frame

Consensus uncertainty is uncertainty caused by "disagreement, controversy, or discrepancy across expert opinion or across evidence" (Gustafson, 2018, p. 14). To determine whether the consensus uncertainty frame is present or not, the following question can be answered with yes (=1) or no (=0):

- *Reflects the article disagreement or controversy between experts and/or across evidence?*

Scientific uncertainty frame

Scientific uncertainty is uncertainty caused by "the perpetual potential for future research to reform or reject the current assumptions or body of evidence" (Gustafson, 2018, p. 14). Scientific uncertainty thus refers to the nature of scientific research: that it is in constant progress and never complete. To determine whether the scientific uncertainty frame is present or not, the following questions can be answered with yes (=1) or no (=0):

- *Does the article suggest that further research is needed?*

- *Does the article refer to the nature of scientific research (as being continuously in motion and never settled)?*

Examples uncertainty frames

DUF1: Does the article mention a lack of study and/or available evidence when spoken about evolution?	En Ardelean is zelf ook „nog steeds teleurgesteld door het gebrek aan snijsporen of andere bewerkingen op beenderen”.
DUF2: Does the articles mention the unknowable nature of the phenomenon in question?	'Wat zij suggereren is zeker mogelijk, maar het blijft speculatie.'
TUF1: Does the article mention quantifiable limits of scientific research?	Dat levert een voorspelling op die zo'n vijf van de zes keer goed zit, schat het team.
CUF1: Reflects the article disagreement or controversy between experts and/or across evidence?	De eerste wetenschappelijke reacties zijn behoorlijk kritisch. Met zijn nieuwe datering van de oudste menselijke bewoning van de Amerika’s stapt Ardelean midden in een van de meest omstreden archeologische kwesties van de laatste decennia. Bijna voortdurend duiken in de Amerika’s extreem oude dateringen op die vervolgens bedolven onder kritiek weer afgevoerd worden.
SUF1: Does the article suggest that further research is needed?	Als onderzoekers van sociale cognitie en emoties bij dieren hebben we nog een lange weg te bewandelen voordat we de unieke manieren waarop dieren emoties ervaren in kaart hebben gebracht.
SUF2: Does the article refer to the nature of scientific research as being continuously in motion and never settled?	In de wetenschap klinken op de achtergrond altijd grote vragen.

Sources

Sources are coded on article-level. For every article, the sources that are present can be checked as present or left empty. This means that multiple sources can be counted as present in one article. When a person is quoted, only one function is coded for that person. While most people that are used as a source will fall into only one category, it is possible that multiple categories account for one person. An example is Richard Dawkins, he can be coded as a scientist and a writer. Another example is Bas Haring, he can be coded as a writer, philosopher and scientist. If a person is quoted and accounts for multiple categories, the coder asks himself what the most prominent function of the person is and codes only that function. In the examples mentioned here they both would be coded as scientists. If there is no source mentioned, the journalist can be coded as the source.

A source is seen as a source when someone or something is quoted or paraphrased. When only a name is mentioned, it is not seen as a source. If an article is a column or opinion article, the journalist is always counted as source. Columns can be recognized by the use of "I" in the article or sometimes it is mentioned above or under the article. This means that a journalist is only seen as a source when the article is a column, or when no other sources are quoted or paraphrased.

A science journal is also seen as a source when the name of the science journal is mentioned and a scientist is quoted or paraphrased that said something in that journal. In this case, both the science journal and the scientist are seen as sources. Science journals are often referred to like for example "(Science, 2017)" in news articles.

Some newspapers often refer to earlier articles in the same newspaper. This means that it should not be coded as 'other media'.

When an article consists only for a part of information about evolution, the coder determines the passages about evolution and codes only the sources that say something about evolution.

The following categories can be selected as sources:

Source	Description
Scientists (sc)	Statements of persons or institutes with a scientific background, like professors, researchers etc. This also includes scientific organizations.
Theologians (th)	Statements of persons or institutes with a theological background.
Religious figures (rf)	Statements of persons that are not theologians, but fulfill a religious function like pastors etc.
Politicians (po)	Statements of politicians on all levels of society.
Writers (wr)	Statements of writers that are not scientists or philosophers
Philosophers (ph)	Statements of people who are described as philosophers
Science journals (sj)	Statements of scientific journals or magazines like Nature, Science etc.
Other media (om)	Statements of media that are not scientific journals or magazines.

Citizens (ci)	Statements of people that do not account for one of the functions mentioned above.
Journalists (jo)	Statements of journalists who express their own view, in for example opinion articles.

Codebook appendix

Table 2. Areas within modern evolutionary science according to the Princeton Guide to Evolution (2014)

Area	Keywords
Phylogenetics and the history of life	*Phylogenetic trees, phylogenetic inference, molecular clock dating, historical biogeography, phylogeography, character macroevolution, fossil record, origin of life, prokaryotic grade, eukaryotes, land plants, fungi, origin of animals, arthropods, tetrapod evolution, human evolution*
Natural selection and adaptation	*Selection in populations, kin selection, inclusive fitness, phenotypic selection, evolutionary limits and constraints, modifier genes, reaction norms, life histories, biochemical and physiological adaptations, ecological niche, adaptation to biotic environment*
Evolutionary processes	*Genetic drift, mutation, geographic variation, population structure, migration, recombination and sex, genetic load, inbreeding, selfish genetic elements, evolution of mating systems*
Genes, genomes, and phenotypes	*Molecular evolution, genome evolution, comparative genomics, evolution of sex chromosomes, gene duplication, evolution of new genes, evolution of gene expression, epigenetics, molecular networks, genetics of phenotypic evolution, dissection of complex trait evolution, ancient DNA*
Speciation and macroevolution	*Species and speciation, speciation patterns, range evolution, speciation and natural selection, speciation and sexual selection, gene flow, hybridization, genetics of speciation, adaptive radiation, macroevolutionary rates, macroevolutionary trends, extinction, species selection, evolutionary innovations, evolution of communities*
Evolution of behavior, society, and humans	*Brains, behavior, hormones, game theory, male-male competition, mate choice, evolution of communication, parental care, cooperation and conflict, cooperative breeding, human behavioral ecology, evolutionary psychology, evolution of eusociality, cognition, nonadaptive behavior, aging, menopause*
Evolution and modern society	*Medicine, parasite virulence, antibiotic resistance, microbial forensics, domestication and agriculture, conservation, directed evolution, computing, human language, cultural evolution, notions of human race, future of human evolution, evolution and religion, creationism and intelligent design, evolution and the media*

D. Intercoder reliability

	DUF 1 / 1	DUF 1 / 2	DUF 2 / 1	DUF 2 / 2	TUF / 1	TUF / 2	CUF / 1	CUF / 2	SUF 1 / 1	SUF 1 / 2	SUF 2 / 1	SUF 2 / 2
1	1	1	0	0	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	1	1	0	0	0	0
11	0	0	0	0	0	0	1	1	0	0	0	0
12	0	0	1	1	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	1	0	0	0	0	0	0	0	0	0	0	0
17	1	0	1	1	0	0	1	1	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	1	1	0	0	1	1	0	0	0	0
24	1	1	0	1	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	1	1	0	0	0	0	1	1	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0
28	1	0	0	0	0	0	0	0	1	1	0	0
29	0	0	1	1	0	0	1	1	0	0	0	0
30	0	0	1	1	0	0	1	1	0	0	0	0
31	0	0	0	0	0	0	1	1	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	1	1	0	0	0	0	0	0	0	0
34	1	1	1	1	0	0	0	0	0	0	0	0
35	1	1	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	1	1
38	0	0	0	0	0	0	0	0	0	1	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	0	1	1	1	0	0	0	0	0	0	0	0
41	0	0	1	1	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0

43	0	0	0	0	0	0	0	0	0	0	0	0
44	1	1	0	0	0	0	0	0	1	1	0	1
45	0	0	0	0	0	0	1	1	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	0

	sc/ 1	**sc / 2**	**th / 1**	**th / 2**	**rf / 1**	**rf / 2**	**po / 1**	**po / 2**	**wr / 1**	**wr / 2**
1	1	1	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0	0	0
3	1	1	0	0	0	0	0	0	0	0
4	1	1	0	0	0	0	0	0	0	0
5	1	1	0	0	0	0	0	0	0	0
6	1	1	1	1	0	0	0	0	0	0
7	1	1	0	0	0	0	0	0	0	0
8	1	1	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	1	1	0	0	0	0	0	0	0	0
12	0	0	0	0	1	1	0	0	0	0
13	0	0	0	0	1	1	0	0	0	0
14	1	1	1	1	0	0	0	0	0	0
15	0	1	1	1	0	0	0	0	0	0
16	0	0	1	1	1	1	0	0	0	0
17	1	1	0	0	0	0	0	0	0	0
18	1	1	0	0	0	0	0	0	0	0
19	0	0	1	1	1	1	0	0	0	0
20	0	0	1	1	0	0	0	0	0	0
21	1	1	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	1	1	0	0
23	1	1	0	0	0	0	0	0	0	0
24	1	1	0	0	0	0	0	0	0	0
25	1	1	0	0	0	0	0	0	0	0
26	1	1	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0
28	1	1	0	0	0	0	0	0	0	0
29	1	1	0	0	0	0	0	0	0	0
30	1	1	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0
34	1	1	0	0	0	0	0	0	0	0
35	1	1	0	0	0	0	0	0	0	0
36	1	1	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0

38	1	1	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
41	1	1	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0
43	1	1	0	0	0	0	0	0	0	0
44	1	1	0	0	0	0	0	0	0	0
45	1	1	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0
47	1	1	0	0	0	0	0	0	0	0

	ph / 1	**ph / 2**	**sj / 1**	**sj / 2**	**om / 1**	**om / 2**	**ci / 1**	**ci / 2**	**jo / 1**	**jo / 2**
1	0	0	1	1	0	0	0	0	0	0
2	0	0	1	1	0	0	0	0	0	0
3	0	0	1	1	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	1	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	0	0	0
9	0	0	0	0	1	1	0	0	0	0
10	0	0	1	1	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	0	0	1	1	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
23	0	0	1	1	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	1	1
26	0	0	1	1	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	1	1
28	0	0	0	0	0	0	0	0	0	0
29	0	0	1	1	0	0	0	0	0	0
30	0	0	1	1	0	0	0	0	0	0

31	0	0	0	0	0	0	1	1	0	0
32	0	0	1	1	0	0	0	0	0	0
33	0	0	1	1	0	0	0	0	0	0
34	0	0	1	1	0	0	0	0	0	0
35	0	0	1	1	0	0	0	0	0	0
36	0	0	1	1	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	1	1
38	0	0	0	0	0	0	0	0	0	0
39	0	0	1	1	0	0	0	0	0	0
40	0	0	1	1	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0
42	0	0	1	1	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	1	1
47	0	0	0	0	0	0	0	0	0	0