Brain Change – How Is Our Brain Coping with Fake News and Misinformation

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I Preamble: To Avoid Misunderstandings

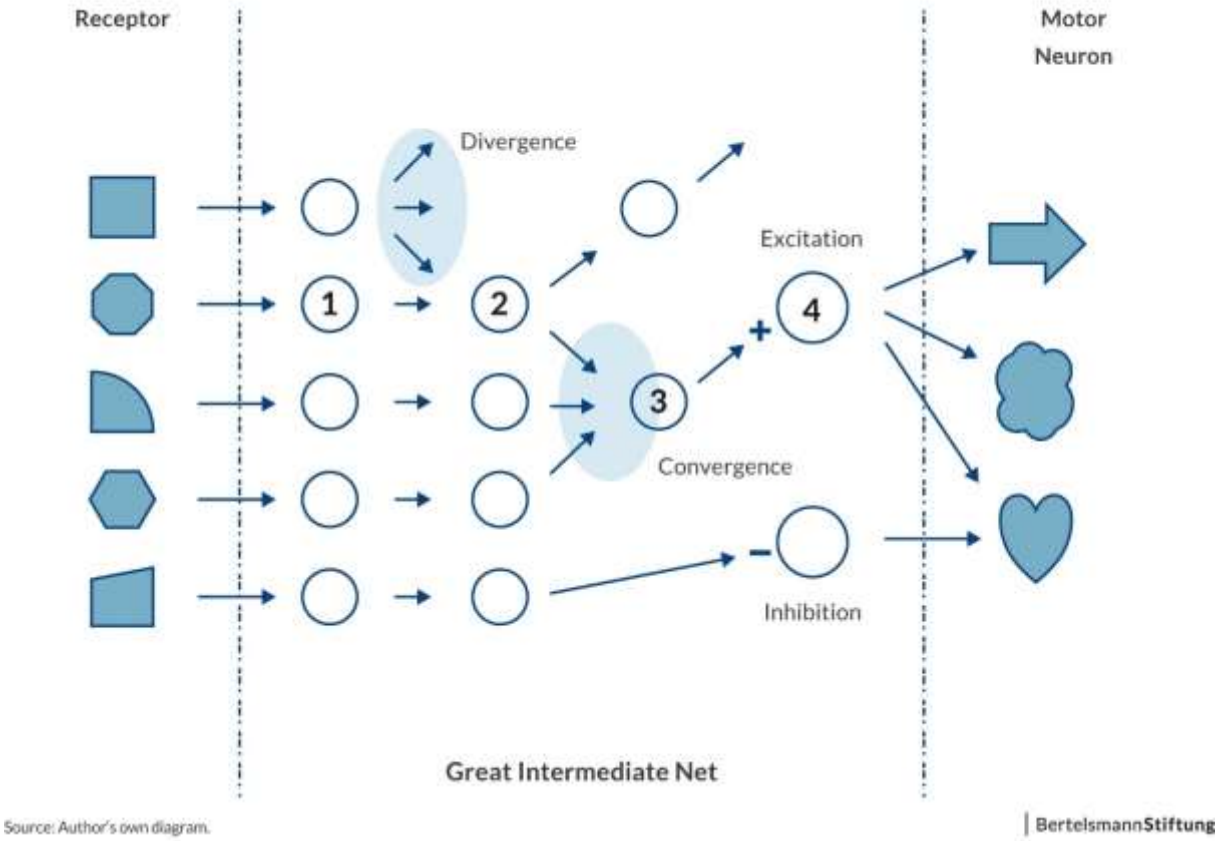
In case the reader is convinced that the brain and the mind are fundamentally different "things", or "substances", as some philosophers believe, in case "dualism" is considered to be the only acceptable epistemological position with respect to the so-called "mind-body-problem", it is not necessary to continue to read. The reader would only waste time. Whatever will be described here by somebody who is a representative of a "pragmatic monism" with respect to the "mind-body problem" will appear to be rather questionable, even meaningless; the conclusions concerning psychological mechanisms, for instance a strong belief in fake news, would appear most likely far-fetched. The reasoning of a brain scientist with such a monistic position is conceptually far away from a dualistic understanding of how the human mind functions.

What could be the basis of a *monistic* position? The reasoning is rather simple. Whatever can be defined as a psychological phenomenon, whatever is represented in consciousness, whatever has a subjective reality (seeing, hearing, tasting, feeling, loving, remembering, believing, talking, deciding, wanting, thinking, etc.) can be lost or disrupted because of an injury or a disease of the brain. On that basis the conclusion is: *The loss of a function is a proof of its existence*. Common sense dictates: If psychological phenomena would not be based in the brain, they could not be lost after structural damage or disease of the brain. The monistic reasoning is also reflected in a famous statement in the life sciences by the biologist Theodosius Dobzhansky: "Nothing makes sense in biology (which includes brain science) except in the light of evolution". It should, however, be noted that such a statement about our evolutionary heritage or the epistemological position of a "pragmatic monism" cannot be proven in a mathematical sense. This is an expression of a scientific attitude about how the human mind functions, and how the mind can be explained on the basis of neural mechanisms in the brain. This scientific attitude is the consequence of a consistency of observations, the results of many experiments, and of theoretical reasoning; it is not claimed to communicate "absolute truth". Brain scientists as any scientists are (or should be) modest.

II Short Overview on Basic Features of the Brain and its Functions on the Cellular Level with Some Surprising Consequences

Before making some statements about the human psychological repertoire, it appears to be useful to get an understanding about some basic mechanisms and structural features of the brain. In Figure 1, the principle structure of the brain is shown on the *cellular* level. This is an abstract representation of fundamental principles that are shared by all organisms which have brains. This universal principle of "sharing" indicates also that humans within the evolutionary history are part of a "universe of all living beings" on this globe. That nerve cells are separate elements has been an important discovery in brain science (being honoured with a Nobel Prize). This fact, (and it is a fact), leads to one of the great questions and challenges in brain science: how such distinct and separate elements work together to give rise to experiences or to consciousness.

Figure 1



Source: Author's own diagram.

There are basically only three types of nerve cells:

1. Receptors (or sensory cells); these are the “antenna” that provide information from the world around us and also the world within us (like receptors in the eyes, the ears, or sensory cells that signal pain). Humans have several hundred million such receptors. Although this is a big number, it has to be stressed that we do not have “antenna” for everything. The sense organs are specific adaptations to properties of the physical world that are extremely limited. It is counter-intuitive, but it is a fact: We are blind and deaf to most regions of the physical environment. One task of research is (and always has been) to expand our access to the world by the invention of microscopes and telescopes, i.e. to go beyond what “mother nature” has given us. This is a recent development in science (compared to the many million years of evolution) going back a few hundred years only. Indeed, believing in the “truth” or correctness of what we observe in telescopes and microscopes has been a major revolution. Can something still represent “reality” if it is accessible only indirectly by technological means?

2. The other type of cells is “motor neurons” (a few million in humans) which represent the output of what has been processed in the brain. These motor neurons make movements possible, like walking, talking or facial expressions, and they control the internal organs. Although we have much fewer motor neurons than receptors, they represent the active link to the world. We scan the world with eye movements, we pick up information by reading. And motor neurons create the structural basis for social contacts as certain muscles in the face signal emotional states like happiness, sadness, or anger. If motor neurons can no longer control muscles, we are “frozen”, and the link to the world around is disrupted.

3. The third type of nerve cells is the Great Intermediate Net (GIN), and we have more than 100 billion of those. This GIN represents nerve cells between the input (receptors) and the output (motor neurons). During evolution, the GIN has expanded, particularly in higher mammals like humans. So-called “primitive” life forms have a much smaller GIN, and some have actually none, i.e. only receptors and motor neurons. For the GIN, three aspects are important for a basic understanding of information processing in our brain and our experiences:

   a) Each nerve cell sends information to some 10,000 other nerve cells: “divergence of projection”. In a complementary way, each nerve cell receives information from some 10,000 other nerve cells: “convergence”. This fact, (and it is a fact), invites a little mathematical calculation. If one assumes that of the 10,000 inputs, 100 are independent of each other (which would imply a substantial complexity reduction in information processing which happens all the time in the brain), then each nerve cell would have 2 to the power of 100 (minus 1) potential functional states, which is 10 to the power of 30, i.e. a “1” with 30 zeros. Our life expectancy is much less than 10 to the power of 10 seconds. This means that the richness of potential functional states of one nerve cell during our lifetime can never be exhausted. This also means that, in principle, functional states of nerve cells are not predictable as they are not computable; even the most powerful computers dealing with Big Data cannot solve this problem. Thus, unpredictability is an essence of life; the question is whether the principle of unpredictability on this cellular level of information processing is “cured” on the organismic and behavioural level. The answer is an energetic “no”, although this is not a welcome answer.

   b) How do nerve cells talk to each other? The language of the brain is “excitation” and “inhibition”. Chemical transmitters at “synapses” (the contacts between nerve cells) are responsible for influencing receiving nerve cells either by increasing or decreasing their level of activity. This phenomenon, which has been another great invention of “mother nature”, adds to unpredictability. Apparently, it has become an advantage in the evolutionary process that others cannot anticipate exactly what one is going to do. But unpredictability applies also to ourselves in spite of all attempts to control our behaviour. How can I know what is in my mind in a minute? The balance between excitation and inhibition in circumscribed regions of the brain is another essential feature of information processing. If the equilibrium is broken, i.e. if in a certain area of the brain excitation is too high or inhibition is too low, specific diseases may be the consequence – one example being epilepsy, another one Parkinson’s disease. It is important to note that “inhibition” is an overriding principle in the brain, and that “disinhibition” (inhibition of inhibition) releases activity patterns like controlled movements and also thinking. All behaviour patterns (being genetically pre-programmed or learned) are represented by neural algorithms in the brain, but they are inhibited, and they are only released given a specific situation, for instance by drawing the attention by inhibiting the inhibition and focusing the mind on a new content of interest.

   c) The third characteristic of the GIN may at first sight be unbelievable, but it is also a fact. When one asks the question how far away any nerve cell in the brain is from any other nerve cell to express its influence, one gets an amazingly small number: It is only 4 steps “in between”. Thus, one nerve cell inhibits or excites a next one, which excites or inhibits the next next one, and so on, and in only 4 steps any nerve cell in the brain can be reached and, thus, express its influence. Of course, longer ways are possible, as “every road leads

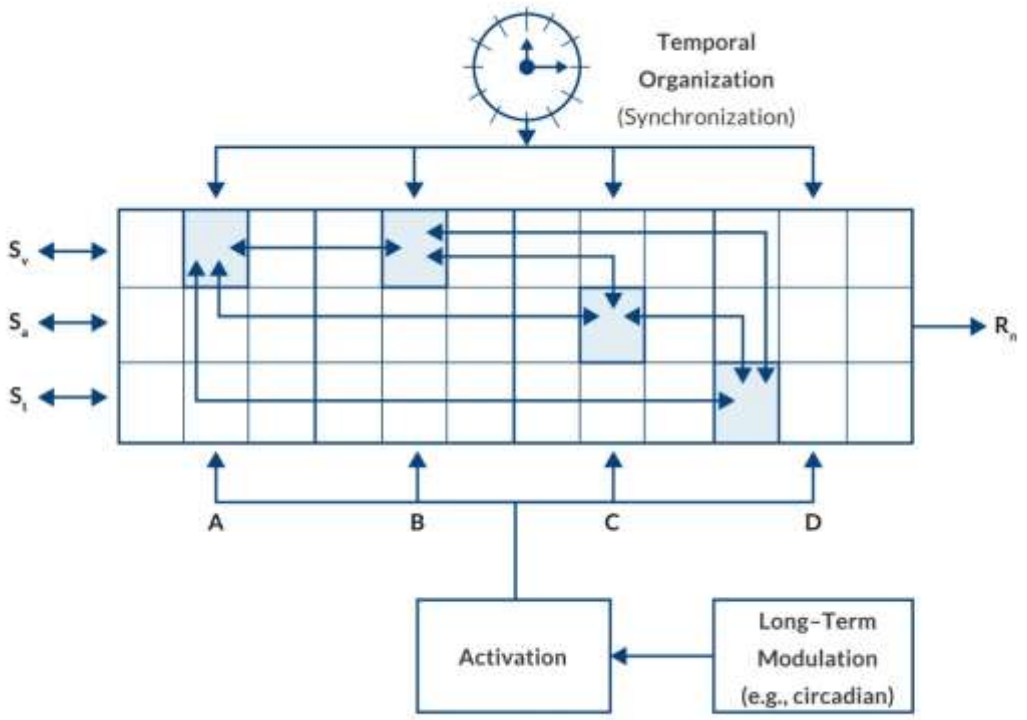
to Rome", but the shortest connection is extremely short. This architectural principle (which has been named "Nauta's Law" after an eminent neuroanatomist at MIT in Cambridge) has fundamental psychological consequences. It indicates the high inter-dependence of all functions in the brain and, thus, the intrinsic connectedness of all psychological phenomena. It follows for instance that it would be an illusion to claim that a decision can be only "rational". Decisions are necessarily embedded in a frame of emotional evaluations. Words are misleading; there is nothing like a pure decision, but there is also nothing like a pure emotion or a pure belief. Seeing, hearing or any other sensory activity is always linked also to memory functions; any thinking or any belief is never free from emotional evaluations. The way "mother nature" has created humans invites modesty; pure rationality or being free from prejudices is structurally impossible. We are victims of evolutionary processes, and we better know about it.

III Short Overview of Our Psychological Repertoire: What Can Be in the Mind, and How is this Managed

The sketch in Figure 2 represents on an abstract level a taxonomy or classification of psychological phenomena or subjective experiences. The key element of this taxonomy is the distinction between "content functions" ("what" is represented in the mind) and "logistical functions" ("how" the "what" in the mind is managed). "What-functions" refer to what we perceive in seeing, hearing or tasting, to what we remember as facts or images, to what we feel, like pain or pleasure, joy or anger, to what we think about, to what we talk about, to what we anticipate and want to happen. "How-functions" refer to the activation of the brain, i.e. the necessary power-supply, to attentional control, i.e. which content is moved into the focus of the conscious mind, and to temporal organization and synchronization of the distributed neural activities of the brain, like what is "now" in the mind.

The big rectangle with the many squares inside represents the "what-functions". The different letters A to D refer to the different domains of mental content like perception (A), functions of memory and learning (B), emotional evaluations (C), and actions as reflected for instance in talking or thinking (D). Each little square within the different domains symbolizes a module or area in the brain that represents a specific function. Such a modular representation of functions can be derived from observations using for instance imaging technologies (like functional magnetic resonance imaging, fMRI), from the loss of functions in brain-injured patients, and also from experiments with animal models. If for instance in the visual domain a special module in a circumscribed area of the brain is lost, it may happen that this patient no longer can see colours; the world has become black and white. If another module is lost, a patient no longer may be able to recognize individual faces; he may not even recognize himself in a mirror. If another module is lost, a patient no longer may be able to see that something is moving; the world views become temporally disconnected, and he can no longer cross a street as the movement of a car cannot be recognized.

Figure 2



Source: Author's own diagram.

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In other psychological domains, a specific lesion of the brain may result in the loss of storing information in memory; the understanding of speech may suffer; emotional experiences may disappear; thought processes may lose their continuity. On the basis of such observations that cover the psychological repertoire, one can conclude that the integrity of local modules in the brain is the *necessary* condition for subjective experiences, (and it supports the general position of a pragmatic monism mentioned in the preamble that the loss of a function proves its existence). But is it also a *sufficient* condition for subjective experiences? The answer is “no” for at least two reasons; one reason being that the activity of one module is always connected with the activity of other modules, which is symbolized with the inter-connected squares in grey in Figure “Temporal Organization”; the other reason being that logistic functions are necessary to create experiences and a subjective representation of the world around us and also system states within is.

What is referred to as “representation” (R on the right) is the consequence of information processing within all interconnected domains of the brain, and of course also of the processing of stimuli in the different sensory stimuli (S on the left, and Figure 2). As can be seen, the arrow of the three indicated sensory channels for visual (Sv), auditory (Sa) and tactile (St) point in two directions. This indicates that sensory information is necessary, and this is symbolized by the arrow pointing to the right; a classical statement in philosophy says that “nothing is in the mind which has not been before in the senses”. But the arrows point also to the left, which symbolizes that stimuli are selected by our attentional machinery. We are not passively processing information, but we are selecting according to personal importance. We see and hear what we want to see and hear. Information is processed within a frame of expectations and anticipations. What applies here is the “law of economy” in neural processing of the brain. Thus, our attentional machinery serves also our prejudices. Quite often, we are looking only for a confirmation of what we already see, feel, believe. This brain strategy is indeed very economical and saves energy.

Energy management is a big challenge for the body. The volume of the brain is just 2% of the body, but the brain uses 20% of the energy. Because of the energy demand, it is in the interest of the brain to spend as little energy as possible, but without a power supply, without activation, no content on the psychological level would be available. As is indicated, all domains from A to D get input from the activation system which itself is modulated for instance by the 24-hour (or “circadian”) rhythm. A reduction of activation as for instance observed during “burnout” or depression results in typical changes on the level of “what-functions”; emotions can get flat, activity is reduced, thinking is slowed down, and it becomes difficult to remember. Thus, a functional attentional system and a power supply by activation are necessary “how-functions” for the human mind.

The third logistic function refers to temporal organization as sketched by the clock in Figure “Temporal Organization”. As different functions are represented in different areas of the brain, and as any mental act is characterized by the simultaneous activity of many modules indicated in the grey squares and the arrows connecting them, the brain is confronted with the problem with distributed activities and the temporal availability of information. What has “mother nature” done to overcome this problem? The solution at first sight sounds strange: The neural machinery steps out of the continuity of time as it has been defined in classical physics, and it creates “time windows” of finite duration within which time in the normal physical sense does not exist. Technically the brain uses oscillations to manage the distributed activities in local modules, and it has been found that the period of some 30 to 50 milliseconds defines such time windows within which all information is treated as co-temporal, and on that level distributed activities can be synchronized and united. These time windows represent a subconscious neural machinery that is used to create content of the mind, i.e. it provides the elementary building blocks of consciousness. One becomes only aware of this neural mechanism if something goes wrong. After specific brain injuries, information processing can be slowed down, i.e. falling out of the frame we consider to be “normal”.

Another time window has a duration of some 3 seconds, and this time window is crucial for subjective experiences, for decision processes, for communication, or in general for the creation and maintenance of identity of percepts or thoughts in our mind. One can also refer to this time window as the “subjective present” or the “experienced now”. Thus, from the viewpoint of brain science, the present or the now is not a durationless point between past and future, but it has a duration of approximately 3 seconds in humans. This is an operative range and not a physical constant. This time window can be looked at as a temporal stage to represent what goes on in the mind. When we make a decision, it happens within this time window. But what does this mean with respect to the parameters that have to be considered when making a decision? They cannot be consciously available in the moment of a decision. Thus, because of temporal constraints a decision cannot include everything on an explicit level that contributes to the decision. If one believes to have made a pure rational decision, this is an illusion. Because of our evolutionary heritage we are also victims of implicit information processing going on all the time in the brain. But implicit or unconscious information processing is not irrational; it prepares the next conscious representations in the time window of 3 seconds. In certain forms of schizophrenia or after the consumption of too much alcohol, this continuity may break down.

IV A Hierarchical E-pyramid about What Perhaps to Do and What to Consider

Sometimes trivial statements cannot be avoided: One of the basic characteristics of all organisms including humans is to maintain an equilibrium, and if the equilibrium has been lost to regain it as fast as possible. Needs that we experience are the signals that an equilibrium on the physiological or psychological level has been violated. In such a moment, the motivation machinery is switched

on to switch off the needs. This striving for an equilibrium is implemented both on an explicit and an implicit level, i.e. regaining an internal balance may be consciously controlled, or it is regulated on an unconscious level automatically. “Homeostatic regulation” (to use a medical term) as the strategic goal for our psychological and bodily needs is thus at the top of the E-pyramid. It just so happens that an equilibrium, more precisely a dynamic equilibrium, (or “allostasis”), is also the strategic goal of groups or organized social systems. To reach and maintain an equilibrium, “energy” is necessary; as shown in Figure “E-Pyramid”, without power supply or activation, without energy, a personal equilibrium cannot be maintained, and this applies of course also to social systems. It should not be concealed that for some individuals or institutions the strategic goal is “excellence”, but this never can override the basic principle of a physiological or psychological equilibrium.

E-Pyramid

Source: Author's own diagram.

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For all of us (with only rare exceptions) it is necessary to be embedded in a social environment, and this embedding creates emotional stability. If one looks at the main motivational systems that guide human behaviour, it has been discovered that there are basically just three dominant motivational domains: It is 1) indeed the social embedding or the belongingness to a group; it is 2) the expression of power and control, and it is 3) the need for achievement. The latter relates to “emergent creativity” on the second level of the pyramid. Every human is driven by curiosity, and it is the task of societies on all levels of education to support such emergence for achievements (which sometimes is frustrated in educational processes).

The third level of the pyramid refers to characteristics of information processing as consequences of our brain machinery. One essential feature of brains is to invest as little energy as possible. “Easy access” to information is thus a consequence and, even more so, “effortless processing” to allow for “efficient action”. The operational advantage of “prejudices” is primarily that one does not have to reflect any more; thinking is not necessary. Without effort, fast decisions can be made and presumably efficient actions can be initiated. Together with emotional embedding in a social environment, quick and unreflected actions allow circumventing rational conjecture. At this operational level, together with the desire to belong to a group that promises safety, and with the brain machinery to create and maintain an equilibrium, we humans are victims of our evolutionary heritage.

How can one deal with the potentially negative effects of our evolutionary endowment? The only way is to know about it, and knowledge as a key control element can obviously be provided by "education" – another "e-term". Interestingly, the most important educational targets in some advanced societies focus on STEM: Science, Technology, Engineering, Mathematics. It is strongly recommended to move from the stationary stem to the dynamic STEAM, i.e. to include the Arts as an element of education. This is recommended not only because the "aesthetic sense" should be an important argument also for "environmental responsibility" (which it is usually not). New results in brain science show that the aesthetic sense is also fundamental for moral as well as economic judgments. Again, we observe the inter-dependence of mental operations. Furthermore, without some basic "economic understanding" both on the personal and the level of a society, everything would be in vain anyway.

At the basic level, future perspectives become key elements of human behaviour which are confronted with our past endowments by "mother nature", the evolutionary heritage. How can a future be envisioned and structured combining environmental responsibility with economic understanding and applying ethical principles? The answer is again to foster knowledge about ourselves by education. But one has to be realistic: A new "enlightenment" is far away, and possibly even disappearing. Immanuel Kant wrote "Was ist Aufklärung?" (What Is Enlightenment?) in 1794, and he said "aude sapere" – dare to think; today we should add "aude agere" – dare to act. But how could that happen on a global level? If one is realistic, i.e. given the constraints dictated by human nature, given the challenges concerning the global environment, observing the different ethical principles (or their neglect), and accepting the different economic interests, an optimistic attitude is difficult to defend. One has to deal with humans not as they should be, but as they are.

V Some Ambiguous Statements: News is Always Fake News, Information is Always Misinformation

The brain cannot be changed, at least not within short time scales, unless one is willing to accept genetic engineering for humans. This has already been tried. However, in that case the outcome could not be predicted because of the complexity of the brain; the interconnectivity of different brain areas and the billions of neurons result in unpredictability and are beyond control. The intention to improve genetically intelligence, to get rid of all diseases, to increase our life span, to make humans more peaceful, or whatever a political program would be, could have also unwelcome consequences.

The brain can be changed, at least partly, if we accept open or hidden dictatorship. We enter the world with genetic programs of possibilities. During the first years of life specific neuronal programs or algorithms are selected by imprinting within the physical and cultural environment. This imprinting is not absolute as anthropological universals; the "how-functions" of the brain like temporal processing are very conservative, but the "what-functions" can be modified. Different value systems or religions are the consequence of such imprinting, and if one wants to have all humans equal, global dictatorship would be necessary.

The real challenge for any human is to create and maintain personal identity. This may be the source of accepting fake news and "enjoying" misinformation. The reinterpretation of facts begins with ourselves when we construct retrospectively our identity. Every autobiography is full of lies. We create a "narrative" about ourselves that simulates consistency throughout life. This allows personal face saving, and it is the basis for playing roles towards others. Nobody can be completely honest with himself or herself and even saints are not completely "clean". We are our own story.

Another reason to be a grateful victim of misinformation is the need to belong to a social group. Belongingness provides safety. Responsibility is delegated to leadership. Information is always processed within a social frame of reference. Prejudices allow fast orientation by looking for medial confirmation of what one believes anyway. Alternative perspectives would disrupt the effortless flow of daily life. In fact, “fake news” is not fake news at all, but is located within a frame of expectations; our fake news is appreciated as support of our personal worldview.

Everybody produces fake news by re-interpreting information to support or even create personal identity. Matters become more complicated when information is intentionally modified or traditionally verified in social systems to create specific frames of subjective realities. Do people in power within such systems, be it in the political or religious domain, be it in the economic or cultural sphere, do these people actually know that they are re-interpreting facts, that they select and modify information, that in some cases they are lying, for the purpose of creating stability in the system and providing a frame of cultural identity for everybody? Do they (we) believe indeed that they (we) are telling the truth?