

University of Amsterdam
Honours Elective: The Universe That Made Us

Essay Assignment

**Modelling the Spread of Extraterrestrial
Life Information and Beliefs on Social Media**

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Introduction

In this essay I will be covering how information spreads and disseminates across users of social media/networks , specifically info (including false info) over extraterrestrial life. The aim is to understand the factors of information spread - diving into specific factors of information spread on social media, as well as understanding what forms belief about extraterrestrial life within society. The findings from literature on these subjects will then be incorporated into a computational model, which will simulate the spread of info on social media. Results will be analysed to make conclusions on the key factors of how beliefs about extraterrestrial life spread on social media, and the outcomes of the spread of these beliefs online. Social networks and social media in the context of this essay do not have a distinction, both meaning *online platforms with capacity for social interaction*, and I will be using the term social media throughout this essay.

Literature Review

Information Spread

The definition of information and the nature of its spreading is highly studied. One way of defining information is *knowledge with meaning pertaining to facts, ideas, objects and/or events* (Rowley, 1998). In terms of belief over extraterrestrial life, we could view this as any meaningful notion about factors behind or even “proof” of extraterrestrial life, essentially any presented *fact, idea, object or event* providing meaning over extraterrestrial life. To give examples for this extraterrestrial-life-scope of information, this could be astronomical evidence that implies

possibilities of life, theoretical thinking on the matter, objects retrieved from space and extraterrestrial events (regardless of being true or false).

Beliefs are formed through information, received in all manners, such as peers, colleagues and leaders in the sphere of an individual's social influence, although many more actors too. This does however mean that information is never guaranteed to be accurate, and individuals/societies are prone to being misled by false news and stories, clinging on to these ideas as due to information's nature there is no way to inherently delineate the true and the false (Acemoglu et al., 2010). Acemoglu et al. (2010) also provide a simple model for information spread between two entities. They define two types of *agents*. The first is the *Regular Agent (Ra)*; an agent that seeks to average their belief out with another's. The other being the *Forceful Agent (Fa)*; an agent that influences other agents to hold their pre-belief, and does not change theirs - a stubborn actor in some senses. This can be derived mathematically, denoting the beliefs of an agent as X_b , such that:

- $Fa + Ra \Rightarrow Ra_b = Fa_b$
- $Ra + Ra \Rightarrow Ra_b = (Ra_b + Ra_b) / 2$
- $Fa + Fa \Rightarrow \text{No Change}$

Forceful agents don't necessarily have to be an individual, but can also be media outlets and social influencers. Muhlmeyer & Agarwal (2021, p. 129-138) present their own model from their findings, which add to this. What they call *ignorant class members* (the same idea as forceful agents), commonly spread information over a topic once they learn it, until the information becomes 'old' or 'dull', at which point they stop spreading the information.

In these contexts, the spread of information can be seen as an averaging or passing of info that can come from any agent, and the results of an "information interaction" depends on the nature of the entities themselves. Lastly we can say there is a "lifecycle" of information which captivates the time period of its spread.

The Spread of Information on Social Media

Social media changes the nature of information spread in multiple ways, due to its unique interconnectivity and the reach it provides agents. First off, the reach or "penetration" speed of information on social media is the quickest of any method of information dissemination that exists, although ultimately requires no verification for info shared, creating room for misinformation (Adekoya & Fasae, 2021). Many social medias such as *Instagram*, *X (formerly Twitter)* and *Facebook* have high information connections between users and their "followers" or "friends", meaning information shared by an agent is guaranteed an initial spread among these agents in their individual context (Ozturk et al., 2015). Lastly, a key difference is that info is absorbed much heavier by agents than traditional medias, due to social media's interactive nature (Shumpenthung Ezung & Kekhronei O Koza, 2024), which means the previously defined mathematical representation of agents' interactions is robust and there is little room for the model not to be correct when applied to information spread on social media.

Moving onto the spread of true or false info, Zubiaga et al. (2016) studied how misinformation spreads on social media, making multiple conclusions; It is more difficult for false info to stay unchecked than for true info to be corroborated, new info that isn't fact checked spreads much quicker than (de)verified info, and that info that is still unverified is almost always spread. In other terms, the lifespan of information is influenced by it being verified or not.

Factors of Belief in Extraterrestrial Life

The last section of this literature review is exploring what founds belief in extraterrestrial life. A big basis for belief in extraterrestrial life is that there is existing scientific info that could suggest or be grounds for extraterrestrial life (Aldiss, 2001; Dean, 1997). This can come from info such as research on Mars showing that ice-form water exists, and that there is possibly liquid water underground (Petrovych, 2024), that there exists slight amounts of water vapor in the atmosphere of Mars (Nazari-Sharabian et al., 2020), even research about the past of Mars having water exist on the surface due to an atmosphere Mars no longer has (lost by outgassing after impact erosion) (Carr, 1987), as belief about extraterrestrial life doesn't necessarily have to be tied to the present, it can also include the idea that there was extraterrestrial life in the past.

This belief is also not linked to intelligence in any form, and one does not require a "fantasy prone" mind to carry extra terrestrial belief (Patry & Pelletier, 2001). This is corroborated by a study from Swami et al. (2009), where they found that large amounts (up to 50%) of people believe in extraterrestrial life. Another finding of theirs useful is that those with right wing orientations and religious individuals are less likely to believe in extraterrestrial life, in the case of religious individuals this is most likely because existence of extraterrestrial life opposes the foundations of their faiths.

In summary, most individuals have the possibility to believe in extraterrestrial life, and there are a few factors that reduce this likelihood.

Methodology

Model Used

The model I used is a network model. 1000 (n) simulated agents were created and attributes were mapped to them. The agents have randomly initialised relations between them, to simulate the reaches and relations on social media. Lastly, the simulation covers a time period of 100 days, each day having 4 "spread-steps" to allow for information that spreads quicker to be represented doing so within the day cycle, as well as represent the fast reach speeds of social media.

Model Creation

Relevant factors about interactions and agents themselves from the literature review are incorporated in the model, randomly assigned with different chances.

The attributes of information are as follows;

- Factual (True or false) - 50% chance for either
- Fact Checked (True or False) - Starts as false
- Lifecycle - Will be set as 7 days
- Active (True or False) - Starts as true
- Extraterrestrial belief (True or False) - 1% chance to be True, as it is only making up a very small fraction of information spread online

The attributes of agents are as follows;

- Agents are either a forceful agent (Fa) or regular agent (Ra) - 20% chance to be a forceful agent
- Political orientation - 50% chance for agent to be right-leaning
- Religious (True or False) - 65% chance for true
- Agents have a connection to $n / 200$ other agents, n being the simulated agent size
- Agents are given 10 pieces of information that they hold

The rules of spread (or interactions) are as follows;

- The formulae shown in the literature review of Fa and Ra interactions will be used for interactions;
 - $Fa + Ra \Rightarrow Ra_b = Fa_b$
 - $Ra + Ra \Rightarrow Ra_b = (Ra_b + Ra_b) / 2$
 - $Fa + Fa \Rightarrow$ No Change in belief
- The $Ra + Ra$ interaction will take 5 of the other's information and lose 5 of their own
- The $Fa + Ra$ interaction will result in the Ra losing their own information and copying all the Fa information
- If one of the information selected to be spread is not active, it is not spread
- If extraterrestrial belief information is being spread, there is only a 35% chance it is spread if the other agent is religious and/or right leaning

The rules of spread-steps are as follows;

- In spread-steps 1 & 3, each agent will interact with their connections and 3 random agents they aren't connected to, applying the formula dependent on their agent type
- In spread-steps 2 & 4, these interactions will occur again but only unverified info is spread, as this type of info spreads faster

The rules of days are as follows;

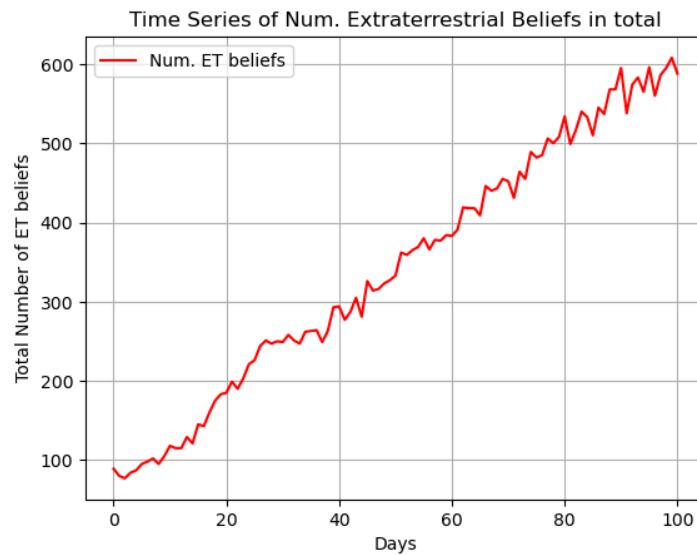
- Per day, one is deducted off of an information's lifecycle, when this reaches 0, the information is no longer active.
- Every day information has a chance to be fact-checked - 75% if factual, 50% if false.
- Every day every forceful agent has a 65% chance to learn one new information, initialising a new information piece with the attributes and chances stated earlier

These are the variables and processes that make up the simulation model. The code can be found under Appendix 1.

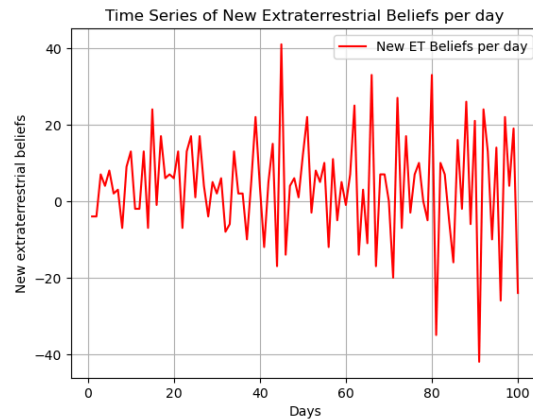
Results

The simulation was run, and metrics were recorded. The metrics taken were; Total number of extraterrestrial beliefs by day, new extraterrestrial beliefs by day, percentage of extraterrestrial beliefs by day, final amount of misinformation and the amount of agents who hold an extraterrestrial belief.

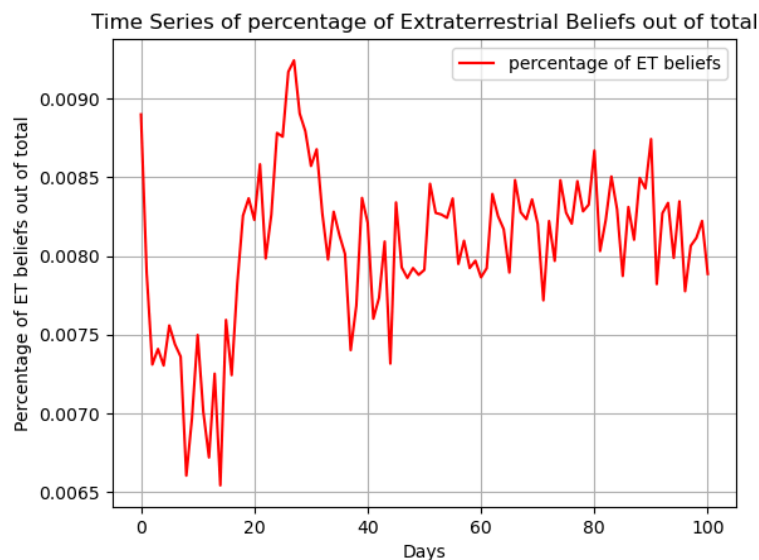
To start, the total number of extraterrestrial beliefs (see below) grew by six times over the 100 days, suggesting that extraterrestrial beliefs are founded and spread at a rather constant and high rate.



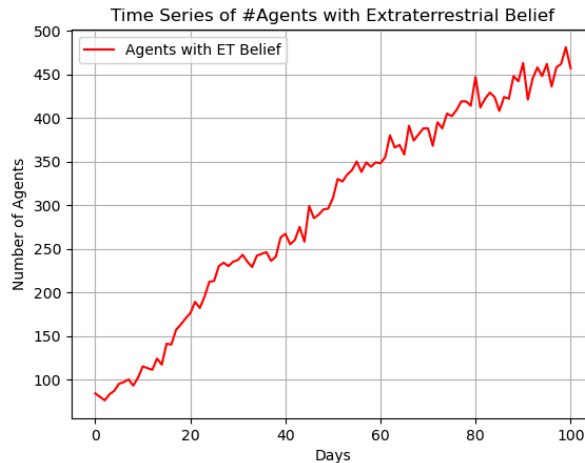
The amount of new extraterrestrial beliefs by day (see below) exhibits a constant average although many peaks and valleys. A possible explanation for this is that extraterrestrial info may have become inactive (dull/old) or was attempting to be spread to agents who do not wish to gain info or specifically are worse at gaining extraterrestrial info/beliefs.



The percentage of extraterrestrial beliefs out of all information held (see below), does provide some normality that the other results do not. The percentage begins at its second highest peak (0.0088%) and stays considerably low. What is inferable from this is that while extraterrestrial beliefs spread fast and highly within connections and circles, overall, it stays within these circles and does not become a predominant piece of information shared online, kept in its own ‘bubble’ of information.



The amount of agents who hold an extraterrestrial belief (see below) increases greatly over the simulation. While our previous result showed that extraterrestrial info does not become predominant on social media, most likely a reflection of the real world, it does reach many people who adopt these beliefs, as seen below where only ~75 agents hold extraterrestrial beliefs and this spreads to ~425 on day 100. This shows that extraterrestrial beliefs do spread amongst people fastly and highly on social media.



After the simulation, the percentage of extraterrestrial beliefs that were not factual was 53.06%. This tells us there is high potential for misinformation about extraterrestrial life on social media.

Conclusion

The simulations ran reflected the findings from the literature, where factors over belief in extraterrestrial life were incorporated, factors of information spread on social media and information spread in general.

What was found was that even with a small starting amount of extraterrestrial beliefs, this information/belief does spread highly and quickly across users of social media, even after factoring in agent attributes that contribute negatively to the adoption of these beliefs. The proportion of info that exists which pertains to extraterrestrial life though, does not increase significantly, staying very low. This meant that regardless of the high spread, extraterrestrial beliefs do not become a large part of people's larger belief set, yet many do adopt these beliefs. Lastly, it was shown that there is large room for misinformation as these beliefs spread across social media.

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Appendices

Appendix 1: Simulation Code

The code is viewable on Github at <https://github.com/br3nd0g/extraterrestrial-belief-simulation>