

# “The truth is out there”: Tracking the rise of pseudoscience

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The rising tide of misinformation is compromising civic discourse, and the pervasiveness of pseudoscience threatens rational decision-making on scientific issues. This paper uses Google Books and Google Trends data to report on several types of astronomical pseudoscience in English language books since 1800 and English language online searches since 2004, with a particular focus on the United States regarding Internet searches. These tools can be unreliable for diagnosing subtle or short-term trends, but they are robust for major trends over long timescales. *Astrology*, *UFO* and related terms have increased in occurrence in books over the past half-century and in web searches since 2004. In the 21st century, there is a striking rise in the occurrence of the word *horoscope* in books and its use in web searches. Mention of *UFO* has increased steadily in books since 1950, and spikes in web searches in the 21st-century track with a national *UFO* reporting database. Three aspects of the “culture” of *UFOs* have appeared much more frequently in books since the 1990s: alien abduction, crop circle, and ancient astronauts. For web searches since 2004, the first two dominate, with the search peaks generally correlated with the release of related movies. By all these measures, pseudoscience is on the rise.

## Introduction

The modern world is awash in misinformation on subjects ranging from politics to science (Scheufele & Krause, 2019). A pernicious form of misinformation is pseudoscience: beliefs, statements, or practices that claim to be factual and whose proponents claim are scientific but which are incompatible with the scientific method. Pseudoscience is a hybrid word from the Greek *pseudo* and the Latin *scientia*, meaning “false knowledge.” For an extensive and rigorous discussion, see Hansson (2021). Over half a century ago, the science writer Martin Gardner was the first to thoroughly debunk pseudoscience (Gardner, 1957). Differentiating pseudoscience from science matters because many legal, medical, and public policy decisions depend on understanding the natural world. The National Science Foundation has used belief in astrology, the quintessential pseudoscience related to astronomy, to demarcate the public’s ability to distinguish science from pseudoscience (National Science Board, 2016). Astrology might be considered a harmless belief system, but in the health arena, misinformation and anti-scientific mindsets are dangerous and can be fatal (Hotez, 2021).

Drawing the boundary between science and pseudoscience is not always

straightforward, and there is no litmus test for distinguishing them (Pigliucci, 2010; Pigliucci & Boudry, 2013). This was referred to as the “demarcation problem” by Karl Popper, who argued that science is marked by statements that can be falsified (Popper, 1959). He used the examples of Einstein’s theory of general relativity, verified by tests of gravitational lensing, and Freud’s theory of human behaviour, which Popper claimed ignored many cases that did not support the theory. However, falsehood as a sole criterion is problematic. String theory is a legitimate scientific framework but is not currently falsifiable (e.g., Villavicencio, 2019). Meanwhile, the hypothesis that intelligent extraterrestrials exist is scientifically plausible, but falsifying it would require inspection of the billions of habitable exoplanets beyond the Solar System (e.g., Cockell, 2014; Perryman, 2018). Philosophers have explored these demarcation and definition issues (e.g., Grodin, 2021; Hansson, 2021).

This paper focuses on pseudoscience topics related to astronomy, particularly astrology and unidentified flying objects, or *UFOs*. A practical criterion for pseudoscience will be used (Shermer, 2011), based more on what scientists do than on what science is. Science is concerned with testing hypotheses and building testable theories. Research that

propagates in a community of scientists and produces useful knowledge has the attributes of science. It has been argued that pseudoscience is becoming more pervasive as part of the rising tide of misinformation and “fake news,” particularly online (e.g., Iammarino & O’Rourke, 2018).

The title of this paper refers to a catchphrase from *The X-Files*, a science fiction television show featuring paranormal phenomena ran from 1993 to 2002 (Lowry, 1995). Most people now seek information from unvetted corners of the Internet rather than reputable sources. This percentage has grown from 9% in 2001 to 57% in 2018 (National Science Board, 2020). This paper focuses on books written in English and web pages searched for in English (with a particular focus on the United States). The era of the Internet is defined as starting around 1990. The most rapid rate of growth in Internet users in North America was from 1995 to 2005, when the share of the population using it rose from 9% to 68%, with a similarly steep rise 5–15 years later in other parts of the world (Roser et al., 2022).

## Surveys of beliefs

At the University of Arizona, we have been surveying undergraduate non-science majors for thirty years, with a sample size of

13,000. Pseudoscience beliefs run high. About 40% think that the positions of the planets affect everyday life, and the same percentage think some people are psychic. A quarter believes in faith healing and a similar fraction trust in lucky numbers. Strikingly, these beliefs correlate poorly with science literacy (Impey *et al.*, 2011). Beliefs and attitudes were measured with 24 Likert-scale items subject to factor analysis (Impey *et al.*, 2012). One factor included pseudoscience items on astrology, psychic powers, and lucky numbers. Another item included the belief that UFOs are alien spacecraft visiting Earth and the belief that aliens visited ancient civilisations, often called the alien astronaut idea. The strength of these beliefs did not change significantly over 27 years (Impey *et al.*, 2017).

A benchmark on pseudoscience beliefs in the United States comes from biennial reports called *Science and Engineering Indicators* (National Science Board, 2020). In surveys conducted by the National Science Foundation (NSF) spanning forty years, the public has been polled about ten topics: extrasensory perception, haunted houses, ghosts and spirits, telepathy, clairvoyance, astrology, channelling, communicating with the dead, witches, and reincarnation. Among these items, only a quarter of Americans believed in none, 32% believed in four, and 22% believed in five or more. These beliefs rose throughout the 1990s (Newport and Strausberg, 2001). It can be argued from data in the NSF surveys that pseudoscience beliefs show a widespread misunderstanding of how science works and how scientists judge evidence (Losh *et al.*, 2003). Similar results were found in surveys by Chapman University of seven paranormal beliefs (Chapman University, 2018). Only a quarter believed in none, a third believed in four or more, and the belief levels in all seven have risen in recent years. The paranormal has become a firmly rooted strain of modern American culture (e.g., Bader *et al.*, 2017).

In what follows, pseudoscience terms appearing in digitised books and used for web searches will be analysed to diagnose public interest in various topics. Word counts in books may only measure the topic's popularity among authors, and web searches may only measure awareness of the topic. Each of the two metrics has its quirks and biases. This exploratory analysis is, therefore, only a starting point, with the

goal of deciding whether this approach has merit for a deeper investigation.

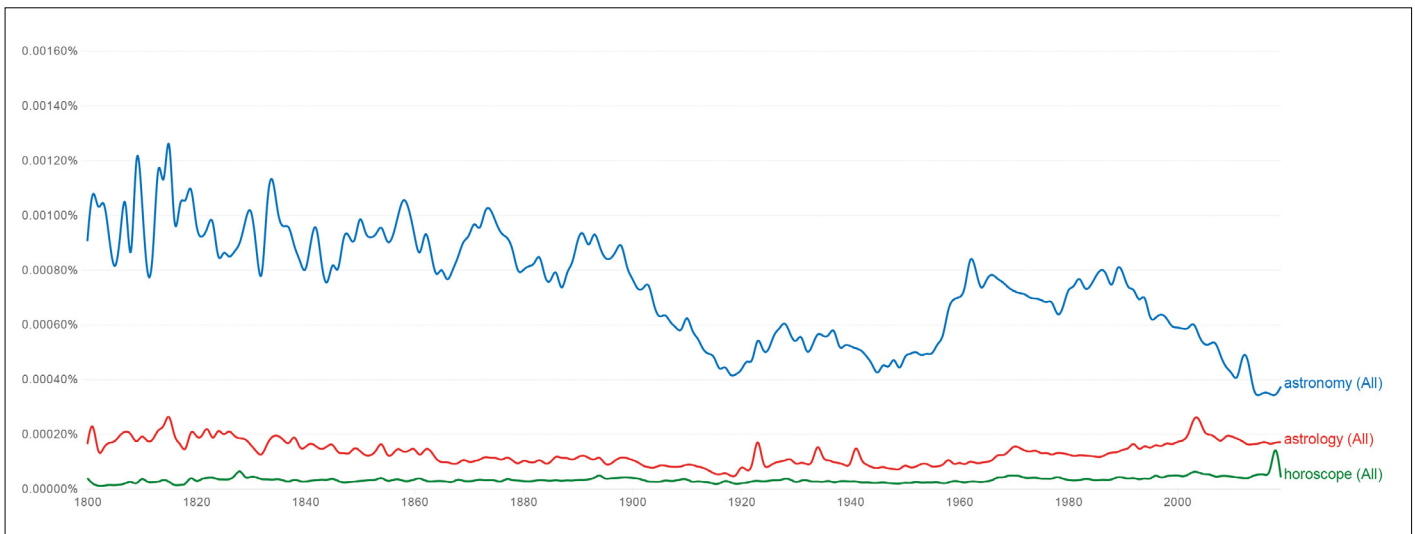
## References in books

Google Books is a project that scans many books, converts the data into text using optical character recognition, and stores it in a digital database. Analysis of this corpus allows cultural trends to be tracked quantitatively (Michel *et al.*, 2011). The database holds over 40 million books going back five hundred years, including nearly two trillion words and a third of the titles ever published. All book editions are included, and all instances of a particular word are counted. Google also provides a tool called the Ngram Viewer, which counts the occurrence of strings of up to five words, including wildcards and searches of parts of speech (Google Books, 2022). Only matches found in 40 or more books are returned, and the data are normalised by the total number of books published each year. This strategy attempts to avoid the problem of sparse data and the increasing publication rate over time. The Ngram viewer was set up in such a way that capitalisation did not affect the results.

It was quickly recognised that Google Books could provide cultural insights by tracking trends in word usage across decades and centuries (Bohannon, 2010). The tool has led to research in diverse fields like economics, medicine, political science, and literature (e.g., Zieba, 2018; Richey & Taylor, 2019; Sheffer *et al.*, 2021). However, there are caveats and significant limitations. The early data are sparse. From 1500 to 1800, there are very few published titles. By 1800, the corpus grows to 100 million words per year, then it rises rapidly, by 1900 to two billion words, and by 2000 to 11 billion words. Additionally, the Google Books corpus is essentially a library. A single, prolific author can have disproportionate weight; any book appears once, regardless of whether it has been read once or a million times. With the growth of science in the 20th century and the fact that many scanned books are from academic libraries, scientific terms have become an increasing part of the database (Pechenick *et al.*, 2015). With care, these effects and biases can be understood, controlled for, and mitigated (Younes & Reips, 2019). This paper is exploratory and should not be considered a definitive analysis.

Astrology is an over 5,000-year-old practice (Tester, 1990) that claims to learn information about human affairs by studying the movements and relative positions of celestial objects (Allum, 2010). The word comes from the Greek *astron* and *logia*, meaning “a telling of the stars,” and the European etymology dates to the late 14th century (*Online Etymology Dictionary*, 2022a). If astrology is the practice, a horoscope is a tool astrologers use, with their interpretation or predictions given as text, found in many newspapers, magazines and, increasingly, online. The fraction of Americans who thought that astrology was at least partly scientific grew from a quarter to a third in the first decade of the 21st century (National Science Board, 2014), with a burst of popularity since then as a loosely held belief that is comforting in stressful times (Beck, 2018). This booming industry is worth over \$2 billion annually (Kaplan & Stenberg, 2020). Nonetheless, astrology is definitively classified as a pseudoscience (Thagard, 1978).

Figure 1 shows the incidence of the words astronomy, astrology, and horoscope in the Google Books database over the past 200 years. The use of the term astronomy relative to the size of the corpus fell for most of the 19th century, hit a low in 1918, peaked in 1964, and then fell by 40% until now. The astronomy trend maps to societal trends in science. Universities grew globally after World War II (Frank & Meyer, 2007). Federal funding for physical science grew rapidly in the 1950s and peaked in 1965 before falling by 50% in constant dollars (American Association for the Advancement of Science, 2022). The use of the term “astrology” in books fell through the 19th century to a low in 1916 but has since risen by a factor of three. Although there is the potential for word confusion between astronomy and astrology, a Pew Survey found that three-quarters of Americans could distinguish the two definitions, and NSF surveys use an item to control for word confusion (Funk & Goo, 2015; National Science Board, 2018). In the 21st century, as the Internet has become ubiquitous, the incidence of *astrology* has not changed substantially, while the incidence of *horoscope* has doubled. The rise of this pseudoscience in books is most clearly seen by comparison with its scientific parent term, *astronomy*. At the beginning of the Internet age in 1995, *astrology* occurred at 27% of the frequency of *astronomy*, similar to its occurrence in the



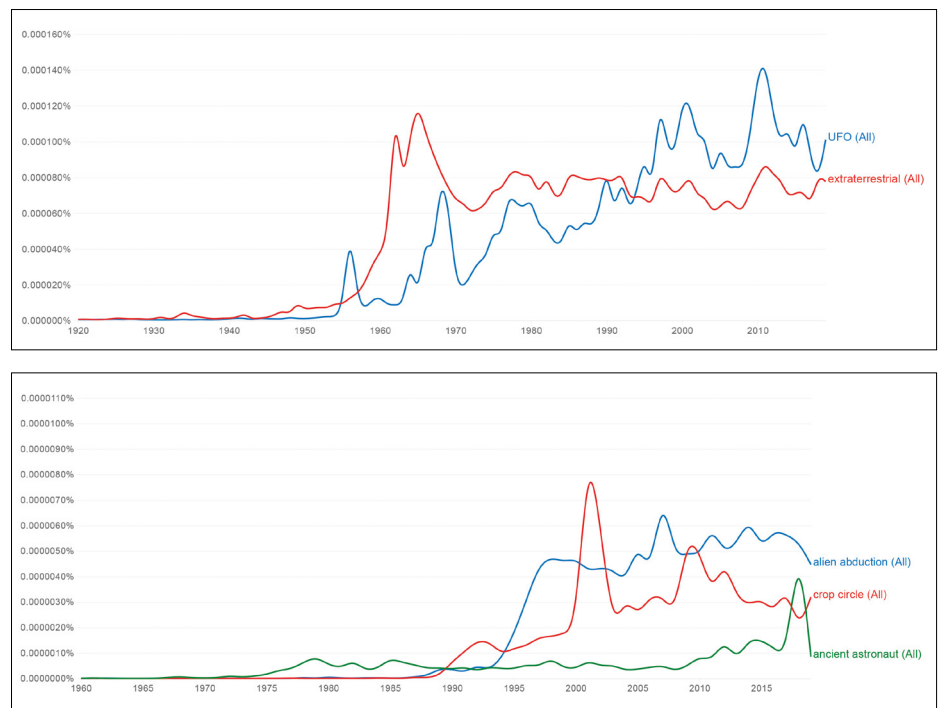
**Figure 1:** The incidence of the words astronomy (blue), astrology (red), and horoscope (green) in Google Books since 1800. By contrast to astronomy, which is near its lowest level in two centuries, astrology and horoscope are near their all-time highs. Image Credit: Google

19th century, and horoscope occurred at 10% of the frequency of astronomy. Now, the percentages are 52% and 30%, relative rises of a factor of two and three, respectively.

Unidentified Flying Objects have migrated from being a fringe belief to the mainstream of modern American popular culture (Pasulka, 2019). The many Earth-like exoplanets being discovered make it statistically likely that there is intelligent life beyond the Solar System, and it is plausible that some of these creatures could have surpassed our technical abilities to achieve interstellar travel. The subject is even getting scholarly attention (e.g., Andresen & Chon Torres, 2022). However, scientists consider reports of extraterrestrials visiting the Earth lacking verifiable evidence and unconvincing (Fraknoi, 2010). The UFO acronym dates to 1953, in a book by an American aviator (Keyhoe, 1953), and 1956, when Air Force officer Edward Ruppelt claimed he invented it to replace the earlier term *flying saucer* (Clarendon Press, 1989). The phrase *flying saucer* originated in 1947 when pilot Kenneth Arnold reported saucer-shaped objects flying in formation, and reporters coined *flying saucer* even though Arnold himself never used the phrase. Within six weeks, 90% of Americans had heard the term *flying saucer*. The contemporary idea of UFOs dates back to that time (Eghigian, 2021).

the Latin *extra* and *terrestris*, which means “outside the Earth.” *Extraterrestrial* used as a noun dates back to 1956, contemporaneous with the origin of the acronym *UFO* (Online Etymology Dictionary, 2022b). Usage of *UFO* in books begins in the early 1950s, a few years after the 1947

Arnold sighting and the 1947 Roswell incident (Saler et al., 2010). It rose steadily until 2000 and has flattened since then. While likely a coincidence, it is amusing that the strongest rise is during the nine-year run of *The X-Files*. The use of *extraterrestrial* rose strongly until 1964 and has been relatively



**Figure 2:** Top: Incidence of the acronym UFO (blue) and the word extraterrestrial (red) in Google Books since 1920. Both show a rise after the 1947 Roswell incident. Bottom: Incidence of the phrases alien abduction (blue), crop circle (red), and ancient astronaut (green) in Google Books since 1960. All three rose after 1990 as the Internet became more widespread. Image Credit: Google

The top panel of Figure 2 shows the incidence of the term *UFO* since 1920, along with *extraterrestrial*. The word comes from

flat for over half a century. The rise in references to UFOs in books tracks publicly reported sightings in the United States (*National UFO Reporting Center, 2022*). Reported sightings began at the time of the Roswell incident, climbed to dozens of reports per month in the 1970s and 1980s, grew to several hundred per month at the end of the 1990s, and have plateaued at 300–500 per month in the past few decades. The all-time peak of 1050 UFO sightings occurred in April 2020, when the Pentagon officially released three U.S. Navy videos showing UAPs (Unidentified Aerial Phenomena; *U.S. Department of Defense, 2020*). Despite intense public interest and speculation, most military UFO reports show no evidence of visits from aliens (*Barnes, 2022*).

UFOs are part of a broad ecosystem of beliefs, including other manifestations of advanced alien life forms visiting Earth. The bottom panel of Figure 2 shows the incidence of three of these since 1960; before that, the terms rarely appear in any book. Ancient astronauts are an extension of the UFO hypothesis: the claim that intelligent extraterrestrials visited Earth in ancient or prehistoric times and the idea that some religious deities were extraterrestrial in origin. The occurrence of this term started in the late 1960s. The rise is associated with the bestselling novel *Chariots of the Gods* (*von Daniken, 1968*) and nine sequels that came out between 1970 and 1984, selling over 60 million copies (*Feder, 2010*). After a decline in the 1980s, there has been a more recent rise to its current highest level, which may be associated with the proliferation of UFO religions (*Pasulka, 2019*). Crop circles have been claimed to be created by visiting aliens. Ironically, the incidence of this phrase in books took off in the early 1990s, soon after two self-professed English pranksters confessed to inventing the phenomenon 25 years earlier (*Irving & Brookesmith, 2009*). Crop circles then proliferated worldwide, including some of dizzying complexity (e.g., *Physics World, 2011*; *Stables, 2021*). Alien abduction is the claim of direct interaction with aliens and often removal from Earth. While the phenomenon is psychologically fascinating, no evidence suggests it is real (*Appelle et al., 2000*). References to alien abduction in books grew rapidly in the 1990s, soon after it started getting scholarly attention, particularly from Harvard psychiatrist John Mack (*Matheson, 1998*).

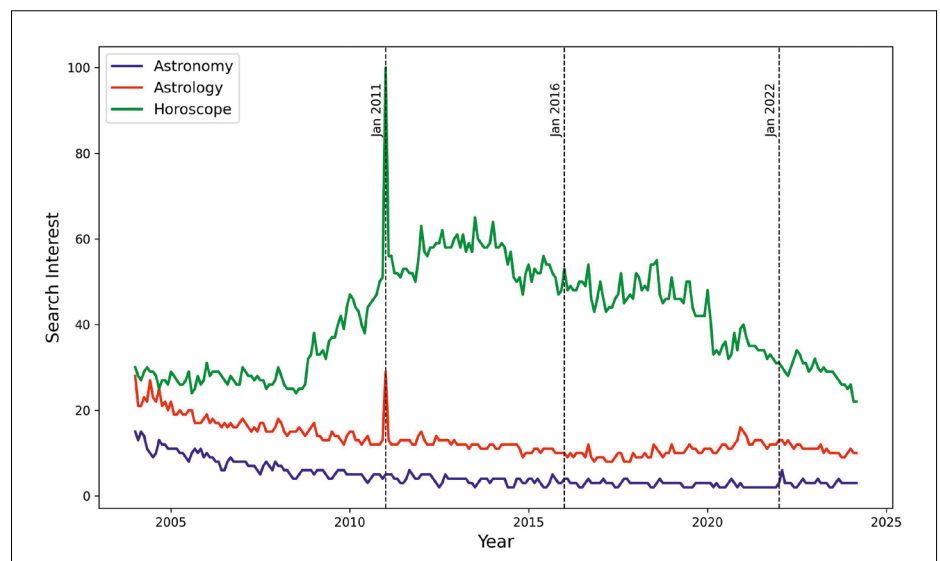
## Searches online

Google Trends is the quintessential tool for measuring the 21st-century zeitgeist. It parses the popularity of queries made in Google Search across many geographical regions and languages and presents the data as graphs over time (*Google Trends, 2022*). Coverage started in 2004, and the relative popularity of two or more search terms can be compared. Dynamic range is limited as the numerical scale goes from 1 to 100, which is the peak popularity for a given region and time. A growing amount of research has been published using Google Trends. The data can illuminate human behaviour (*Mavragani et al., 2018*), track interest in the environment (*Nghiem et al., 2016*), and forecast economic indicators (*Choi & Varian, 2012*) and financial markets (*Preis et al., 2013*). Another important application is analysing searches on health topics. Such data has been used to track and predict outbreaks of diseases (*Mavragani & Ochoa, 2019*). In fact, Google Trends often outperforms some survey-based indicators (*Vosen & Schmidt, 2011*).

However, search engine data must be used with caution. Inconsistencies can arise when considering intervals of less than a year (*Behnen et al., 2020*). Over short intervals, searches for the same term and period at different times can yield very different results. Another study found

statistical variations in a long-interval search when the identical search was repeated weekly (*Cebrian & Domenech, 2022*). The cause of the inaccuracies is unknown and lies deep within Google's sampling algorithms. This does not invalidate Google Trends as a data source but suggests it should only be used to look for large-scale effects. Unlike Google Books, where scientific content has been increasing, the fraction of all Google searches for scientific terms has decreased as the Internet is used increasingly to track leisure and politics and explore popular culture (e.g., *Ficetola, 2013*). For example, from 2004 to 2022, searches for *coffee* and *weather* increased by factors of 12 and 8 relative to searches for *science*. Similarly, one of the National Science Foundation's biennial reports (*National Science Board, 2016*) found that searches for *science*, *engineering*, and *technology* declined from 2004 to 2014. However, little has been published using Google Trends to track interest in science and pseudoscience (*Baram-Tsabari & Segev, 2009*).

Analogous to Figure 1, Figure 3 shows the relative frequency of the search words *astronomy*, *astrology*, and *horoscope* from Google Trends data since 2004 in the United States. In 2004, relative to *astronomy*, searches for *astrology* were twice as frequent, and searches for *horoscope* were 2.5 times as frequent: the reverse trend we see in the relative order of occurrence of



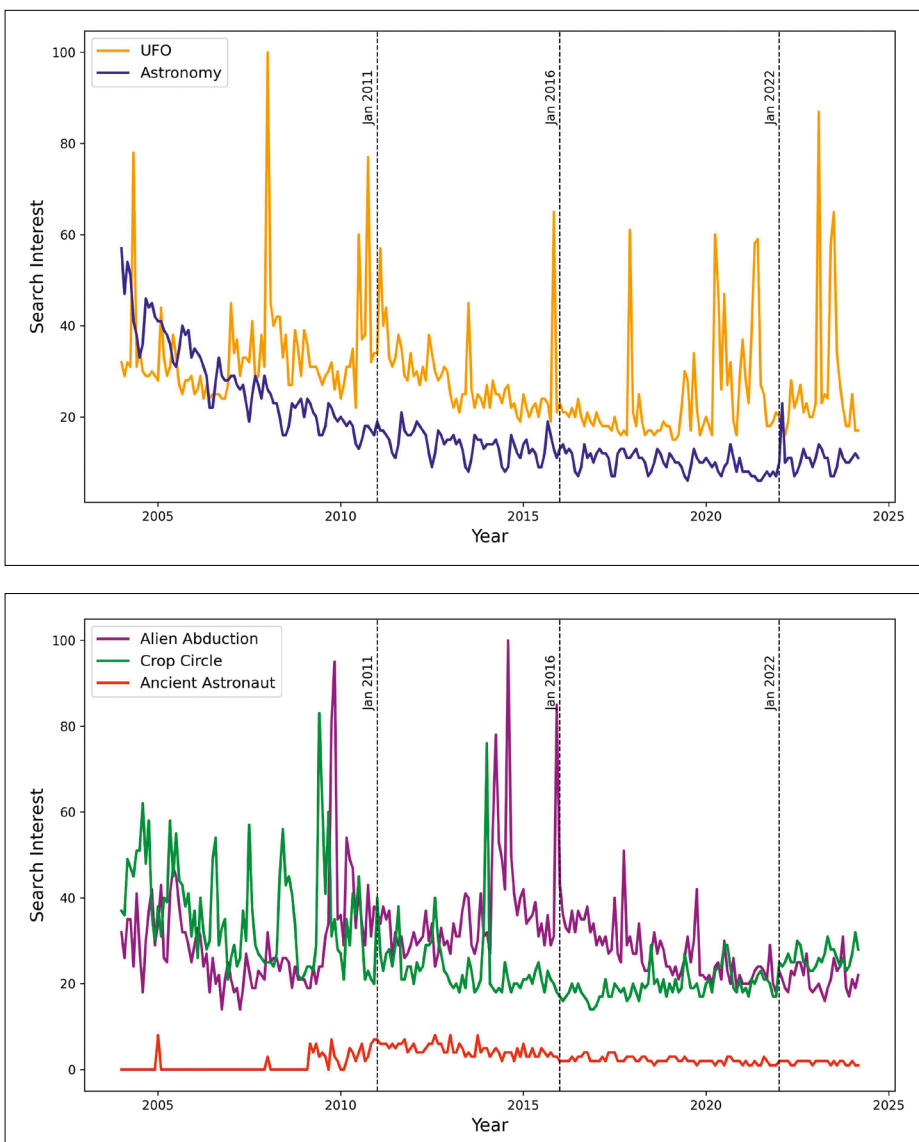
**Figure 3:** The relative occurrence of the search terms *astronomy* (blue), *astrology* (red), and *horoscope* (green) in Google Trends shows a decline for *astronomy* relative to the other terms. Dates with dashed vertical lines correspond to improvements in Google search methodology. Image Credit: Google

these terms in books. The disparity in Internet searches for these terms has increased over the past two decades. In 2013, *astrology* searches were three times as frequent as *astronomy* searches, and *horoscope* searches were 15 times as frequent. Early in 2022, the ratios grew to factors of five and 15. Google Trends can be used to look at searches in the U.S. by state. From 2004 through 2022, Hawai'i had the most *astronomy* searches per capita, which is plausibly explained by the many large telescopes concentrated there. The states with the most *astrology* and *horoscope*

searches were Hawai'i and New York, a result with no obvious explanation. As mentioned earlier, word confusion between astronomy and astrology may be a factor. It is noted that state-level search results involve much smaller samples, so results can be variable. A state-by-state analysis is outside the scope of this work. Anonymous Google searches for *astrology* and *horoscope* return around 200 million unique web pages. The rise of astrology in the 21st century can be seen as a reflection of New Age thought and its pervasive influence on Western culture (e.g., *Campion, 2012*). The

rapid rise of searches for *horoscope* before 2010 matches when the fraction of the American public thinking astrology was at least partly scientific grew significantly (*National Science Board, 2014*). As people increasingly believe in astrology, acting on that belief means looking up your horoscope. The rise of the Internet and social media has led to more horoscopes online (e.g., *Smallwood, 2019*).

The search frequency of *UFO* relative to *astronomy* is shown in the top panel of Figure 4. Unlike the case for books in the Google corpus (Figure 2), web searches for *extraterrestrial* are relatively rare. As they are about 20 to 30 times less frequent than searches for *UFO*, searches for this term are not displayed in Figure 4. Though searches for *astronomy* rivaled those for *UFO* around 2004, searches for *astronomy* have declined, the relative frequency dropping to 20%–25% in recent years. Searches for *astronomy* show a dip every summer in the Northern Hemisphere, an effect seen in other science searches, perhaps indicating student activity in the United States. By contrast, *UFO* searches show sharp peaks correlating with media coverage of a single sighting. In the top panel of Figure 4, the four highest search peaks between 2008 and 2017 correspond to months when the numbers of UFO reports were 25–100% higher than in adjacent months. A recent surge in searches in 2020 and 2021 is tied to the highly publicised release of three U.S. Navy videos of UFOs (*National UFO Reporting Center, 2022*). The states with the most UFO searches per capita are New Mexico, Arizona, and Nevada, all located in the desert Southwest with mostly dark skies. The relative search frequencies for the terms *alien abduction*, *crop circle*, and *ancient astronaut* are also shown in the bottom panel of Figure 4. Comparatively, searches for *ancient astronaut* are sparse. However, all of these phrases are much less common than *UFO* searches, and the peaks do not align with the *UFO* peaks or obvious news stories. However, there may be a tie-in with movies. The highest *alien abduction* peaks correspond to the release of movies on the topic: *The Fourth Kind* in 2009, *Alien Abduction* in 2014, and *The True Story of Travis Walton* in 2015. The highest *crop circles* peaks correspond to the release of *Crop Circles: The Enigma* in 2009 and *The Ultimate Crop Circles* in 2014 (*Internet Movie Database, 2022*). However, searches for *alien abduction* and *crop circle* have



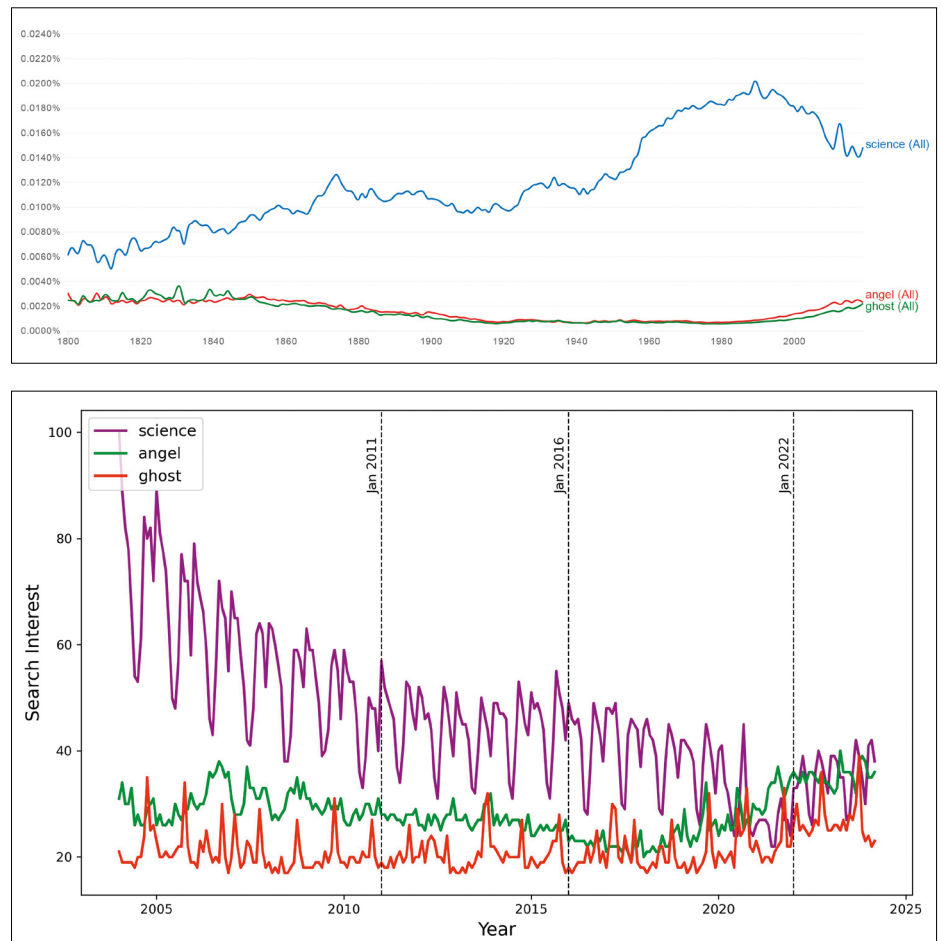
**Figure 4:** Top: The relative occurrence of the search terms *UFO* (yellow) and *astronomy* (blue) in Google Trends shows a stronger decline for *astronomy*. Bottom: The relative occurrence of searches for the phrases *alien abduction* (purple), *crop circle* (green) and *ancient astronaut* (red) in Google Trends. Sharp peaks are often associated with news reports online in the case of *UFO* and movies in the case of *alien abduction* and *crop circle*. Dates with dashed vertical lines correspond to improvements in Google search methodology. Image Credit: Google

increased by a factor of four relative to *astronomy* since 2004, showing the enduring fascination of these exotic forms of pseudoscience.

As another example showing how media-driven pseudoscience can lead to a surge in online searches: in 2012, there was a spike in searches for the term *Nibiru*, which refers to a planet that was supposed to collide with the Earth and wipe out civilisation. It was tied to an erroneous interpretation of the Mayan calendar predicting the end of the world on December 21, 2012 (Sittler, 2006; NASA, 2011). This heavily debunked conspiracy theory resurfaced in 2017 with an even stronger spike in online activity. Additionally, the idea that the Earth is flat has persisted for millennia after ancient Greeks presented arguments that the Earth is round. Flat Earth searches online climbed by an order of magnitude from 2015 to 2018, declined, and then recently has settled at a level twice as high as before 2015. Much, but not all, of this activity was driven in 2017 by the high-profile basketball player and social media influencer Kyrie Irving, who came out publicly to say that the Earth was flat, but subsequently recanted his belief in 2018 (Reuters, 2018). Social scientists have analysed the propagation of pseudoscience beliefs and find that it is like a “contagion” spread by media (Schiele, 2020), where intuitive appeal outweighs intellectual integrity (Boudry et al., 2015). A journey down the “rabbit hole” of these and other astronomy-related conspiracy theories would make a rich subject for future investigation.

## Discussion

Despite its limitations, Google Books is a unique resource for parsing the occurrence of words in print, and Google Trends is unrivalled for tapping into the gestalt of the Internet age. The other social media giants like Meta (Facebook) and X (formerly Twitter) zealously guard their data because they use it to target advertising. Third-party developers have added functionality to Google Books by allowing users to execute more complex searches and copy data into other applications (English Corpora, 2024). Interestingly, English Corpora also operates a free tool called iWeb that does for the Internet what Google Books does for books: counts words, in this case, 14 billion words



**Figure 5:** Top: The relative occurrence of the words *science* (blue), *ghost* (green), and *angel* (red) in Google Books shows a strong rise for *ghost* and *angel* in the past forty years. Bottom: The relative occurrence of the search terms *science* (purple), *ghost* (red), and *angel* (green) in Google Trends data. Dates with dashed vertical lines correspond to improvements in Google search methodology. Image Credit: Google

in 22 million web pages from 100,000 top-ranked websites. It is a powerful resource for studies like this one.

The rise of pseudoscience concerns scientists, educators, and policymakers. Book references and web searches show the persistence and rise of astrology and UFOs in modern culture despite a lack of evidence that they have scientific explanations or bases in verifiable facts. However, other beliefs eclipse the astronomy-related topics explored in this paper. Figure 5 compares the frequency of *science* relative to *ghost* and *angel* using the Google Books corpus (top) and Google Trends web searches (bottom). Books referencing angels became rarer through the 19th century, but references to angels and ghosts have soared by more than a factor of four in the last forty years while references to *science* have been steady.

Since 2004, online searches for angels and ghosts have risen by a factor of three relative to searches for *science*. Three-quarters of Americans think angels are real (CBS News, 2011). The word *angel* is predominantly a religious term and, therefore, is often a matter of faith and not necessarily anti-scientific; however most non-Christians also think angels exist. A third of Americans believe in ghosts, similar to the belief level for UFOs (Ipsos, 2021). In the bottom panel of Figure 5, web searches for *ghost* seasonally spikes by 20-30% around Halloween, but most searches occur throughout the year.

The caveat of this analysis is that book references and web searches are imperfect proxies for interest and belief. A particular term might occur in a book on an entirely different topic, and a web search might occur for various reasons. A follow-up study

is required to connect data like this to belief systems and the reasons for those beliefs. Finally, a fascinating counterpoint to this study of astronomy-related topics in pseudoscience comes from a textual analysis of sentiment and rationality (e.g., Scheffer *et al.*, 2021). Words related to rationality, like *determine* and *conclusion*, rose after 1850, while words related to human experience, like *feel* and *believe*, declined. This century-long trend reversed around 1980, as measured by Google Book Ngrams, web searches, and articles in the *New York Times*. The rise in pseudoscience tracked in this paper has been accompanied by a more general decline in rationality in language. We live in a world where major societal decisions depend on an understanding of science, but the pervasiveness of pseudoscience may threaten our ability to move forward as a society.

This study has illustrated the growing popularity of pseudoscience terms related to astronomy at the expense of conventional scientific terms. Educators and science communicators must operate in a world where they are not the gatekeepers of information. A seminal report from the Rand Corporation, *Truth Decay*, highlighted four trends underlying the declining importance of truth in American society: (1) increasing disagreement in evaluating facts; (2) blurring of the line between opinion and fact; (3) increase in the volume and influence of opinion over facts; and (4) declining trust in formerly respected sources of factual information (Kavanagh & Rich, 2018). Studies have shown that young people are particularly impacted by misinformation. In one study of high school students, a climate change denial website misled 97% of the students, and in tasks to evaluate the veracity of social media, 90% scored at a beginning level, and only 3% scored at a mastery level (Breakstone *et al.*, 2021). For astronomy educators and outreach specialists, the archetype of a growing and erroneous belief system is astrology (Das *et al.*, 2022).

Teaching information literacy is an essential strategy in combating science misinformation. Strategies for improving information literacy must accommodate the fact that we live in a dynamic ecosystem of digital information (Howell & Brossard, 2021). In academia, librarians are key allies

in this effort (Goodsett, 2020). A useful resource is the *Debunking Handbook*, which is the current consensus on the science of debunking pseudoscience and misinformation for engaged citizens, policymakers, journalists, and science communicators (Lewandowski *et al.*, 2020). This manual explains why misinformation is "sticky," and it presents strategies for inoculating against it and debunking it. Combating scientific misinformation starts with a clear demarcation between legitimate science and pseudoscience (Gerges, 2022). In practice, debunking a piece of misinformation or a myth creates a gap in people's mental models, so the myth has to be replaced with factual information, keeping in mind the cognitive mechanisms that drive misinformation in the first place. Moreover, the new facts have to be "sticky," able to grab attention and stick in the memory (Cook, 2015). Communicators can use books and internet search data to present pseudoscience case studies to their audiences. The ecosystem of UFO beliefs is a particularly rich example since it ranges from straightforward sightings, which are innocuous, to outlandish abduction reports. The goal would be to reduce credulity and increase scepticism and critical thinking.

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## Biography

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