Are Ideologies Epidemics?

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Contents

1 Introduction and aim

This essay aims to discuss the development of ideologies unfurling in societies, drawing on methods emanating firstly from epidemiology, secondly in applying a simple bayesian technique.

Technically, the approach consists in studying the solutions of one of the simplest differential equations applied in epidemiology, not by calculating simulations on a computer, but by solving it analytically, "with a pencil in the hand, on a sheet of paper"[1], and by studying the solutions developed in an analytical and discursive way. The bayesian approach elected afterwards enables the introduction of noise in the indoctrination process and suggests a putative description of what might become dubbed an "elementary indoctrination step". From this perspective, it will be a matter of establishing a dictionary (mathematicians would rather speak of a "functor") between two categories, on the one hand epidemiological, on the other related to social issues.

Methodologically, I try to simplify a standard model (here that of epidemiological prediction) down to its minimal complexity, just beyond triviality. This modus operandi has proven successful on numerous occasions. An exegetic example is provided by Edward N. Lorenz: in wisely oversimplifying his meteorological equations, he succeeded in highlighting the deterministic chaos, now encapsulated in a single meme, the "butterfly effect". This example, chosen among many others, demonstrates that this reduction to the essence is rich in lessons directly speaking to the human mind.

The final challenge consists in assessing the translation from epidemic to ideological against examples provided from history as well as from current events. The science of memes, cultural equivalents of biological genes, provides clues in this direction.

Last, but not the least, I bear alone the responsibility for the ideas sketched in this essay.

[1] sharpener, eraser and wastebasket are not far away ...

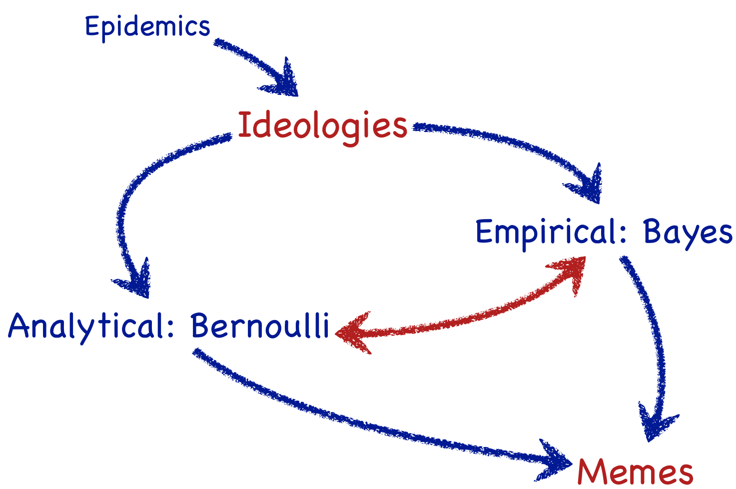

Figure 1: *Minimalist representation of the connexions developed in this work*

2 Basic definitions and dictionary

The first step consist in establishing a dictionary between concepts emanating from the epidemiology and those, less accurately defined, related to ideologies. We only consider those parameters that are relevant to our exercise.

Epidemics	***Ideologies***	***Symbols***
Prevalence	Ideological Susceptibility	P
Infection	Indoctrination / Imbuation	$i_{(t)}$
Infection rate	Indoctrination rate	$\frac{di}{dt}$
Reproduction factor	Indoctrination factor	R
Healing factor	Ideological healing factor	$G_{(t)}$

- P is the fraction of the population susceptible of becoming either biologically infected, or imbued in a doctrine. $P \in [0, 1]$ is dimensionless.

- $i_{(t)}$ measures the fraction of actually infected or imbued people in the prevalent population at time t. $i_{(t)} \in [0, P]\ \forall t$, and is dimensionless.
- $\frac{di}{dt}$ measures the rate at which an infection or a doctrine spreads in the prevalent group P at time t. It has the dimension $\frac{1}{Time}$.
- R is the epidemical reproduction factor, or equivalently the indoctrination factor, both being supposed to be time independent in this simple exercise. As we shall see, R has the dimension $\frac{1}{Time}$.
- $G_{(t)}$ is a healing function among the infected, or among those who are indoctrinated. $G_{(t)}$ will be expressed as a ratio and discussed later. It will be dimensionless[2]

No other parameter or variable will be necessary in the following work.

3 The model

Making use of the above definitions, the evolution of an epidemic, or an ideology, is described by the following differential equation:

$$\frac{di}{dt} = R\, i_{(t)} \, (P - i_{(t)} - i_{(t)}\, G_{(t)}) \tag{1}$$

This equation simply specifies that the infection rate $\frac{di}{dt}$ at time t is proportional to:

- the reproduction rate R. It is counting how many people in a crowd will be infected by one already infected person, per unit of time when being in close reach to this person.
- multiplied by the fraction of people currently infected, $i_{(t)}$,
- multiplied by the reservoir of susceptible people. This reservoir comprehends the fraction P of susceptible people entering in contact with an infected person, minus those who are already infected, $i_{(t)}$, minus the fraction of the infected that are healed at time t: $i_{(t)}\, G_{(t)}$.

[2] The indoctrination factor R could be branded as the "proselyting factor". Other expressions for the ideological healing factor $G_{(t)}$ could be linked to "apostate, defector or renegade"; all of them sound ugly.

Rephrased in the ideological jargon, the equation simply tells that the indoctrination rate $\frac{di}{dt}$ at time t is proportional to:

- the indoctrination factor R,
- multiplied by the fraction of people currently indoctrinated, $i_{(t)}$,
- multiplied by the reservoir of people susceptible of indoctrination. This reservoir comprehends the fraction P of ideological susceptible people, minus those who are already indoctrinated, minus the fraction of them that are drained out, or de-indoctrinated at time t: $i_{(t)}\, G_{(t)}$.

An introduction to the field of spreading phenomena is provided in the book "Network Science" by Albert-László Barabási [1].

3.1 Initial derivation

Up to now, the ideological jargon will be favored and the epidemiological language abandoned. Armed as we are, we now start to tackle the issue and try to solve:

$$\frac{di}{dt} = R\, i_{(t)}(P - i_{(t)}(1 + G_{(t)}))$$

Firstly, we notice that this differential equation is dimensionally consistent. Both sides of the equal sign are expressed in $\frac{1}{Time}$. Making use of a classical method initially presented by Jakob Bernoulli, we introduce the ancillary function $u_{(t)} = \frac{1}{i_{(t)}}$ with $\frac{du}{dt} = -\frac{1}{i^2_{(t)}}\frac{di}{dt}$. Thanks to this this artifice, our equation reads[3]:

$$\frac{1}{i^2_{(t)}}\frac{di}{dt} = \frac{PR}{i_{(t)}} - R(1 + G_{(t)})$$

and may be rewritten:

$$\frac{du}{dt} + PR\, u_{(t)} = R(1 + G_{(t)}).$$

We now introduce the second ancillary function $v_{(t)} = e^{PR\,t}$ with $\frac{dv}{dt} = PR\ e^{PR\,t} = PR\ v_{(t)}$. Multiplying both sides of the previous equation by this function and making use of the Leibniz derivation rule yields:

[3]See for example Wohlgemuth Martin. 2011. Mathematik für Anfänger.[2].

$$\frac{du}{dt}\, v_{(t)} + u_{(t)}\, \frac{dv}{dt} = \frac{d(u_{(t)}\, .\, v_{(t)})}{dt} = R(1 + G_{(t)})\, v_{(t)}$$

A first step towards the integration of this differential equation is now immediate and delivers:

$$\begin{aligned}
u_{(t)}\, .\, v_{(t)} &= \int R\, (1 + G_{(t)})\, v_{(t)}\, dt + \ C_1 \\
u_{(t)} &= v_{(t)}^{-1} \int R\, (1 + G_{(t)})\, v_{(t)}\, dt + v_{(t)}^{-1}\, C_1 \\
&= R\, e^{-PR\,t} \int (1 + G_{(t)})\, e^{PR\,t}\, dt + e^{-PR\,t}\, C_1 \\
&= \frac{1}{P} + R\, e^{-PR\,t} \int G_{(t)}\, e^{PR\,t}\, dt + e^{-PR\,t}\, C_1
\end{aligned}$$

C_1 is a first integration constant. Regarding the integral term, it may be seen as $R\, e^{-PR\,t} \int G_{(t)}\ e^{PR\,t}\ dt = \Phi_{(t)} +\ e^{-PR\,t} R\, C_2$, with $\Phi_{(t)}$ the integral and C_2 the corresponding integration constant. Thus both constants C_1 and $R\, C_2$ can be combined as $C = C_1 + R\, C_2$, leaving us with C as sole integration constant. Making use of this simplification and recovering the indoctrination term $i_{(t)}$ at time t gives the our main ideological equation in this highly simplified setting:

$$i_{(t)} = \frac{P}{1 + P\, R\, e^{-PR\,t} \int G_{(t)}\ e^{PR\,t}\ dt + e^{-PR\,t}\ P\, C}$$

However, the inverse formulation is more manageable and will be used in the sequel:

$$u_{(t)} = \frac{1}{P} + R\, e^{-PR\,t} \int G_{(t)}\ e^{PR\,t}\ dt + e^{-PR\,t}\ C_1 \tag{2}$$

Everything depends on the fraction term of ideologically susceptible people P, the indoctrination rate R and the healing function $G_{(t)}$. As the argument in the exponential e^{PRt} has to be free from physical dimensions, it happens that PR factor has to be expressed in $\frac{1}{Time}$ units. This requirement is treated below on the basis of simple cases.

At this point, it is legitimate to ask why the following simpler differential equation has not been taken into consideration: $\frac{di}{dt} = R\, i_{(t)}\, (P - i_{(t)} - G_{(t)})$.

In this setting, $G_{(t)}$ would be the fraction of people de-indoctrinated at time t, and not the rate of healing at this time. Unfortunately, the solution of this simpler formulation reads: $u_{(t)} = \frac{1}{P} + R\, e^{-PR\,t} \int G_{(t)}\, u_{(t)}\, e^{PR\,t}\, dt + e^{-PR\,t}\, C_1$ and is not tractable analytically, at least for me: $u_{(t)}$ appears on both sides of the equation, under the integral in the right hand side. Thus, following the initial aim at working analytically, I disregarded this formulation and operated with equation (1).

4 Simple cases

The healing function $G_{(t)}$ is almost always unknown and has to be conjectured. Let we dare, however, to elucidate some simple cases, firstly assuming that indoctrinated people remain in this state forever.

4.1 No ideological healing. $G_{(t)} = 0$

Starting with equation (2) in which $G_{(t)} = 0$, we estimate the integration constant C. We choose for reference time $t = T_0$ the instant at which half of the susceptible population has been indoctrinated: $u_{(t=T_0)} = \frac{2}{P}$, (equivalently $i_{(t=T_0)} = \frac{P}{2}$). Plugging this condition in the main equation yields $C = \frac{1}{P} e^{PR\,T_0}$. Inserting this relation back in the main equation and recalculating the indoctrination rate $i_{(t)} = \frac{1}{u_{(t)}}$ yields:

$$i_{(t)} = \frac{P}{1 + e^{-PR(t-T_0)}} \tag{3}$$

Following figure 2 exhibits the corresponding curve, named *sigmoid*, with $\lim_{t\to\infty} i_{(t)} = P$. After a 'long enough' time, all the individuals belonging to the susceptible fraction of the population are indoctrinated.

As one notices on figure 3, the sigmoid curve obeys a rotational symmetry of π, or half-a-round, around its inflection point $\{T_0, \frac{P}{2}\}$. Working as a kind of fulcrum, the inflection point will be elected as our standard initial condition[4]. The indoctrination grows exponentially until the inflection point is reached and decreases exponentially afterwards. Thus, detecting an inflection point in the spread of an ideology allows one to guess that the total

[4]It is always a good deal to choose initial conditions satisfying observed or expected symmetries of the problem at hand.

number of people becoming indoctrinated is likely to double when no mitigating actions are taken.

Furthermore, it is worth noticing the time at which the inflection occurs does not move when P or R are changed, and solely depends on T_0. However, the striking observation here is that the indoctrination (or infection) process engenders its own pace of the time, solely determined by the PR factor. This quality will be discussed in section 4.4.

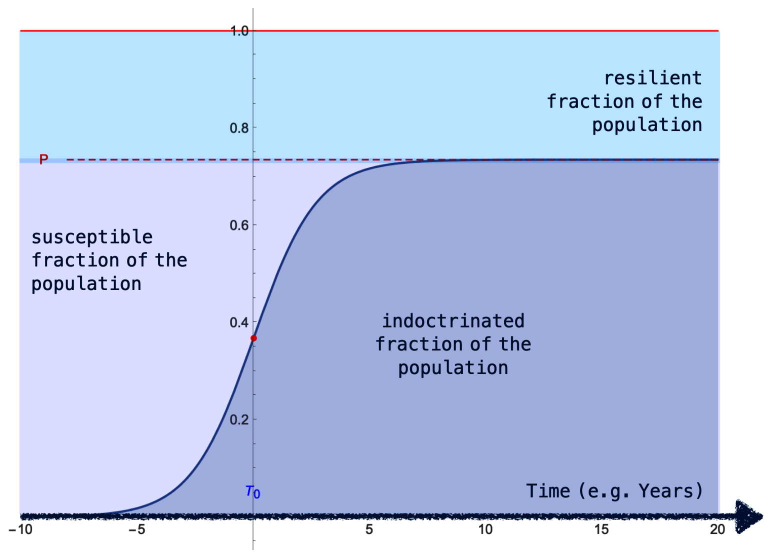

Figure 2: *Evolution of the ideology without healing according to equation (3). Abscissa: time, Ordinate: Indoctrination. The evolution of the indoctrination in time describes a pure sigmoid that is asymptotic to the level P of the susceptible fraction of the population.*

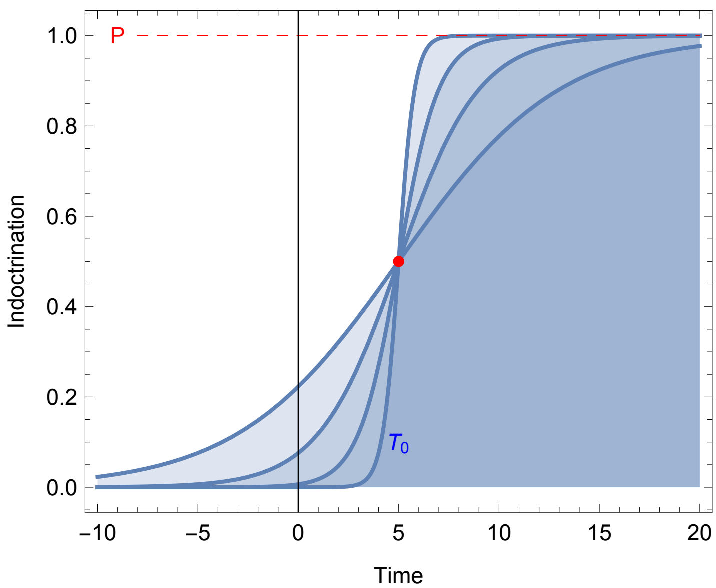

Figure 3: *Evolution of the the ideology without healing according to equation (3). Abscissa: time, Ordinate: Indoctrination. The inflection point is well betokened as the red dot located at the center of the rotational symmetry. Four indoctrination factors are presented:* $R \to \{1/4, 1/2, 1, 5/2\}; P = 1; T_0 = 5; G_{(t)} = 0$.

4.2 Healing constant in time. $G_{(t)} = G_0$

We now integrate equation (2) with $G_{(t)} = G_0 > 0$ and estimate again the integration constant C with reference time $t = T_0$ at which half of the susceptible population has been indoctrinated: $i_{(t=T_0)} = \frac{P}{2}$. Plugging this condition in the equation (2) yields $C = \frac{1-G_0}{P} e^{PR\,T_0}$. Inserting this relation back in the main equation and recalculating the indoctrination rate yields:

$$i_{(t)} = \frac{P}{(1+G_0) + (1-G_0)\, e^{-PR(t-T_0)}} \tag{4}$$

In this case where the healing effort is constant with time, only a fraction of the susceptible population is finally indoctrinated:

$$\lim_{t\to\infty} i_{(t)} = \frac{P}{1+G_0} < P$$

As one observes on figure 4, adequate education or unbiased information reduces and slows down the spread of the ideology in the susceptible fraction of the population without, however, eradicating it. The entropic evaluation of the indoctrination process presented below attempts to clarify the point. Variations of this configuration are presented in the Appendix, figure 17.

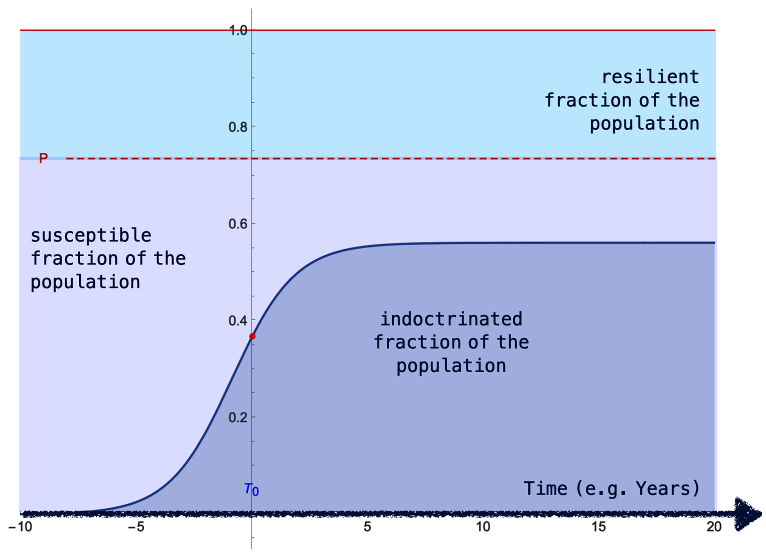

Figure 4: *Evolution of the ideology with healing constant in time according to equation (4). Abscissa: time, Ordinate: indoctrination.* $P = 3/4; T_0 = 0; G_{(t)} = G_0 > 0$.

4.3 Entropy

Entropy is a property of a thermodynamic system that expresses the outcome of spontaneous changes in the system. The term was introduced by Rudolf Clausius in the mid-nineteenth century to explain the relationship of the internal energy that is available or unavailable for transformations in form of heat and work. In statistical mechanics, entropy is formulated as a statistical property using probability theory. The statistical entropy perspective was introduced in 1870 by Austrian physicist Ludwig Boltzmann, who described the linkage between the macroscopic observation of nature and the microscopic view based on the rigorous treatment of a large ensembles of micro-states that constitute thermodynamic systems. The concept of information entropy, applied here, was introduced by Claude Shannon in 1948 and is also referred to as Shannon entropy.[5]

Following Shannon, the information entropy $H_{(p)}$ is expressed as:

$$H_{(p)} = -[\, p\, Log_2(p) + (1-p)\, Log_2(1-p)\,]$$

for a binary system with $H_{(p=0)} = H_{(p=1)} = 0$. The states $p = 0$ and $p = 1$ represent absence of, respectively total indoctrination. Fortunately, $\lim_{p\to 0} p\, Log(p) = 0$. The entropic evolution of the ideological indoctrination in time, $(H \circ i)_{(t)} = H_{(i_{(t)})}$, is then computed according to equations (3) in the case of perfect indoctrination with $G_{(t)} = 0$, and (4) in case of constant healing with $G_{(t)} = G_0$. The base of the logarithm equals 2 in order to ensure the normalization to 1 of the entropy.

Following figure 5 exhibits both cases. On the upper panel, the indoctrination occurs without healing. The entropy is zero before and after the indoctrination process. Indeed, the susceptible fraction of the society is pure before and after the process, messy during its development. The lower panel shows indoctrination with constant healing. The entropy is null before the indoctrination process, but remains positive after it, thus suggesting a perennial state of discrepancy within the susceptible fraction of the society.

A more practical application of these notions is presented in sections 6.1 and 7.1.

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[5] Source: Apple Lexicon, 2021.

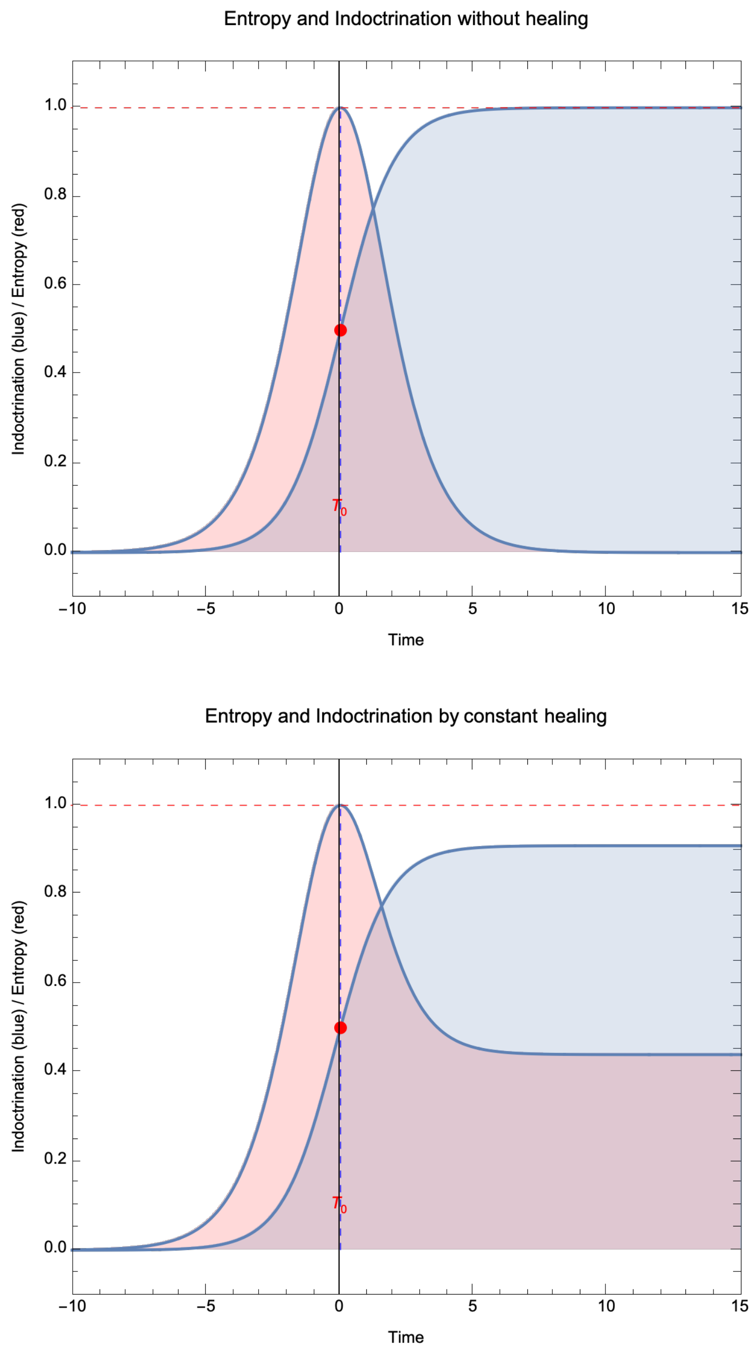


Figure 5: *Both panels: Abscissa: time. Ordinate: indoctrination (blue), respectively entropy (red). Upper panel: Indoctrination without healing. The entropy is zero before and after the indoctrination process. In such a case, the susceptible fraction of the society is pure before and after the process, messy during its development. Lower panel: indoctrination with constant healing. The entropy is null before the indoctrination process, but remains positive after it.*

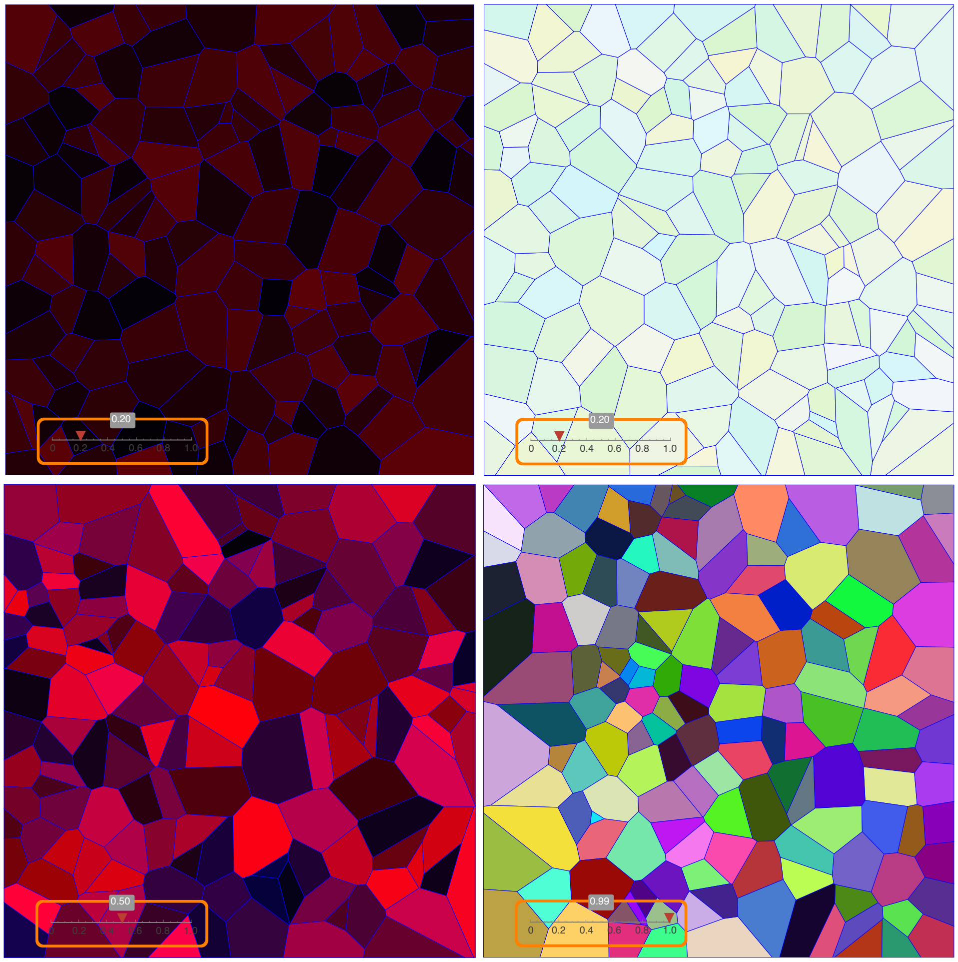


Figure 6: *As an example, it is possible to calculate the entropy of the above graphs, called Voronoi mosaics. We discover that the colors are uniform when the entropy is low on the upper panels: E=0.2 in both cases. With E=0.5, the entropy is medium on the lower left panel, it is maximum on the lower right panel and the colours are intense and varied there: E=0.99. This graphical representation of the entropy is in intuitive agreement with the main text when we associate opinions with colours. Some indications related to the construction of these diagrams are provided in the appendix, page 45.*

4.4 Graphical evaluation of the indoctrination factor

At this stage, a discussion of the dimensionality of the parameters enables us to define the time scale of an indoctrination. Remembering that -

- P is the fraction of the population susceptible of becoming imbued in a doctrine, or indoctrinated. $P \in [0, 1]$ is dimensionless.
- $i_{(t)}$ measures the fraction of actually imbued people in the prevalent population at time t. $i_{(t)} \in [0, P]\ \forall t$, and is dimensionless.
- $\frac{di}{dt}$ measures the rate at which a doctrine spreads in the prevalent group P at time t. It has the dimension $\frac{1}{Time}$.
- $G_{(t)}$ is a dimensionless healing function among those who are indoctrinated.
- R, object of the present discussion, is the indoctrination factor.

As the argument of the exponential term $e^{-PR(t-T_0)}$ has to be free from physical dimension in equations (3) and (4), thus the PR factor has to be expressed in $\frac{1}{Time}$ units. The P parameter being a dimensionless ratio, this is the indoctrination rate R that has to be expressed in $\frac{1}{Time}$ units. Computing $\frac{di}{dt}$ from equation (4) and evaluating it at $t = T_0$ delivers, remembering that $\Delta i = \frac{P}{2}$ at $t = T_0$,

$$\left.\frac{di}{dt}\right|_{t=T_0} = \frac{P^2 R(1 - G_0)}{4} = \frac{\Delta i}{\Delta t} = \frac{P}{2\,\Delta t}$$

and yields, with σ being the summed areas of the triangles on figure 4:

$$R\,(1 - G_0) = \frac{2}{P\,\Delta t} = \frac{1}{\sigma}$$

Geometrically, R is inversely proportional to this area if and has dimension $\frac{1}{Time}$, whereas the "indoctrination time unit" is Δt. This observation enables a graphical evaluation of the indoctrination factor on a graphic, under the prerequisite that the ideological healing factor G_0 is known.

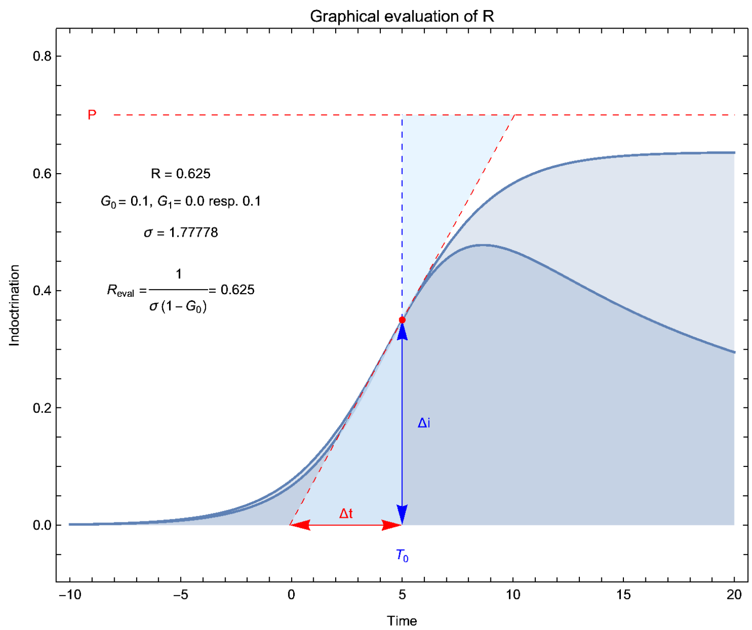


Figure 7: *Evaluation of the indoctrination factor R. The areas of the two triangles is given by $\sigma = \Delta i\, \Delta t$ and is inversely proportional to R. Δt is the "indoctrination time unit". Two situations are presented, with constant healing: $G_0 = 0.1; G_1 = 0$ and linear healing: $G_0 = 0.1; G_1 = 0.1$.*

5 Healing effort increases in time

The main conclusion of the previous section is that ideologies remain present for ever in societies, even at homeopathic levels, when educational, or elucidation, or healing efforts remain constant in time. Thus, ideological healing rising in intensity as time flows down have to be considered in order to achieve the final eradication of an ideology. As initially mentioned, defining a healing function *a priori* is a dared attempt for an epidemic disease, and a quixotic enterprise in cases regarding ideological events. Let we, however, try this and consider two cases:

- the ideological healing effort increases linearly in time.
- the ideological healing effort increases exponentially in time.

5.1 Ideological healing effort increases linearly in time

The healing process is expressed as $G_{(t)} = G_0 + G_1(t - T_1)$, where $G_0 > 0, G_1 > 0$. The time T_1 has to be chosen as an initial condition of the solution. Starting again with equation (2)

$$u_{(t)} = \frac{1}{P} + R\, e^{-PR\,t} \int G_{(t)}\, e^{PR\,t}\, dt + e^{-PR\,t}\, C_1$$

and computing the integral term:

$$\int (G_0 + G_1(t - T_1))\, e^{PR\,t}\, dt = \frac{e^{PR\,t}}{PR}\, (G_0 - G_1\, t_1 + \frac{G_1}{PR}\, (PR\,t - 1) + C_2$$

delivers:

$$u_{(t)} = \frac{1}{P}(1 + G_0 - G_1\, t_1 + \frac{G_1}{PR}\, (PR\,t - 1) + (C_1 + C_2 R)\, e^{-PR\,t}$$

We now compute the integration constant $C = C_1 + C_2 R$, making use of the simplification $T_0 = T_1$. This simplification means that at time $t = T_0 = T_1$ the healing effort equals $G_0 + G_1$. This condition requires, however, that the infection is negligible at a time $t_{past} = T_0 - \frac{G_0}{G_1}$, otherwise, the healing effort would become negative earlier. Following this setting and choosing again $u_{(t=T_0)} = \frac{2}{P}$, the integration constant happens to satisfy:

$$C = \frac{1}{P}(1 - G_0 + \frac{G_1}{PR})\, e^{PR\,T_0}$$

Inserting the result back in the previous equation delivers, after some pencil work and writing $\gamma = \frac{G_1}{PR}$:

$$i_{(t)} = \frac{P}{(1 + G_0) + (1 - G_0)\, e^{-PR(t - T_0)} + \gamma(PR(t - T_0) - 1 + e^{-PR(t - T_0)})} \quad (5)$$

Equation (5) reduces to equation (4) if the healing effort is constant in time: $G_1 = 0$. It reduces to equation (3) if no healing occurs: $G_0 = G_1 = 0$. The initial condition $i_{(t=T_0)} = \frac{P}{2}$ is also satisfied, as required, and the indoctrination vanishes in a distant future, as depicted on figure 5:

$$\lim_{t \to \infty} i_{(t)} = 0$$

This situation is presented on figure 5. Variations of this configuration are given in the Appendix, figure 18, upper panel.

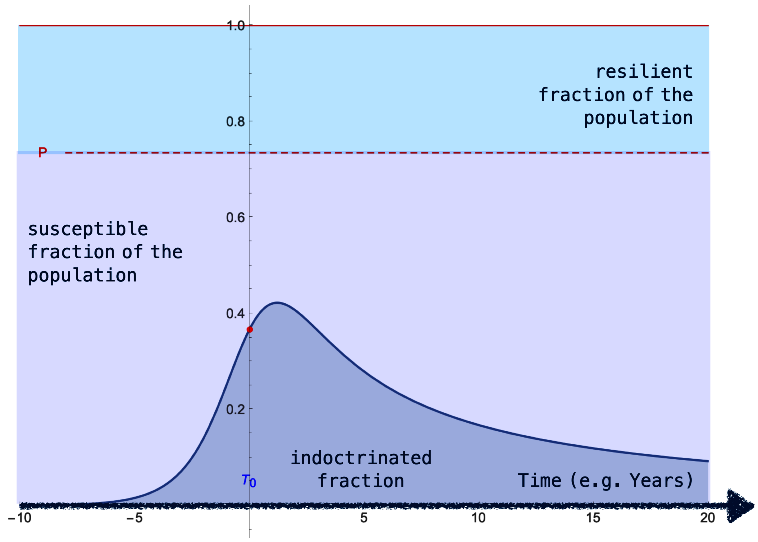


Figure 8: *Evolution of the ideology under healing effort increasing linearly in time according to equation (5). Abscissa: time, Ordinate: Indoctrination rate.* $R = 1; P = 1; T_0 = 0; G_{(t)} = 0$. *The indoctrination vanishes in a distant future.*

5.2 Ideological healing effort increases exponentially in time

This rather artificial feature is expressed as $G_{(t)} = G_0 + G_1 e^{\alpha(t-T_1)}$, where $G_0 > 0, G_1 > 0$ and the exponent satisfies $0 < \alpha \ll 1$. The time T_1 has to be chosen as an initial condition of the solution. Starting with equation (2)

$$u_{(t)} = \frac{1}{P} + R\, e^{-PR\,t} \int G_{(t)}\, e^{PR\,t}\, dt + e^{-PR\,t}\, C_1$$

and computing the integral term yields:

$$\int (G_0 + G_1 e^{\alpha(t-T_1)})\, e^{PR\,t}\, dt = e^{PR\,t}\, (\frac{G_1}{\alpha + PR}\, e^{\alpha(t-t_1)} + \frac{G_0}{PR}) + C_2$$

Plugging this expression in equation (2) gives:

$$u_{(t)} = \frac{1}{P} + (\frac{G_1 R}{\alpha + PR}\, e^{\alpha(t-T_1)} + \frac{G_0}{P}) + (C_1 + C_2 R) e^{-PR\,t}$$

We now compute the integration constant $C = C_1 + C_2 R$, making use of the simplification $T_0 = T_1$. This simplification means that at time $t = T_0 =$

T_1 the healing effort equals $G_0 + G_1$. The effort is weaker before this instant and equals $G_0 > 0$ a long time earlier. It is supposed to grow infinitely in the distant future, obviously a foible in this snippy setting that can only be indulged if $\alpha \ll 1$. Following, however, this setting and choosing again $u_{(t=T_0)} = \frac{2}{P}$, the integration constant happens to satisfy:

$$\frac{1}{P} = (\frac{G_1 R}{\alpha + PR} + \frac{G_0}{P}) + C\, e^{-PR\,T_0}$$

Solving for C and inserting the result back in the previous expression delivers, after some pencil work and writing $\beta = \frac{G_1 PR}{\alpha + PR}$:

$$i_{(t)} = \frac{P}{(1 + G_0) + (1 - G_0)\, e^{-PR(t-T_0)} + \beta\,\big(e^{\alpha(t-T_0)} - e^{-PR(t-T_0)}\big)} \tag{6}$$

Equation (6) reduces to equation (4) if the healing effort is constant in time: $\alpha = G_1 = 0$. It further reduces to equation (3) if no healing occurs: $G_0 = G_1 = 0$. Furthermore, and as required, $i_{(t=T_0)} = \frac{P}{2}$. Finally, as in the previous simulation with linearly growing healing performance, the indoctrination vanishes in a distant future:

$$\lim_{t \to \infty} i_{(t)} = 0$$

This situation is presented on figure 9. Variations of this configuration are given in the Appendix, figure 18, lower panel.

5.3 Susceptibility and indoctrination

Both the ideological susceptibility P and the indoctrination factor R have been kept constant in all the previous calculations. This is of course an (over) simplification aimed at enabling the analytic integration of the initial differential equation (1).

In real societies, the ideological susceptibility P can be reduced in isolating susceptible people or crowds by exerting censorship onto the press, the web, the internet and the social media. In this respect, a lockdown happens to be the epidemiological correspondent to such actions: people are physically separated in order to impede the viral transmission.

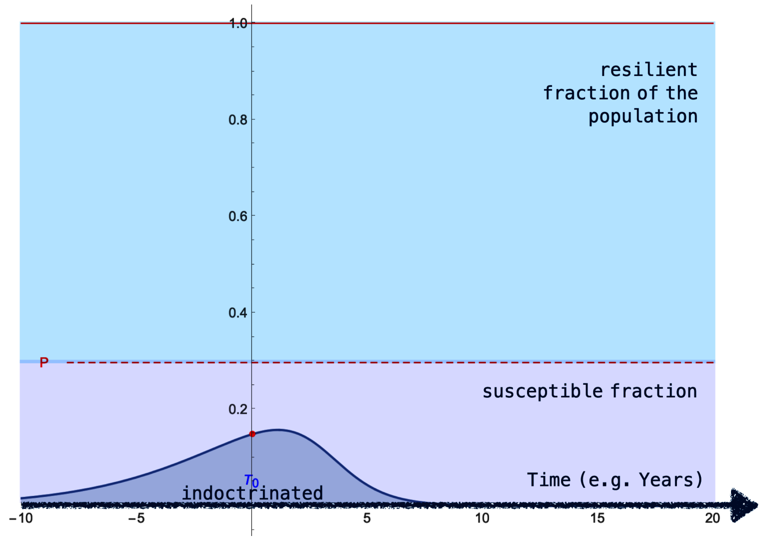


Figure 9: *Evolution of the ideology under healing effort increasing exponentially in time according to equation (6). Abscissa: time, Ordinate: indoctrination.* $R = 1; P = 3/10; T_0 = 0$. *In this case, the fraction of the susceptible population is chosen to be low:* $P = 3/10$, *the indoctrinated fraction remains low and vanishes swiftly.*

The biological reproduction factor R is counting how many people one infected person will infect per unit of time when being in close reach to them. Being of intrinsically biological nature, R depends on the characteristics of the virus and its host. Mostly intangible, it can be solely modified following a natural mutation of the virus or the application of a vaccine. Without a vaccine at hand, medical care does usually not significantly impede the intrinsic virulence.

Translated from the epidemiological to the societal frame, this short reflexion suggests that the indoctrination factor R is likely to be resilient. Many examples of old religious practices or sects having survived over centuries happen to confirm this observation, as exemplified on figures 4 and 5 lower panel. On the contrary, figures 8 and 9 depict the simulated impact of linear, respectively exponential ideological healing within sub-societies of susceptible people. Various intensities of the healing effort are presented on figure 18 for linear and exponential settings, according to equations (5 and 6).

The considerations presented so far failed to deliver a description of the putative "elementary indoctrination step" evoked in the introduction. On the contrary, the "elementary infection step" is accurately documented in biology, as for example through the atmospheric spread of droplets, or the exchange of physiological fluids. The bayesian approach presented in the next section might deliver a clue in this respect.

6 Is the Bayes' Rule an ideological tool?

Sharon Bertsch McGrayne wrote a fascinating tale on the fate of the Bayes' Theorem [3]. Her book's title forebodes its content: *'the theory that would not die; how bayes' rule cracked the enigma code, hunted down russian submarines & emerged triumphant from two centuries of controversy'*. Such a bombastic phraseology is to the point: bayesian methods are nowadays ubiquitous in technologies related to artificial intelligence, as for example in Kevin Murphy's Opus Magnum *'Machine Learning, a probabilistic perspective'* [4].

Put in a nutshell, the 'Mythical Bayes' Rule' enables one to reinforce a judgement based on a weak initial presumption.

Let we try to verify whether a connection can be established between this approach and the ideological/epidemiological setting discussed in the previous chapters. Following the Rule, the probability of occurrence of an event A, provided that another related event B occurs, is defined as the probability of simultaneous occurrence of A ***and*** B, $\mathbb{P}(A \wedge B)$, divided by the probability of B, in symbols $\mathbb{P}(A|B) = \frac{\mathbb{P}(A \wedge B)}{\mathbb{P}(B)}$. As this property is symmetric in A and B, one has:

$$\mathbb{P}(A|B)\mathbb{P}(B) = \mathbb{P}(A \wedge B) = \mathbb{P}(B|A)\mathbb{P}(A).$$

Now considering the dichotomic case where B equals non A and $\mathbb{P}(B) = \mathbb{P}(B|A)\mathbb{P}(A) + \mathbb{P}(B|\neg A)\mathbb{P}(\neg A)$, then the mythical theorem reads[6].

$$\mathbb{P}(A|B) = \frac{\mathbb{P}(B|A)\mathbb{P}(A)}{\mathbb{P}(B|A)\mathbb{P}(A) + \mathbb{P}(B|\neg A)\mathbb{P}(\neg A)} \tag{7}$$

At this point, a simple example is on order. Let we name:

[6] $B = \neg A$ with $A \wedge B = \emptyset$ and $A \vee B = 1$

- $\mathbb{P}(A)$ the prior probability that gods exist. Assume $\mathbb{P}(A) = \frac{2}{3} = 66.6\%$.
- $\mathbb{P}(B|A)$ the conditional probability that people believe in gods if they exist. Assume that 75% of a population believe this, then $\mathbb{P}(B|A) = \frac{3}{4}$.
- $\mathbb{P}(\neg A)$ the probability that gods do not exist. $\mathbb{P}(\neg A) = 1 - \mathbb{P}(A) = \frac{1}{3}$.
- $\mathbb{P}(B|\neg A)$ the conditional probability that people believe in gods if they do not exist. $\mathbb{P}(B|\neg A) = 1 - \mathbb{P}(B|A) = \frac{1}{4}$.

The Bayes' rule delivers: $\mathbb{P}(A|B) = \frac{6}{7}$. In this setting, the pivotal statement asserts that *"under the auspex that gods exist with a probability of 66%, if 75% of a population believes in gods if they exist, then the probability of their existence increases from 66.6% to 85.7%"*. A dared statement indeed, can it be true?
Let we now try to iterate this procedure according to the following chain rule in which $\{\,\mathbb{B}\,\}$ is a condensed writing for the right hand side of equation (7), repeated here:

$$\mathbb{P}(A_i|B) = \frac{1}{1 + \frac{\mathbb{P}(B|\neg A)\mathbb{P}(\neg A_{i-1})}{\mathbb{P}(B|A)\mathbb{P}(A_{i-1})}}$$

$$\cdots \Rightarrow \mathbb{P}(A_{i-1}) \to \{\,\mathbb{B}\,\} \to \mathbb{P}(A_i|B) \Rightarrow \mathbb{P}(A_i) \to \{\,\mathbb{B}\,\} \to \mathbb{P}(A_{i+1}|B) \Rightarrow \cdots \tag{8}$$

The critical step in the sequence is the assumption encapsulated in $\mathbb{P}(A_i|B) \Rightarrow \mathbb{P}(A_i)$. It corresponds to the lazily formulated statement printed in italics above and is formalized as "***the conditional probability*** $\mathbb{P}(A_i|B)$ ***delivered from previous step*** $i-1$ ***is assimilated to the absolute probability*** $\mathbb{P}(A_i)$ ***at step*** i. To my understanding, this implication identifies the elementary ideological step. I express it as an implication "$\Rightarrow$" instead of an equality "$=$" in order to stress the fact that this implication - or deed - is founded on a decision.

Assuming this and having chosen an initial condition $0 < \mathbb{P}(A_1) \ll 1$, the iteration over 35 steps is presented in following figure 10 where, in order to show the intrinsic robustness of the process, the computation has been repeated thirty six times with weak random perturbations applied to the conditional probability $\mathbb{P}(B|A) = 3/5$. The evolution of the indoctrination exhibits a sigmoid pattern that is asymptotic to the $P = 1$ level representing the whole population. The corresponding ideal sigmoid sketched as the dashed purple line is the average of all these thirty six evolutions with the indoctrination factor $R = 0.408141$ computed according to the method presented in section 4.4 and sketched on figure 7.

6.1 Logit

How should this perspective be connected to the ideological/epidemiological setup developed in the previous sections? The quantity called "logarithmic odds", or Logit, provides the link. We consider the ratio expressing the odds between two assumptions, firstly the probability that A is true when B is true and, secondly, the probability that A is true when B is false: Working with the logarithm of the odds yields to some quantity L called Logit:

$$L = Log(\frac{\mathbb{P}(B|A)}{\mathbb{P}(B|\neg A)}) = Log(\frac{\mathbb{P}(B|A)}{1 - \mathbb{P}(B|A)})$$

Computations making use of the iterative method are presented for different values of $\mathbb{P}(B|A)$ in the Annex on figure 19. They suggest a functional relationship between R and L, both expressed as functions of $(\mathbb{P}(B|A))$. $\mathbb{P}(B|A)$ is kept constant up to weak random perturbations during the iterative process given in expression (8), in a similar way as R is kept constant during the integration of the original differential equation (1). How should we prove this? Solving Logit for $\mathbb{P}(B|A)$ delivers a sigmoid that can be related to the right hand side of the bayesian rule, equation (7), after some re-ordering of its terms:

$$\frac{1}{1+e^{-L}} \quad \longleftrightarrow \quad \frac{1}{1+\frac{\mathbb{P}(B|\neg A)\mathbb{P}(\neg A)}{\mathbb{P}(B|A)\mathbb{P}(A)}}$$

$$\frac{1}{1+e^{-L(i-T_0)}} \quad \longleftrightarrow \quad \frac{1}{1+e^{-(L+Log(\frac{\mathbb{P}(A_{i-1})}{\mathbb{P}(\neg A_{i-1})}))}}$$

Following this pragmatic approach, having chosen a (small) initial value $\mathbb{P}(A_{i=1})$, solving the left hand side of the previous equivalence yields:

$T_0 = 1 - \frac{1}{L}\, Log(\frac{\mathbb{P}(A_1)}{1-\mathbb{P}(A_1)})$, where the Log expresses the odds at the initial time.

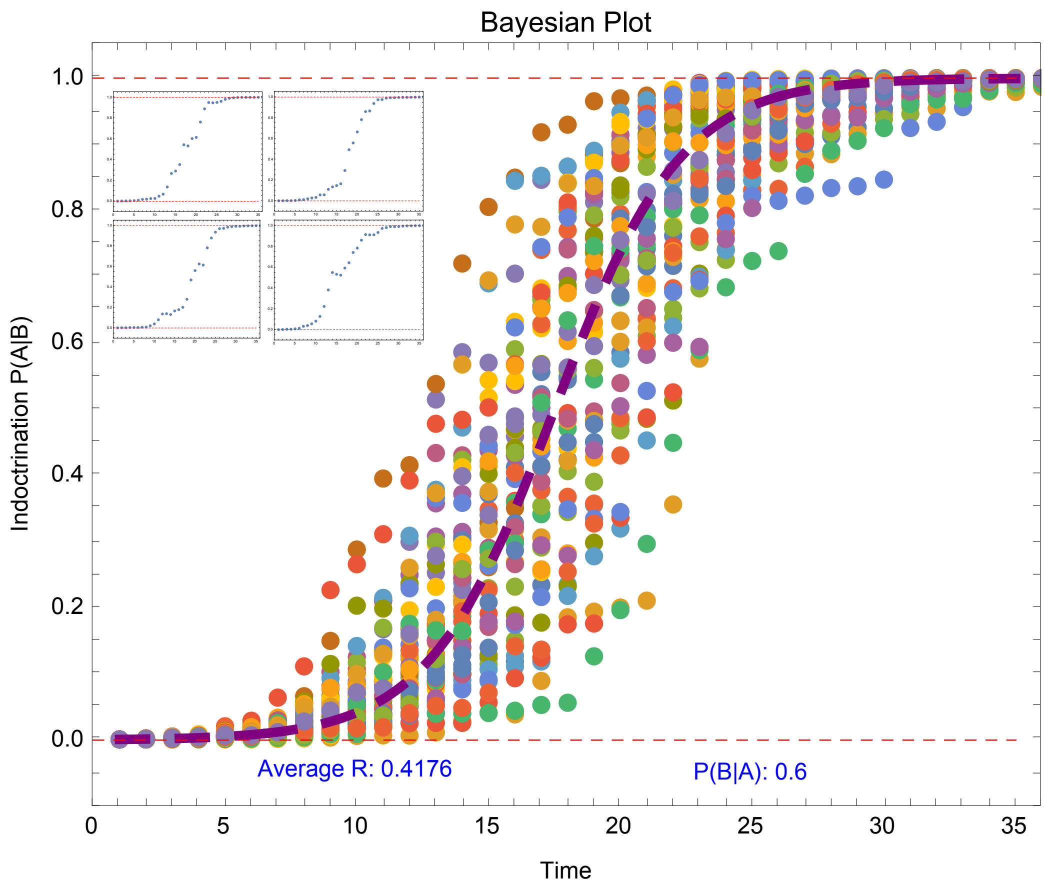


Figure 10: *Evolution of the ideology without healing computed according to sequence defined above. Abscissa: time, Ordinate: Indoctrination. Inset panel: four individual stochastic evolutions. One notices that the estimated average indoctrination factor* $R = 0.4176 \simeq Log(\frac{0.6}{0.4}) = Log(\frac{\mathbb{P}(B|A)}{1-\mathbb{P}(B|A)})$. *The frontal picture of this document results of a dramatic graphical treatment of this figure.*

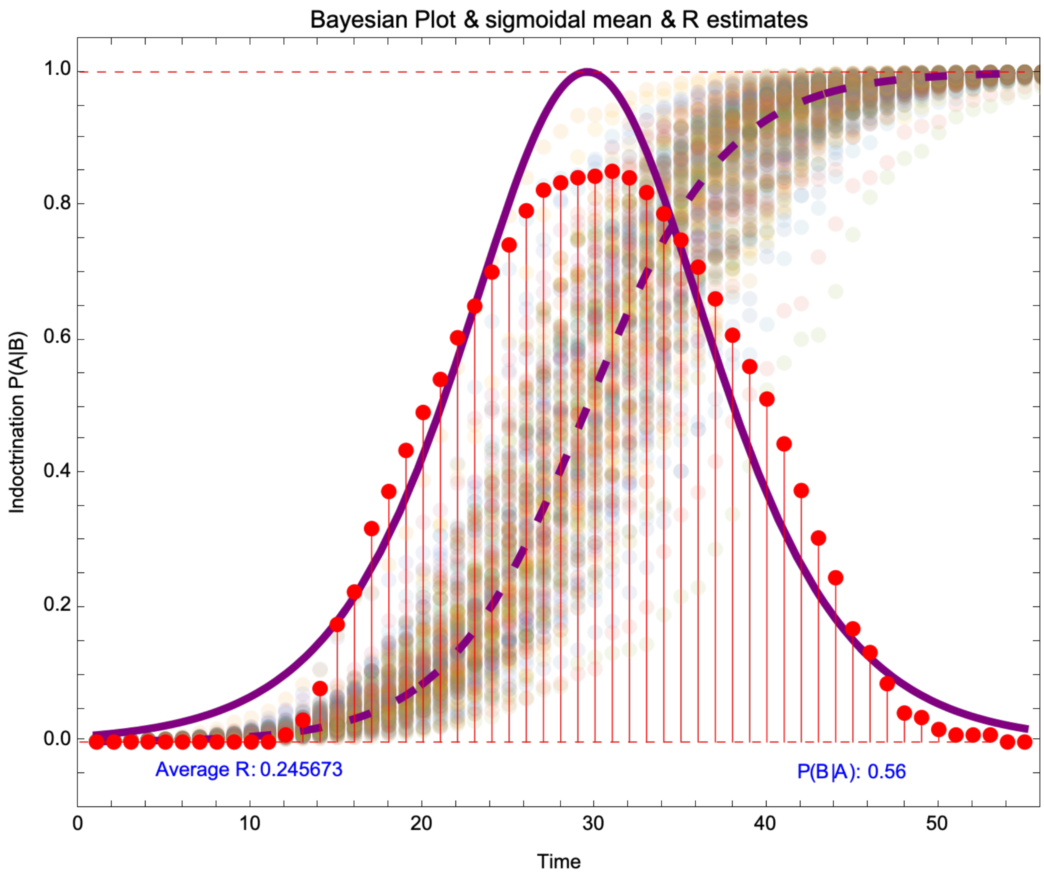


Figure 11: *Entropy of the ideological evolution without healing. Abscissa: time, Ordinate: entropy of the indoctrination process laid in the background. The dashed sigmoidal purple curve describes the evolution of the indoctrination, computed according to the method developed in section 4.4. The continuous purple curve depicts the evolution of the entropy, following section 4.3. Finally, the red dotted distribution describes the actual evolution of the entropy of the indoctrination process.*

A striking trait of the bayesian approach is its resilience against perturbations, as pictured on figures 10 and 11. At the beginning of the process, on the left, all protagonists are located on the bottom horizontal line. In between, the transition is messy due to the randomization arbitrarily implemented in the bayesian rule. However, despite its simplicity, the process happens to be merciless. By the end, on the right, all are on the top, 'indoctrinated'. Accordingly, the entropy, deemed a measure of the order in the societal system, is low before and after the transition. It is high during the transition, thus heralding the messiness of the indoctrination process.

The explicit calculation of the bayesian scheme provides an insight in the indoctrination process: A conditional statement (formulated as a conditional probability) delivered from a previous step of the bayesian sequence is assimilated to a fact (expressed as an absolute probability) at the following step of this sequence. This feat is not distinctly pointed up in the deterministic - analytical approach provided by the Bernoulli's equation, in which the step is hidden under a mere multiplication.

6.2 Meme machines

The question may be raised whether this elementary ideological step does contribute to describe the emergence of memes in our cultures, following here the insights published two decades ago by Susan Blackmore in her book *'The meme machine'* [5].

Ideas, almost like living beings, struggle to survive: cultures and ideas are subjected to intense Darwinian selection. Comparing ideas with genes, Susan Blackmore reframes on a cultural basis the problem raised in the mid seventies by Richard Dawkin: Are my genes -my ideas- there to ensure me to live, or am I the vehicle enabling the transmission of my genetic heritage, my convictions, to my descendants?

Indeed, I may expect to live a few decades but my genes are millions of years old, and they should last a while after me. Therefore, who is the egg, who the chicken? Sue Blackmore wisely notices that ideas, crazes and doctrines, almost like living beings, struggle to survive in a dense and competitive ocean of information. Thus, following her thesis, cultures and ideas are subjected to an intense Darwinian selection. Living beings struggle for life, indeed for the survival of their genes in oceans, savanahs, forests and mountains. Correspondingly, ideas exist and compete in our brains. And, of course, we compete and fight and die for the survival of our ideas. Taking the gene as the unit of biological information (whose part is no longer a gene), and establishing the connection with the cultural world, she defines the meme as unit of cultural information (whose part is meaningless). Dialectically equipped in this way, Blackmore raises again the Dawkinian paradox: Are the memes populating our minds at our disposal, or are we their slaves? Are we Meme Machines?

In her book, the evolution of humankind is addressed first. The development of tools, weapons and ornaments, the eve of languages, as well as the emergence of cultures and religious feelings, is vividly discussed from a memetic point of view. Ideological conflicts and skirmishes occurring in politics, among religions, spiritual chapels and new age worshippers of all kinds are memetically dissected. Altruism, considered the positive effect of an ethical meme, is deserved special attention. The chapter related to modern sexual life, advertisement, fashion and crazes of all origins is exhilarating; indeed, the serious issue of the competition between genes and memes is discussed in this section.

The description of a society of cultivated artificial intelligences, who would live their autonomous life in the Internet and would conspicuously mob those stupid humans, no longer clever enough to grasp the tenets of their robotic cultures and religions, is frightening[7].

Thinkers in social or communication sciences, a guild I do not belong to, may better answer the question raised above.

[7]Source: J. Ambühl 2006.

7 Spatial Bayes

As no interaction among the members of the population has been considered so far during the indoctrination process, the next step will consist in simulating such a relationship.

Staying faithful to the tenet of maximal simplicity, we construct a network whose vertices represent the individuals in the population and the edges the relations among them. Two vertices are related if they are connected, strangers if they are not, and the intensity of their relationship is inversely proportional to the length of the edge connecting them. In reality, the distance between individuals - vertices - is likely to be expressed as convictions, in economical, societal or even statutory endowments, or any combination of them.
This minimal setting may be represented as a graph whose vertices are points randomly distributed in a square, and edges relationships. In this setting, each vertex is arbitrarily given three neighbours. This construction is presented in figure 12 for ten, respectively one hundred individuals. As one notices, some vertices have been chosen as neighbours by more than three other vertices, thus the degree of vertices may be higher than three. The colors express the euclidian distances from the left most vertex to each other, the more bluish, the more far away.
On the right side of the left panel, the lone blue vertex, together with the pink, purple and red vertices are related, building a small sub-crowd. Bluish vertices on the left side are member of another crowd. On the right panel, the graph exhibits three distinct connected components that may be considered as isles, or disconnected tribes. In both cases, the Voronoi tessellation in the background has no other purpose than esthetics.

Finally, it must be stressed that the euclidian distance used here has to be considered a surrogate for a more complex and abstract metric that could measure societal, statutory or ideological differences. In this perspective, the underlying space should no longer be considered as geometrical, but as a realm whose coordinates span societal, statutory or ideological qualities.

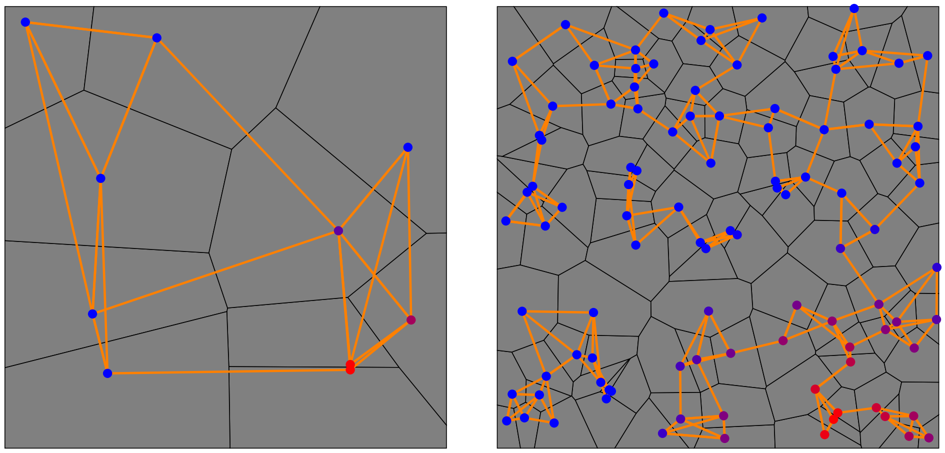


Figure 12: *Two examples of relational graphs among populations of ten and one hundred members.*

7.1 Iteration

The temporal iterative step given in expression (8), $\mathbb{P}(A_i|B) \Rightarrow \mathbb{P}(A_i)$, is now augmented in order to take into account the network of relationships among the population and takes the following form:

$$\cdots \to \{\,\mathbb{B}\,\} \to \mathbb{P}(A_i|B) \to \mathcal{M}_{j\in N_i}[\mathbb{P}(A_j|B)] \Rightarrow \mathbb{P}(A_i) \to \{\,\mathbb{B}\,\} \to \cdots \tag{9}$$

The set N_i denotes the neighbours of a vertex i, three in the current setting, plus the vertex i itself.[8] $\mathcal{M}$ is an operator that may be tuned in order to compute the Max, the Mean, the Weighted Mean of the $\mathbb{P}(A_j|B)$ belonging to N_i, or simply act as the neutral operator delivering $\mathbb{P}(A_i|B)$ again, as in expression (8).

Following figure 14 exhibits the a spatial spread of the ideology according to the bayesian rules expressed in the sequence (9). In this example, the population is 500 individuals, the evolutions lasts for 200 steps, the conditional probability is set at $\mathbb{P}(B|A) = 0.52$ and the averaging operator $\mathcal{M}$ is tuned on 'Mean'.
The upper left panel describes the temporal evolution of the indoctrination, as in figure 10. On the upper right panel, at time unit 40 after the beginning

[8] Following Bertrand Russell, logicians may frown upon this.

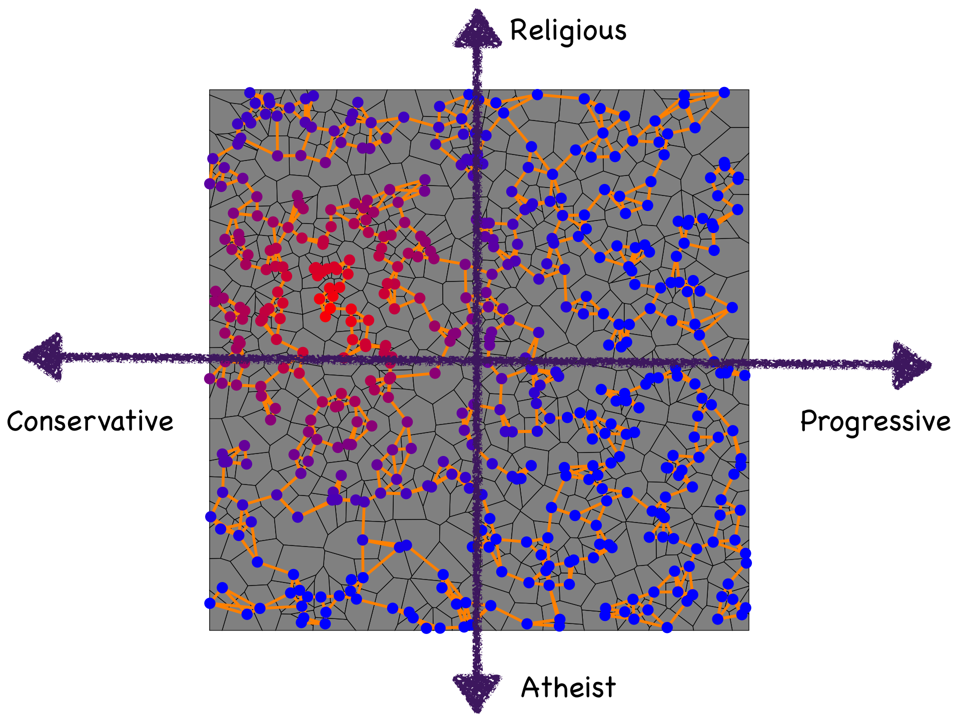


Figure 13: *Example of the geometrical representation of alleged contrasts that may occur between atheism versus religiosity, and liberality versus conservatism. The spread of an opinion, or an ideology, is sketched as a crowd of reddish vertices on the network. In that hypothetical case, the ideology spreads among people - or agents - who are weakly religious, but definitely conservative.*

of the process, most of the vertices are blue, un-indoctrinated. Only one ideological super-spreader that has been arbitrarily located slightly to the right of the middle of the diagram has started to imbue his/her/its neighbors. On the lower right panel, at time unit 160, the indoctrination has reached a vast fraction of connected vertices. In between, the spreading process is shown at time units 70, 100 and 130. The indoctrination occurs along "roads of affinities" among the vertices and does not reach isolated isles, as for example the disconnected sub-network located at the upper left corner of the network. Furthermore, the randomization $\mathbb{P}(B|A)+Random[-0.1+0.1]$ may take values lower than 1/2, thus yielding negative odds.
Figure 15 is computed according to the setting presented in figure 14 with the evolution of the entropy pictured on the upper right panel.

Chance reigns unchallenged on the indoctrination processes simulated with help of the Bayes' rule applied in sections 6 and 7, in full opposition to the deterministic approach presented in the sections 3 to 5 of this essay. However, both approaches - deterministic and stochastic -, happen to stay in a dualistic relationship and deliver coherent and compatible conclusions.

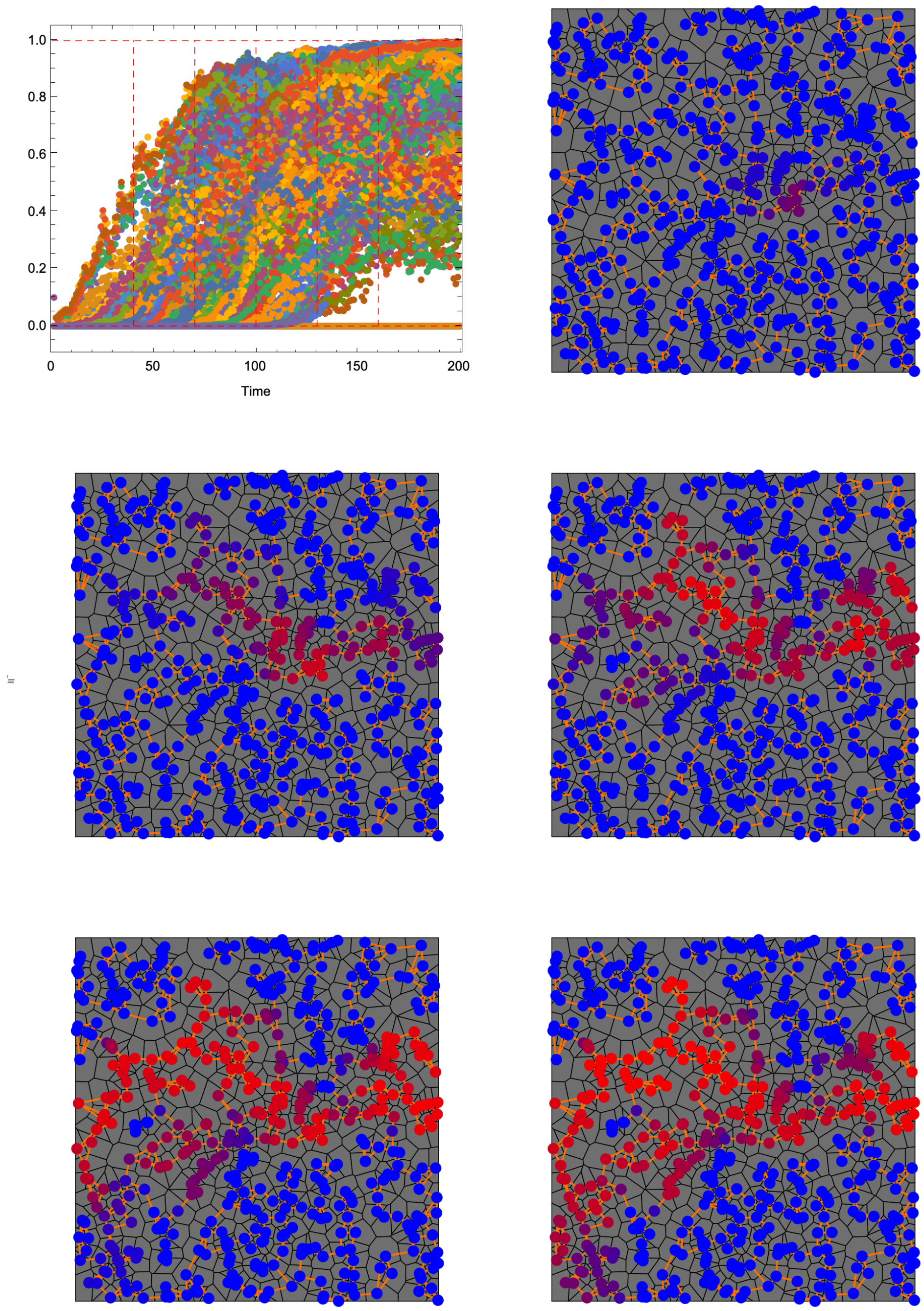


Figure 14: *Spatial evolution of the ideology without healing. As explained in the main text, the underlying space should no longer be considered as geometrical, but as a realm whose coordinates span societal, statutory or ideological qualities. Initiating the indoctrination process, a superspreader is well betokened in the upper right panel just right to its centre.*

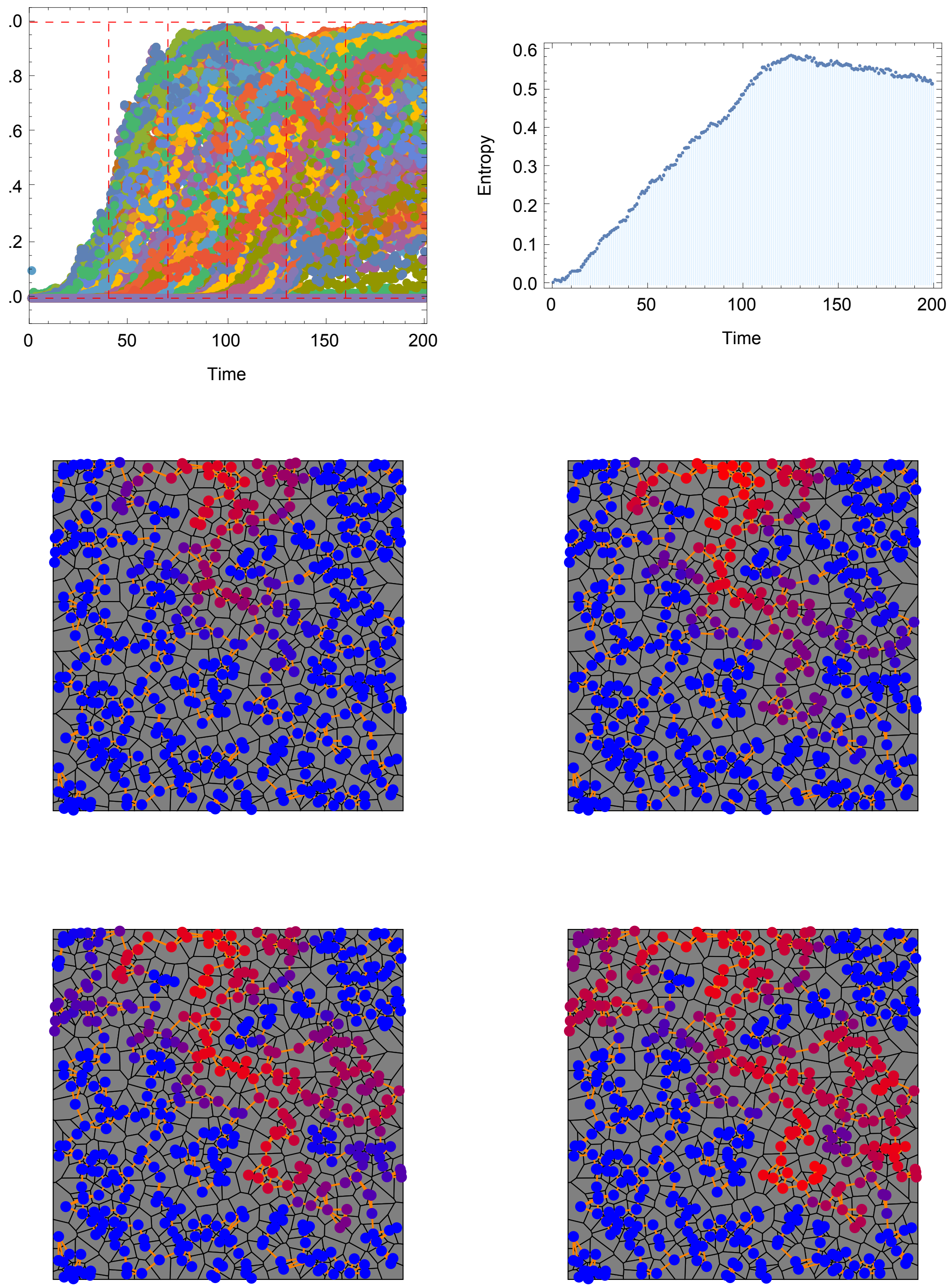


Figure 15: *Spatial evolution of the ideology without healing computed according to the setup presented in previous figure 14. The evolution of the entropy is shown on the upper right panel and exhibits a pattern similar to figure 5.*

7.2 Are ideological superspreaders Maxwell's Demons?

According to classical thermodynamics and its first principle, entropy is a measure of the energy - or heat - unavailable in a system for effective mechanical work. However, would a system be equipped with an entropy sink, it would be able to collect this waste heat and transform it into effective energy, or structure. Such a sink is known as a 'Maxwell demon'. Are there any such demons in the real, familiar world around us? The answer is yes, in a surprisingly manner. Here are two examples:

Firstly, atmospheric convection transforms the water vapor contained in the air into liquid water (or snow or hail) and thus collects the diffuse latent energy of the water vapor through the corresponding phase change. This process induces atmospheric convection and creates the complex (and beautiful) structures that are cumulus and cumulonimbus. It makes liquid water available to the underlying terrestrial eco-system via rain.

Plant photosynthesis is the second paradigmatic example of Maxwell's demon. Photosynthesis is the process by which plants collect carbon dioxide from the atmosphere, make use of water vapor and especially light energy, all substances available in a state of high entropy, and transform these ingredients into vegetal webbing, trunks, branches, roots, leaves, flowers. Plants are air made stuff. The oxygen thus produced is only a reaction residue. Oliver Norton's book: *Eating the Sun, the everyday miracle of how plants power the planet*, describes fascinating aspects of the vegetal world and its entropic properties, [6].

Under favorable auspices, financial systems may also be considered as Maxwell's demons, explaining this would require another essay... But the question raised here is simple: Does this explanation based on entropy sinks apply to our ideological systems? Have not been prophets, gurus, evangelists effective ideological superspreaders in troubled times in their corresponding societies? Is it reasonable to perceive them as avatars of the Maxwell's demon?

They initiate their ideologies during phases of ideological transition in which entropy is high, as shown in figures 5, upper panel, 10 and 11, and their ideologies then spread according to the laws outlined in the essay. Paradoxically, ideological superspreaders may also thrive in societies hosting effective educational systems allowing the free emergence of new opinions, as pictured in figures 5, lower panel, 13 and **??**. It would be reasonable to call endemic ideologies such recurrent or long lasting ideologies. On the contrary, the emergence of ideologies or simply new ideas is systematically inhibited in societies with little or zero entropy. The processes of ideological inhibition presented in Section 5, Healing effort increases in time, figures 8 and 9, describes this situation.

8 Discussion

Common sense and historically established conventions happen to be dismounted in short periods of time when unexpected ideologies spread, imposing new alien tenets in a heretofore stable society.

In case of an ideological infection, if no ideological healing is present, then, as formulated in equation (3), the susceptible and ultimately impacted fraction of the society, when observed from abroad, seems to change its mindset as a coherent, integral body, as sketched in figures 2 and 5, upper panel. In such a circumstance, the ideology acts as a decision process encompassing the susceptible fraction in its integrity. This phenomena occurs only in the fraction of the society susceptible of becoming imbued in a doctrine when $P < 1$. Otherwise, as soon as $P = 1$, the whole society becomes imbued in a doctrine.

Phase transitions, ubiquitous in the physical world, happen to be natural equivalents to the indoctrination process discussed here. The sudden dissolution of the fog in the course of an autumnal day or the abrupt demagnetization of a chunk of iron submitted to increasing temperature are vivid examples of such changes of state. They unfurl swiftly and encompass in uncoordinated manner the totality of the medium - portion of the atmosphere, chunk of iron or a whole society.

The indoctrination (or infection) process does not occur at a discretionary gait. The process engenders its own pace of the time, solely determined by the product PR of the ideological susceptibility and the indoctrination factor. This pace, genuine to the indoctrination, can be estimated afterwards in term of months, years, or any suitable time unit.

As soon as an ideological healing effort $G_0 > 0$ is present in the society and reaches its susceptible fraction, mostly in form of adequate education and unbiased information, then a further reduction occurs and only a subset of the susceptible population becomes infected, a sketched on figures 3 and 5, lower panel. However, if this healing effort remains constant in time, then no suppression of the ideology occurs. In such a circumstance, the society happens to be forever divided into two antonymous camps. This phenomena is captured by the entropic evaluation of the indoctrination process sketched in figure 5, lower panel, and figure **??**. On the contrary, ideologically pure populations sport zero entropy values, as sketched on figures 5, upper panel, and 11. In such a case, the entropic burst occurring during the ideological transition may well be associated to a social revolution.

The introduction of a healing effort increasing as time flows down manages to eradicate the ideology. In the two options considered here, displayed on figures 8 and 9 where the strength of the educational effort increases linearly, respectively exponentially in time, the ideology eventually vanishes after after a "long enough" elapsed period.

Obviously, however, as no educational effort can grow indefinitely, it must be stressed that both models are artificial in their essence. They only deliver a clue of what may happen in real societies. "Educational systems" of that kind should rather be related to the brutal repression methods deployed since time immemorial by humankind, for example in the abrahamic religions, up to the repressive methods nowadays implemented all around the world. In this perspective, societal structures and traditions akin to the catholic inquisition, the sharia, the KGB or many dark departments implemented in various political regimes may well be perceived as societal immune systems.

These four stages of indoctrination and the corresponding healing efforts are recapitulated in the following figure 16. The upper left panel exhibits a full indoctrination in the susceptible population, without ideological healing, according to subsection 4.1. The upper right panel is related to the subsection 4.2, where the healing effort is constant in time. The lower panels correspond to subsections 5.1 and 5.2 with healing efforts increasing linearly, respectively exponentially in time.

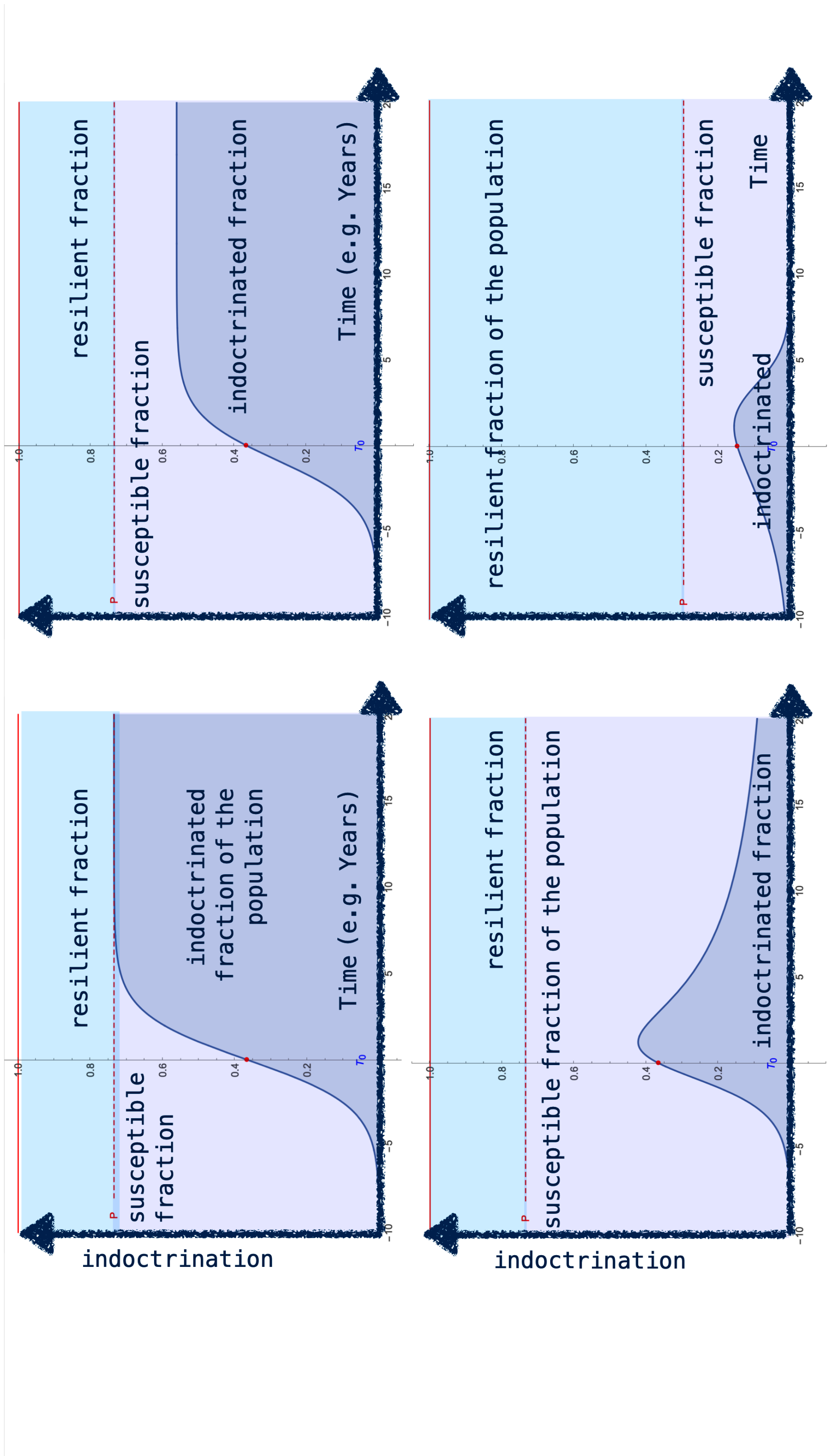


Figure 16: *Four outcomes of an ideological event.*

A fascinating fictional example of an immune system is elaborated in Solaris, the iconic novel by Stanislaw Lem, that was adapted in two quite different films, in 1974 by the Russian director Andrei Tarkovsky and in 2002 by the Hollywood director Steven Soderbergh[9].

The bayesian scheme provides an insight in the indoctrination process. A conditional statement delivered from a previous step of the bayesian sequence is assimilated to a fact at the following step of this sequence. Computations show that this transmission mode happens to be resilient to random perturbations. Whether this elementary ideological step may contribute to the description of the emergence of memes in our cultures and ideologies, following the insights presented decades ago by Richard Dawkin and by Susan Blackmore, remains an open question.

Another question that remains unanswered to me is to know whether Thomas Bayes was influenced by the ontological argument presented by Arch-

[9]Solaris is a planet located a few thousand light years from our solar system. It is covered with an ocean, a mindful ocean, a kind of holistic, organic spirit. Does it make sense? Do we know such examples on earth? Think about James Lovelock's Gaïa Hypothesis. At the same time when Lem's novel was published, James Lovelock and Lynn Margulis proposed that the entire earth biosphere might be one conscious living being. This vision is amply discussed in already cited Morton's book *Eating the Sun*, [6]. Another example? Our immune systems are holistic fluids spread in our blood, operating without brain or central agency, able to monitor thousand of microbiological threats, to memorize their patterns, and to trigger our immune defenses when necessary.

Having discovered Solaris, humankind decides to monitor its behavior and therefore installs a scientific spacecraft in close orbit around it, aimed at deciphering its signals and possibly starting an intelligent relationship. Alas, the undertaking goes berserk. Dr. psychologist Kris Kelvin (George Clooney) is dispatched to the scientific orbiter. What he discovers when entering the vessel is a good deal of dried blood, a few frozen bodies and two mad survivors, the captain (Viola Davis) and a physicist (Jeremy Davies) "If you keep something to a solution, you are borne in on dying soon".

What occurred? Solaris protects itself against the scientific enquiries in projecting back to the researchers their most painful, traumatic and repressed thoughts and memories, thus triggering their madness. Solaris's immune system at work: the alienness of the alien is so inconceivably different from human consciousness that all attempts at communication are unfathomably doomed. Is Dr. Kelvin protected? Not at all. He meets, or he thinks he meets his deceased wife Rhea (Natasha MacElhone) who committed suicide a decade ago after a dispute between them. Is she a dream? Is she a nightmare? Is she real? At least, for him and for the others in the spacecraft she is there, full of life and beauty and, of course, he falls in love, again. He falls in love in the anti body projected by the alien....

bishop Anselm of Canterbury (1033-1109)[10]. Anselm searched a direct proof of god's existence. Bayes is likely to have known this ontological argument, as well as the fact that it was deemed logically mistaken by the middle of the XVIII century. Thus, did Reverend Bayes worked out a contrapositive argument formulated as "if people believe in gods, do they then exist?" An answer to this question lies beyond my intelligence.

9 Conclusion

"Not only microbes, but also news are contagious, and the brain happens to be the most vulnerable part of the body, according to the German philosopher Peter Sloterdeijk, because there are countless suggestions for arousal every day", as cited by the Austrian philosopher Lisz Hirn in her book "Who needs superheroes?"[11]. Thus, are books and writings akin to virus who cannot survive without a host, either biological, or ideological, but succeed in infecting it, her, or him in the corresponding way?

Daring to provide an answer to such a question, the methods applied in this work sought simplicity, just beyond triviality, and may have delivered insights in matters related to the connexions between ideologies and epidemics, renowned for their controversial character. Both approaches, on the one side analytic - deterministic following Bernoulli, on the other side empirical - stochastic and Bayesian, happen to stay in a dualistic relationship. They deliver coherent and compatible conclusions, as suggested in the introduction in figure 1.

[10]The first ontological argument in Western Christian tradition was proposed by Saint Anselm of Canterbury in his 1078 work, Proslogion (Latin: Proslogium, lit. 'Discourse on the Existence of God'), in which he defines God as "a being that which no greater can be conceived," and argues that such being must exist in the mind, even in that of the person who denies the existence of God. From this, he suggests that if the greatest possible being exists in the mind, it must also exist in reality, because if it existed only in the mind, then an even greater being must be possible - one who exists both in mind and in reality -. Therefore, this greatest possible being must exist in reality. Source: Wikipedia.

[11]Molden editor, 2020 & https://www.blick.ch/news/politics/interview-mit-dem-deutschen-philosophen-peter-sloterdijk-man-soll-nie-etwas-fuer-unmoeglich-halten-id6391441.html

Interestingly, these methods were known to the mathematicians by the end of the XVIII century.[12] It would have been a matter of insight to apply them and derive some of the results presented. Working now at the beginning of the XXI century, three software packages I wrote in the Mathematica framework enabled me to cope with the demanding numerical computations, and provided the numerous graphics illustrating the work.

Finally, it should be stressed that the cogitations presented so far are speculative in their essence. Although not suited to actual predictions, they deliver a clear answer to question raised in this essay: Are Ideologies Epidemics? I dare to answer Yes!

[12] Jakob Bernoulli: 1655-1705. Thomas Bayes 1701-1761.

10 Appendix

Figure 17, related to the subsection 4.1 - No ideological healing. Top panel: evolution of the the ideology according to equation (4), without educational effort. Lower panel: evolution of the ideology with constant healing effort in time, according to equation (4). Upper panel: five fraction parameters of the population susceptible to be ideologised are presented: $P \to \{1/5, 2/5, 3/5, 4/5, 1\}$. Lower panel: four strengths of the healing effort are presented: $G_0 \to \{2/7, 3/7, 4/7, 5/7\}$. In both cases, $R = 1, T_0 = 5$.

Figure 18, related to the subsections 5.1 and 5.2 - Ideological healing effort increases linearly / exponentially in time.Top panel: evolution of the indoctrination as the healing performance increases at a linear pace in time according to equation (5).Lower panel: evolution of the indoctrination as the healing performance increases at an exponential pace in time, according to equation (6). Upper panel: four healing parameters $G1 \to \{1/5, 2/5, 3/5, 4/5\}$. Lower panel: four healing parameters $G1 \to \{1/5, 2/5, 3/5, 4/5\}$. In both cases, $R = 1; T_0 = 0; P = 1$.

Figure 19: related to the subsection 6.1 - Logit. Numerical assessment of the relations between $\mathbb{P}(B|A)$, R and T_0. Abscissa: conditional probability $\mathbb{P}(B|A)$. Ordinate: - Red curve: computed Logit; blue dots: estimated indoctrination factor R. Green curve: computed product $T_0 \,.\, Logit$; purple dots: estimated product $T_0 \,.\, R$.

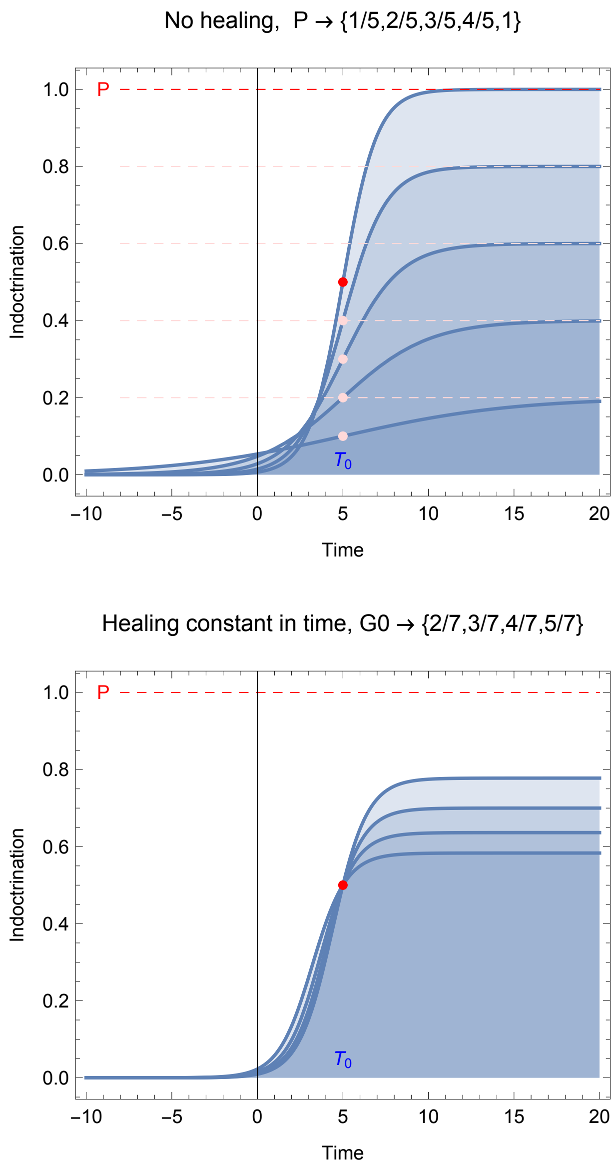
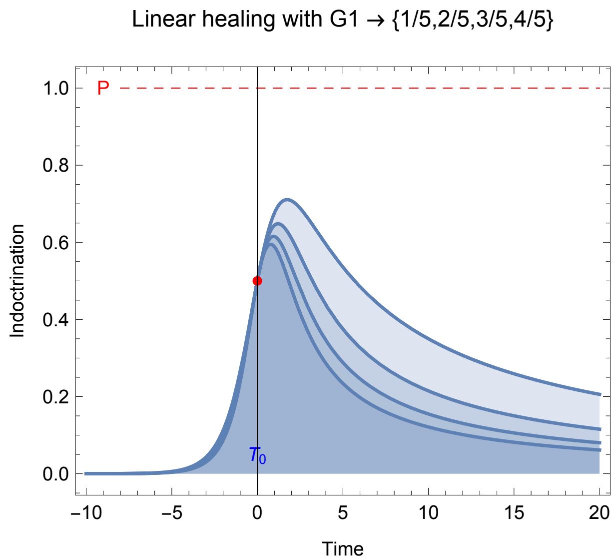


Figure 17: *Top panel: evolution of the the ideology according to various susceptibility factors, without educational effort. Lower panel: evolution of the ideology with constant healing effort in time at constant susceptibility factor* $P = 1$.



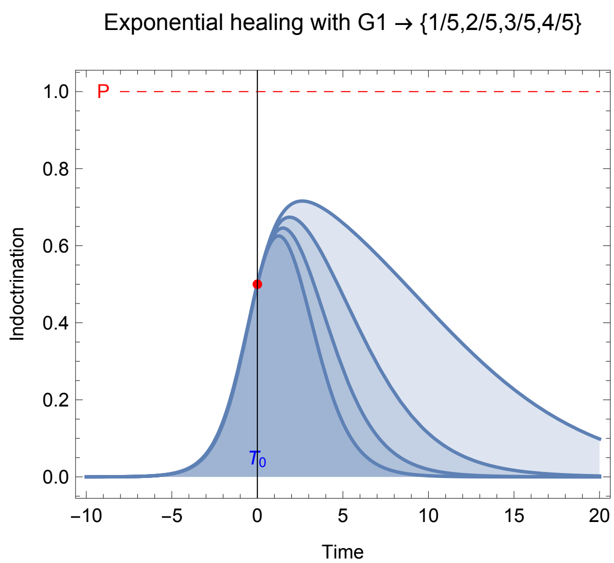


Figure 18: *Top panel: evolution of the indoctrination as the healing performance increases at a linear pace in time. Lower panel: evolution of the indoctrination as the healing performance increases at an exponential pace in time.*

10.1 Numerical assessment of the Logit values

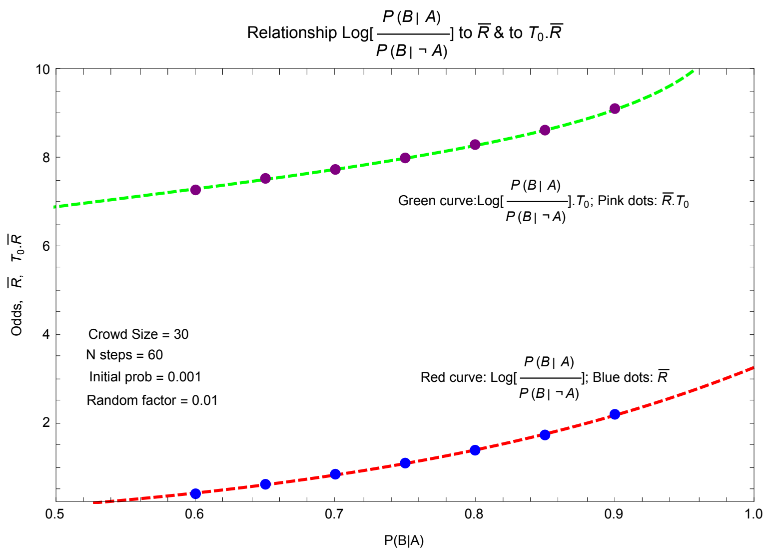


Figure 19: *Numerical assessment of the Logit values expressed as relations between $\mathbb{P}(B|A)$, R and T_0. The curves describe theoretical functions, the dots, computed according to the bayesian sequence, are submitted to the tiny random perturbations.*

10.2 Artist Voronoi

I fistly define a Voronoi tesselation with n tile making use of the procedure *MeshPrimitives[VoronoiMesh[pts,-1,1,-1,1],2]* from Mathemastica.

Working in the RGB realm (Red, Green, Blue) , I then choose three domains of colours $\{[R_{inf}, R_{sup}], [B_{inf}, B_{sup}], [Ginf, G_{sup}]\}$ in which the colors of my tesselation will be picked up. As the domains of colors are sub-segments of the segment $[0, 1]$: RGB colors are defined betwen 0 and 1, I consider these colors as probabilities, manipulated as such.

Making use of a simple uniform random generator operating in the bounds inf and sup defined above, I construct a $\{n, 3\}$ table of the RGB colours to be attributed to the n tiles of the tessellation. The line of that table are of the form $\{r, b, g\}_i$ with $r_i \in [R_{inf}, R_{sup}]$, $g_i \in [G_{inf}, G_{sup}]$ and $b_i \in [B_{inf}, B_{sup}]$.

The coloring of the tesselation is then performed by the graphical procedures provided by Mathematica.

The calcul of the entropy proceeds via l'expression standard
$E = -\frac{1}{3} \sum_{i=1}^{n} (r_i Log(n, r_i) + g_i Log(n, g_i) + b_i Log(n, b_i))$

As in the main text, the logarithm has to be computed in the basis corresponding to the numbers of bins in the distribution, for us here to the number of tiles in the tessellation. This point can be settled with the well known college formulae $Log_a(x) = Log_b(x) Log_a(b)$. This enables the calibration of the entropy to the unity, and fortunately, $\lim_{p \to 0} p\, Log(p) = 0$

11 References

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