Global Brain FAQ

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GLOBAL BRAIN FAQ

1.0 Global Brain:

1.1 What is the Global Brain?

We describe the Global Brain (GB) as a distributed intelligence emerging from the collective interactions of humans and their information and communication technologies (ICT) which are connecting all peoples and machines into one network (1, 2). This network in its future form could be more intelligent and coherent than the current structure of the Internet with the capability to coordinate the necessary functional operations of human civilization via processes of self-organization (i.e. human civilization organized without central-hierarchal forms). Such a system will represent a qualitatively new level of complexity and organization — a new metasystem (3, 4) — which will allow humans to solve planetary problems (i.e. global warming, socioeconomic inequality), consequently opening up the possibility space for new levels of freedom and opportunity (5, 6).

1.2 What is the history of the Global Brain?

Social and technological theorists throughout the modern age have developed concepts related to the future emergence of a higher planetary intelligence/consciousness (7). For example, palaeontologist Pierre Teilhard de Chardin proposed the concept of a “noosphere” describing a future planetary sphere of consciousness emerging from the integration of all human minds (8) and writer H.G. Wells proposed the concept of a “world brain” describing a global encyclopedia that automatically updated and synthesized all knowledge making it accessible to all humans (9). Physicist Peter Russell first introduced the specific term “Global Brain” in an influential book of the same title hypothesizing that the information age would be most fundamentally characterized by the formation of a planetary brain-like structure which would enable a utopian spiritual revolution (10). Cybernetics pioneer Valentin Turchin significantly influenced contemporary GB theory with the description of how a new level of “control and cognition” could emerge on a planetary level, potentially enabling the coordination of the human superorganism as one “super-being” (11). The modern development of GB theory has been marked by the description of real technological mechanisms (Internet and associated technologies) to realize such a global entity in the mid-to-late 1990s by theorists such as physicist Gottfried Mayer-Kress (12), systems theorist Joël de Rosnay (13), cyberneticist Francis Heylighen (14), experimental psychologist Johan Bollen (14), and mathematician Ben Goertzel (15).

1.3 What are Global Brain metaphors?

The GB is typically used as a conceptual metaphor to describe our species organization, intelligence, consciousness, and evolution: in an analogous way to how collectives of neurons formed biological brains enabling the emergence of a higher level of control and cognition (with human symbolic thought as its highest order), the collective of humanity is forming a planetary brain with our technological extensions, which could

result in yet another higher level of control and cognition on the planetary level. This metaphor is used to ground theoretical models/computer simulations that can help us anticipate, guide, and create its foundational structure (1, 2, 4, 16, 17, 18, 19, 20). Director of the Global Brain Institute (GBI) Francis Heylighen posits that GB metaphors often fall into one of three categories: organicism, encyclopedism, and emergentism (7). Organicism is the idea that the human species as a whole is structured like a living system (i.e. a superorganism developing a sociotechnological nervous system). Encyclopedism is the idea that our species is building a global database of all information and knowledge (i.e. a memory for the collective species). Emergentism is the idea that a global consciousness/awareness is emerging as a consequence of our increasing interconnectedness. The Global Brain Institute (GBI) aims to integrate these metaphorical representations into an evolutionary-cybernetic theory of the GB to explain how increasing hyper-connectivity and international cooperation could actualize a distributed intelligence (2, 6, 21).

1.4 Why choose the name Global Brain?

The name “Global Brain” refers to a phenomenon that has planetary scale, exhibits system-level structure analogous to brain organization, and emergent brain-like properties (e.g. learning, problem solving, information processing) (6, 7). We recognize that some feel “Global Mind” would be better suited to describe our species growing awareness of the planet and our species. However, when we refer to “Global Brain” we are specifically referring to the potential phenomenon of self-organizing and distributed intelligence on a planetary scale (1, 22). This “brain-like” activity could lead to phenomena that may also be considered “mind-like” in nature, but the primary focus of our theoretical developments (2, 6, 22) and mathematical model building (1, 16, 17) are directly related to “brain-like” properties and the potential for the emergence of the higher-level intelligence necessary to tackle planetary problems (6).

1.5 Is Global Brain inevitable?

The human species gives the appearance of developing in a convergent direction, i.e. towards the formation of a higher planetary totality (23). However, the GB is not an inevitable phenomenon, and cannot be precisely predicted with the scientific accuracy that has come to be expected as standard in the “hard sciences”. In other words, between our present moment and the potential formation of a higher planetary level of control and cognition, there is an ever-increasing space of contingent possibility dependent on social, political, economic, and technological factors, and consequently, a higher degree of uncertainty and unpredictability in regards to the ultimate fate of the phenomenon of humanity (24). However, we believe that the GB is an achievable and even a likely outcome of the evolutionary process of globalization (6). From the extrapolation of the exponential nature of technological developments, it is not unreasonable to suggest that such a phenomenon could cause a metasystemic change before mid-century (21, 25)

1.6 What would cause the emergence of a Global Brain?

The GB would be the result of directional variation and selection towards a more intelligent, knowledgable, accessible, and efficient information society (6, 21, 25). The direction of this pathway towards a positive-higher dimension is dependent on a number of important evolutionary criteria that includes: (A) the need to

build a global system of governance that is inherently more integrated and cooperative than the contemporary field of governance composed of nation-states and international organizations (4, 19, 26), (B) the need to transition to a global system of energy that is both abundant (non-rival) and sustainable (renewable) in order to ensure that human activity does not destroy its own ecological foundations (27, 28), and (C) the need to transition towards a post-capitalist economy that is capable of assessing humanist and ecological value at the planetary level above purely profit-driven logic characteristic of international organizations structured on neoliberal principles (2, 18, 24). The GBI focuses on these phenomena in order to better understand how a process of guided self-organization can result in the mediation of a planetary metasystem transition (29, 30).

1.7 Is Global Brain a "better" future for humanity?

Current theoretical research suggests that the GB as a distributed and self-organized entity (as opposed to a hierarchal-centralized entity) would embody many of the best characteristics and principles of modern society, including higher-levels of freedom, diversity, and democracy (5, 6). Consequently, this would be a world with reduced economic inequality, abuses of political power, and social injustice, all features that have characterized the historical process largely as a consequence of systemic scarcity and hierarchal-centralized organizations (24, 31). Theoretical models suggest that the GB would be a system with far less social and physical friction due to structural foundations built upon stigmergic principles (common coordination mediums facilitating indirect cooperation) (32) and ephemeralization (the capacity to produce more with less reducing the chance of environmentally-influenced rival/conflictual situations) (21). Therefore, we feel that our current understanding of the potential of a future GB presents us with a positive future for humanity as a whole.

1.8 Will the "Global Brain" have a "Global Body"?

A well-functioning "Global Brain" (with the collective of humanity as "earth neurons" (33) interconnected by technology supporting an invisible virtual web), cannot be sustainably maintained without a "Global Body". Our Global Body maintains our civilizations metabolic processes in the same way our biological body maintains the metabolic processes necessary for a functioning brain (healthy cognition and control). Consequently, the Global Body concept shares many functional parallels with biological metabolic processes. From an organicist perspective, there are 8 functional subsystems within the Global Body: ingestor (i.e. mining, harvesting, pumping), converter (i.e. refineries, processing plants), distributor (i.e. transport networks), producer (factories, builders), extruder (i.e. sewers, waste disposal, smokestacks), storage (warehouses, containers), support (buildings, bridges), and motor (engines, people, animals) (25). A fully functional GB would be capable of coordinating its global activity so that all of these subsystems functioned sustainably, analogous to the way a healthy biological brain is capable of coordinating its global activity so that all of its metabolic subsystems function sustainably.

1.9 What type of energy does the "Global Body" utilize/live on?

All organisms have evolved mechanisms for harvesting and using energy (i.e. they have a metabolism) (34). Our "Global Body" predominantly harvests and uses fossil fuels (e.g. coal, oil, natural gas), but also relies on hydrothermal, nuclear, wind, and solar power (21). Our current energy system does not allow for energy

abundance or sustainability (27). Therefore, it is critical that we improve the functioning of our socioeconomic metabolism so that we can provide energy abundance for all of the Global Brain's "neurons" (human beings) as well as create a Global Body that is in ecological symbiosis with planet Earth (13). The best opportunity we have to achieve energy abundance and sustainability would be to pursue the mastery of both renewable energy (e.g. solar, wind, geothermal) and nuclear energy, and integrate these systems within an interconnected and interdependent international energy grid (34).

1.10 Where does the Global Brain reside?

The Global Brain is an emergent phenomenon characterized by a planetary collective intelligence that is not just more than the sum of its parts but totally different than the sum of its parts (i.e. a super-intelligence consuming the entire field of human activity). Thus, the GB technically exists everywhere and nowhere: it is a total planetary phenomenon that is an an effect of the collective interactions of human beings interconnected within a technological infrastructure supporting a virtual medium. We can contrast the nature of the GB with the nature of historical "super-entities" or "super-creatures" like corporations, nation-states, empires, or kingdoms (31), which are not primarily distributed or self-organized but more-or-less controlled from a central location that was easily identified in physical reality. Consequently, in the "GB age" or "mature information age" there will be no centers of power or organization because the center will be the whole planet. This is the essence of the phenomenon of distributed intelligence.

1.11 What is a global superorganism?

Superorganisms are collectives of individual organisms with a specialised division of labour and a generally poor/complete lack of ability to function and reproduce independent of the larger collective (i.e. they have been subsumed into the substance of a higher whole) (13, 35). The most common example of superorganisms can be found in the eusocial insects like ants, termites, and bees, which have been studied extensively under the superorganism paradigm from an evolutionary perspective (35, 36, 37). Many evolutionary theorists now consider it likely that the human collective functions as a superorganism, especially within the historical process. In history human societies are composed of competing and cooperating "super-entities" characterized by a specialised division of labour, making it difficult for individual humans to function and reproduce independently of the larger collective (i.e. "no man is an island") (36). Thus, although humans are of a totally other order than that of eusocial insects in regards to the symbolic medium of thought and communication, we share common superorganism-like cybernetic properties. Furthermore, there may be an even more radical superorganism phenomenon when we consider the Earth itself. Environmental scientist James Lovelock posited the Gaia hypothesis as the idea that the Earth itself is one global superorganism (38). Currently there is still disagreement in the scientific community about Earth's status as a literal global superorganism. However, few question the concept of Gaia as a useful metaphor to explore the fact that the totality of the biosphere interacts, defines, and reproduces its own environmental boundary in an organism-like way via several complex positive feedback loops with diversified internal elements (living organisms). Such superorganism-like processes have been posited as potentially useful for the field of astrobiology in the attempt to identify other "Earth-like" planets (39).

1.12 Is the human species evolving into a global superorganism?

Several social and technological theorists have argued that our species is a superorganism (with our emerging "Global Brain" and "Global Body"). Indeed, from the evolutionary perspective various human groups have increasingly behaved in superorganism-like ways since the emergence of civilization in the sense that there has been increased cultural specialization in labour and an accelerating difficulty for individuals to reproduce independent of the larger social collective. However, in order for humanity to manifest the properties of a "global superorganism" there would have to be a transition in cognition, control, and organization enabling the fundamental unit of selection to shift towards the planetary level (decisions would be made regarding the survival and reproduction of the whole). For example, because we do not have a coherent global order capable of organizing for the long-term benefit of the whole, we have started to give "Gaia" a "fever" in the form of anthropogenic climate change, thus undermining the stability of all disparate human superorganisms (13).

1.13 Does the Global Brain already exist?

We maintain that the GB is currently best defined as an emerging network in an "embryonic" stage of development. This network primarily develops from the continued automation of "nervous-system-like" properties like storage, transmission, and processing of data through evolving information and communication technologies (ICT). The development of this network increasingly results in the coordination of political, social, and economic activity via GB mediated technologies and platforms (2, 6, 40). We can see that this development is occurring rapidly as contemporary communication networks are already restructuring and integrating all components of global society away from historical modes of organization and towards qualitatively new forms of distributed organizations in areas of energy, communication, transportation, education, and many other fields (41, 42, 43).

1.14 What are the signs of Global Brain emerging?

The biggest empirical signs of the GB's emergence can be found in the automation and integration of almost every industry into the infrastructure of the Internet. This process is being driven by various processes and actors, including major international corporations like General Electric, IBM, Cisco, Google, Amazon, NASA (44), but also via the increasing power of the sharing or gift economy which enables peer-to-peer networks to flourish in ways that were impossible before the existence of the Internet (2, 43, 45). Cumulatively these developments are leading us towards an "Internet of Things" (IoT) world where everything will be connected to everything else (46, 47).

1.15 When do you predict Global Brain will exist?

Based on current trends in the evolution of information and communication technologies, which tend to develop exponentially (48), as well as current trends in the growth and maturation of the Internet (49), we should expect the emergence of a mature GB before mid-century (~2030-2050). However, to achieve this will require not only new technologies, but also the intelligent application and direction of these technologies (2, 24, 45). In other words, the method of social inscription of technology into processes of economics and

politics in particular will play a large role in determining the timing of the emergence of a GB. Thus, as stated above, while technological development may follow a fairly predictable trajectory, the social dimensions of human existence create an irreducible level of contingent possibility, and consequently uncertainty and unpredictability in regards to the prediction of the GB's mature existence (21). Furthermore, we cannot discount the possibility that GB models themselves (1, 2, 4, 16, 17, 50, 51, 52) (irrespective of their contingent symbolic inscription, i.e. "Global Brain" models specifically) could accelerate the process of the emergence of the GB, by influencing the implementation of new technology and the creation of new social forms.

1.16 What will specifically turn human society into a single information processing system?

The emergence of a single coherent globally interconnected information processing system may require some of the following elements:

- emergence of new and more intimate ways for humans to interface with the Internet itself (i.e. wearable computing, brain-interface devices) (46, 53, 54)
- New self-organizing capabilities and distributed intelligence capabilities of the Internet (i.e. RFID tags connected to all "things" allowing them to communicate and create intelligently-ordered environments) (44, 46, 47)
- An Internet with smarter software architecture (i.e. artificially intelligent learning systems embedded in operating systems, websites, and apps, as well as a semantic web that can make sense of abstract data, and imprecise human knowledge) (6, 55, 56)
- New technologies that can help us reduce manufacturing costs and help us efficiently organize the physical world (i.e. advances and diffusion of 3D printers and robotics) (57, 58)

1.17 Do human-machine interactions on Earth form an actual neural network?

Biological brains self-organize via distributed neuronal interactions. The cumulative action of this complex network produces properties like consciousness, goal-directedness, and intelligence (59). Consequently, these emergent properties cannot be found in any of the brain's constituent parts, but are instead the result of their cumulative interactions (60). The essence of the Global Brain concept is that the complex network interactions of biological brains are analogous to the higher-level interactions produced by human-computer networks on Earth (1). Here the technological architecture of computer networks is envisioned as the scaffolding of the "neural network" and the virtual medium/contents of the Internet is envisioned as the emergent global phenomena that cannot be identified in any of its constituent parts.

1.18 How can the Global Brain be scientifically proved to skeptics?

We have developed several theoretical models, including Challenge Propagation (22) and Chemical Self-organization Theory (50), which can be conceptually formalized (16, 17) and quantitatively represented (1) to make predictions of real-world phenomena in the human system (30) but also to help us design systems that

can help us change the world in a positive direction (2). These predictions and new system designs will be tested in computer simulations in order to demonstrate their accuracy and efficacy, as well as help us improve and modify the theory and our assumptions if necessary (1, 30). We believe that empirically demonstrating the validity of our mathematical model in complex computer simulations that can predict the collective behaviour and development of our system will help us demonstrate the validity of the Global Brain concept and help us to develop the foundation for a freer and more abundant world (1, 2).

1.19 Can anybody predict how the Global Brain will develop?

The GB, as a planetary super-intelligence, would be the most complex entity in nature. Therefore, it is difficult and probably impossible to say with any degree of certainty how it will develop after its emergence. This break down of a "prediction horizon" is the general problem for all sociotechnological theory revolving around the concept of a future "Singularity" (6, 15, 23, 48, 61, 62). However, broadly speaking we believe it is reasonable to suspect that GB will generate environments facilitating higher-levels of cooperation between various human groups and higher-levels of possibility for conscious experience and exploration. In the longer-term it is also possible that this metasystem could expand into outer space either modifying the solar system or searching for habitable planets external to our solar system (i.e. expansion hypothesis), or enable the transcendence of mind to inner space in a potential search for other dimensions and universes (i.e. transcension hypothesis) (23, 63, 64).

1.20 Did the human species as a whole lack a brain and consciousness before the Internet?

The Internet opens the potential for a new level of collective intelligence (global problem solving) and consciousness (humanity as one collective). If we are to use these as rough criteria for a "species brain" and a "species consciousness" than we can say that rudimentary multi-local forms of both have been with various human groups since the emergence of small agricultural civilizations. In other words, since the beginning of the historical process forms of collective intelligence and consciousness have emerged as a consequence of technological infrastructures and virtual mediums designed to support thousands to millions of people. Indeed, all large-scale civilizations, in order to exist, have needed to act and engage in problem solving for a higher whole, which requires consciously mediated conceptual notions that there is a whole to be guarded and preserved. Thus, the difference between historical species intelligence and consciousness and the future GB intelligence and consciousness is that the future version will be uniquely planetary and grounded in a hyper-technological infrastructure. From this perspective the modern industrial age, characterized by the emergence of higher-level communication mediums (e.g. telegraph, telephone, radio, television) and new popular and intellectual forms of inclusive thought (e.g. globalization, globality, globalism, internationalism), can be seen as a transitionary stage from human intelligence and consciousness as disparate and fragmented to human intelligence and consciousness as integrated and whole.

1.21 Where can I find more information about Global Brain?

Academic research and popular outreach regarding important aspects of the GB development has increased every decade since its early historical formation. For more information you can find an extensive bibliography at the end of this FAQ with links to both academic articles and popular science books. You can also find more information about the GB on our website (globalbraininstitute.org) and throughout the rest of the FAQ (Section 2-8), which will further discuss the Global Brain Institute (GBI) as well as GB evolution, psychology, philosophy, technology, and more.

2.0 Global Brain Institute:

2.1 How did the Global Brain Institute form?

The Global Brain Institute (GBI) is a interdisciplinary academic institute established in January 2012 to research the phenomenon of the Global Brain (29). GBI emerged out of the Evolution, Complexity, and Cognition (ECCO) group at Vrije Universiteit Brussels (VUB) which was focused on understanding the conceptual foundations of self-organization, collective intelligence, and metasystem transitions (65). Most of the research completed by ECCO was inspired by the GB paradigm and has led to the development of complex systems theory, cognitive theory, and also the implementation of various algorithms that demonstrate the usefulness of collectively intelligent complex systems (for more information on specific developments see: 29, 30, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77). However, ECCO could not provide the GB paradigm with the research infrastructure to reach a critical mass of publications, demonstrations, applications, and dissemination towards a wider audience (29). Therefore, GBI was established to specifically address the next human metasystem transition (1, 2, 3, 4, 5, 6, 7, 18, 19, 20, 22, 23, 24, 31, 32, 40, 41, 42, 45, 52, 79, 80, 81, 82, 83, 84, 85, 86).

2.2 What is GBI's goals?

We aim to address the next human metasystem transition towards a global organization by developing theory, applications, and empirical evidence necessary to help us understand and guide the changes before our species in the 21st century. In order to best achieve these aims GBI is built upon the foundation of four pillars (30):

- A formal theory of the self-organization of distributed intelligence
- Conducting experiments and tests of GB theory
- Proposing practical applications related to GB theory (future university, governance, economics, etc.)
- Disseminating ideas, results, and detailed GB research to a broader audience

2.3 What will these goals produce or lead to?

From these four pillars we aim to produce several "deliverables" that will be free and open access for the entire scientific community and anybody else who is interested in our research (30). Some of these deliverables will

include global economic and social reports on our current and future system, economic consultation for businesses and governments, scientific publications in technical journals, proceedings, and edited collections, an academic and popular book discussing ideas related to the GB, online university undergraduate courses on the future of the Internet, as well as open-source simulation environment that can be used for further development and experimentation (30).

2.4 What are we specifically researching?

GBI is interested in the future of humanity, and specifically the future of the ongoing ICT revolution as it relates to technology, economics, politics, psychology, culture, education, ecology, etc. In order to develop theories and models that are coherent and practical in regards to scientific experimentation, our institutes research foundation is inherently evolutionary and cybernetic. Currently, our major research projects involve the development of a formal theory of self-organization and distributed intelligence that has direct applications to social, economic, and political spheres of human existence (2). We are trying to mathematically describe how independent autonomous agents (i.e. systems that respond to sensed conditions) coordinate their actions on local and global scales to maximize synergy, and thus reduce friction or conflict in the world. We aim to further develop these models and use them to design computer simulations that measure the overall distributed intelligence of the human system, and are eventually able to make specific real-world predictions that can explain a wide-range of phenomenon.

2.5 Do you offer services to the private and public sector?

We offer advice to various interested businesses, academic institutions, and governments to help them better adapt to our current socioeconomic system and prepare for a future world that is diverse, open, and distributed in its foundational architecture (5, 20, 52). Our theoretical approach is evolutionary and cybernetic and thus applies generally to the changing nature of all social systems.

2.6 What is your theory of self-organization and how does it work?

The concept of self-organization is founded in our theory of Challenge Propagation (22) and Chemical Self-Organization Theory (COT) (50). These theories form the framework for our understanding of GB behaviour and development. In Challenge Propagation and COT we represent agents as people, organizations, or computer systems that solve problems, explore opportunities, or both based on a dynamically evolving value system. We condense problems and opportunities into “challenges” and recognize that agents can process challenges individually or they can “propagate” challenges within a weighted network of other agents. Mathematically we quantify this behaviour with vectors that can represent positive or negative valences (a challenge in overcoming (-) or a challenge for growth (+)). Various networks can then be quantified as any agent interaction is a vector representing the transmission of a challenge (problem or opportunity, -/+). The network can then change over time according to a positive reinforcement-learning rule (i.e. links between agents become stronger the more efficient they enable problem solving or opportunity exploration).

2.7 How do your mathematical models analyze Global Brain behaviour?

We use mathematical representations to run multi-agent computer simulations of virtual environments (1). In order to verify the simulated environments accuracy or practical utility we plan controlled experiments with real people, as well as make real-world predictions of phenomena that have not yet occurred and compare the results with our simulated models. Such experiments and tests will allow us to modify our model (if/as necessary) and further improve its ability to make predictions about ever-more complex global networks, as well as inform our philosophical theories of the deep future, and our practical sociotechnological theories of the future of social systems.

2.8 Where do I find Global Brain Institute research?

You can find all of our published work, as well as our pre-publications and working papers at globalbraininstitute.org underneath the headings "publications" and "working papers" (as well as in the bibliography of this FAQ). PDF versions of all of our work are open-access. You can also find video presentations of our work on our YouTube channel (youtube.com/GlobalBrainInstitute). Comments, constructive criticism, and general feedback are always welcome (info@globalbraininstitiute.org).

2.9 How do I participate in Global Brain discussions?

Participation with the GBI is welcomed and encouraged. We run a GB mailing list which is devoted to discussion via e-mail about humanity and our collective future. You can apply for subscription to this list by submitting a form which will introduce you to our community (info@globalbraininstitute.org). If accepted, you will be able to get to know our researchers, as well as participate in our on-going discussion about GB theory and philosophy.

2.10 Does Global Brain Institute have social media?

Yes! In order to keep updated with our research and other developments, we encourage you to "follow" our Twitter (@GB_Institute), "like" our Facebook (fb.com/globalbraininstitute) and "subscribe" to our YouTube channel (youtube.com/globalbraininstitute).

2.11 Is it possible to collaborate, support, or fund the Global Brain Institute?

We invite collaboration with interested parties in the academic, business, and government spheres related to consultation regarding specific social and economic strategies, presenting GB research at conferences, or joint research ventures related to the future of ICT and society with our team at VUB in Brussels. We also welcome external support and/or funding so that we can hire more researchers to continue developing our theories and models, as well as our objectives and presence. Future funding is imperative for us to become a globally recognized and influential research institute focused on efficiently directing the on-going ICT revolution towards a globally distributed intelligence (30).

3.0 Global Brain Evolution:

3.1 Is the Global Brain a higher-level of evolution?

The Global Brain (GB) will require a higher-level of coordination and organization, as well as a more complex interconnection between humans and machines (6). This can be interpreted as a "higher-level" of evolution or a "metasystem transition" (87). Similar transitions of this nature have occurred throughout the history of the universe and life on Earth: from subatomic particles to atoms, atoms to chemistry, chemistry to complex chemistry, complex chemistry to prokaryotic biology, prokaryotic biology to eukaryotic biology, eukaryotic biology to multicellular social biology, and so forth (26, 88, 89). There is a continuity in this evolutionary process, however there is also a fundamental qualitative novelty in regards to mechanisms driving contemporary process, including symbolic thought and communication, as well as technological objects (23).

3.2 What is evolutionary-cybernetics and how does it help explain the Global Brain?

Traditional neo-Darwinian evolutionary theory by itself does not help us explain how a higher-level of evolution could be achieved because its theoretical focus is gene-centric (variation and selection of "gene pools") (90). Therefore, we utilize an evolutionary-cybernetic framework for understanding how evolution achieves higher-levels of organization and complexity (7, 21). This framework was developed by systems theorists and cyberneticians in the mid-20th century (91), and was first applied to the idea of a future global superorganism by Valentin Turchin in *The Phenomenon of Science* (1977) (11). Evolutionary-cybernetics integrates the evolutionary ideas of variation and selection with the cybernetic ideas of multi-level systems (metasystem hierarchies) and the importance of emergent organization and complexity (87). Within this framework higher-level mediums can aid in the production of new synergistic (positive-sum) interactions that cannot be found in any lower processual levels (92). Of course, such a framework has a direct application to understanding the emergence of a global society mediated by the a higher-level communication network (3, 4).

3.3 What major transitions have occurred throughout the history of life on Earth?

There have been several major transitions throughout the history of life on Earth that have resulted in the emergence of qualitatively novel phenomena (88). The theoretical focus of most research on such transitions includes understanding how new synergies are produced and mediated between previously disparate systems (87). A few of the most well-studied examples of such transitions include abiogenesis (the emergence of biological life itself), multicellularity (higher-level life), sexual reproduction (emergence of co-produced biological elements), megafaunal complex societies (large groups and colonies of organisms), as well as language (the emergence of symbolically mediated and constituted human groups) (89). Furthermore, human societies have directly (in-themselves) mediated the emergence of higher levels of evolution throughout the historical process

of civilisation formation in the transitions from foragers to agricultural societies, and from the transition from agricultural societies to industrial societies (3).

3.4 How would Global Brain itself evolve?

In order for the GB itself to evolve (from the perspective of the evolutionary-cybernetic paradigm) there would need to be variation (i.e. multiple planetary totalities) and selection (pressures for certain GB's to reproduce more often than others). Of course this is strictly impossible unless the GB gains access to a currently unknown dimension of interstellar discursive reality. Therefore, if higher levels of variation and selection eventually produce a GB, the GB itself will in some sense have transcended our contemporary notions of evolutionary process, but may continue to develop via alternative mechanisms. In this case the GB would represent a level of complex organization commencing an age of intelligence and consciousness expansion into the rest of the universe, perhaps on a pathway towards forming a "Milky Way Brain" with an "Interstellar Internet" (93).

3.5 Is evolution "progressive" towards increased complexity and intelligence?

There is a long-standing theoretical battle among evolutionary theorists as to whether evolution is "progressive" with a direction towards higher complexity (92, 94, 95). From the evolutionary-cybernetic perspective it is accepted that Darwinian selection does not have an in-built "preference" for "higher complexity" as this fundamental evolutionary process can also favour simplicity in certain environmental contexts. However, there also appears to be a trend in evolution towards the developmental retention of higher levels of the selection process itself. Consequently, once a higher-level of selection has been achieved (a higher metasystem hierarchy), this higher-level itself solidifies a progressive trend towards increased complexity, and increases the possibility that yet another higher-level could emerge from its own emergent processual dynamics of variation and selection. We can see these simplicity-complexity trends at work throughout human history as civilizations do not always become more complex (i.e. civilizations rise and fall, grow larger and smaller), but at the same time, once a fundamental new level emerges (agriculture, industry, etc.), that new level tends to spread and dominate the social field (3, 4).

3.6 Does all life strive to create a Global Brain?

Throughout evolutionary history, as previous noted above, natural selection has not simply selected for increasingly complex functions and structures in a linear direction, but has continually re-invented similar solutions to contingent but general problems encountered by organisms, solutions which are not always necessarily more complex (95). Sometimes simpler and smaller is a better solution than complex and large. Consequently, it would be misguided and perhaps totally wrong to suggest that evolution is programmed to favour the emergence of a highly complex planetary structure like a GB. However, and at the same time, throughout the history of life, and particularly the history of mammalian life and specifically the history of human life, there has been a steady increase in brain size. Furthermore, flexible general intelligence does appear to have highly favourable adaptive advantages in many contexts if certain negative energy costs can be

adequately balanced. Therefore, it seems reasonable to suggest that the formation of higher intelligence is in some sense something that can emerge given the right environmental conditions and given an adequate amount of time for evolution to experiment in a relatively stable region of the universe.

3.7 Is Global Brain the "end" of evolution?

The GB as a higher global super-intelligence would be a totally novel phenomena in nature. Consequently there is no empirical or even theoretical capability to demonstrate how it would behave or change over time. However, it is highly unlikely (although not totally impossible) that the GB would represent the (teleological) "end" or "omega" of the evolutionary process itself (as has been suggested by thinkers such as Pierre Teilhard de Chardin (8)). From a secular perspective evolution has been operating for billions of years and has the temporal and spatial opportunity to continue operating for billions if not trillions of years into the future (64). In this sense the evolutionary process is radically open to a contingent becoming (52, 61). Thus, the GB could become a platform for higher evolutionary order and possibility that enables forms of life and forms of experience that may represent the end of the human world as we know it, but probably not the end of evolution itself (48).

3.8 How does Global Brain fit within the evolutionary history of life on Earth?

The GB does not fit into the evolutionary continuity of life in terms of its technological and virtual nature. However, the GB as cybernetic process displays many system-level parallels with previous metasystem transitions on Earth. For example, during the evolution of prokaryotic life genes were freely shared via horizontal gene transfer on a planetary scale (boundary-less global gene pool). This free and open information sharing enabled large aggregates of prokaryotic life to become more complex by incorporating various "biotechnologies" (i.e. new functional mechanisms for problem solving and opportunity exploration), which eventually led to the emergence of multicellular life (88). Therefore, some theorists have suggested that the GB as total phenomenon is an analogous system-level structure to the prokaryote-eukaryotic metasystem transition with the global human environment becoming increasingly characterized by free and open information sharing enabling individual humans to incorporate "cultural/symbolic technology" via horizontal meme transfer (27). The (potentially positive) consequence for human life is that we, as individuals, could become increasingly complex cognitive nodes capable of higher levels of sociality and community (i.e. the prokaryotic equivalent of forming eukaryotic wholes). In short, although the GB is a novel phenomenon in many of its qualitative properties (cognition and complexity), the cybernetic processual dynamics exhibit similar patterns that evolution has used at lower-levels of cognition and complexity to achieve similar ends.

3.9 Will humans become cyborgs within the Global Brain?

The traditional definition of cyborg is "an organism to which exogenous components have been added for the purpose of adapting to new environments" (96). By this definition humans are already cyborgs and we have technically always been cyborgs since humans have been adapting to varying ecological niches with technological extensions since the emergence of the genus *Homo* (97). Consequently, all of human evolution

can be characterized by the accelerating emergence of technologies that allow us to extend our physical and cognitive reach (98). However, the GB will still likely represent an environmental change of a qualitatively higher order (6). This simply means that our individual perceptions and conceptions of the world could become transformed to higher levels with the incorporation of advanced technology ultimately confronting us with fundamental consequences for our status as animals (48).

3.10 Is technology going to become more "biology-like"?

The biotechnology genetics revolution and the computational nanotechnology revolution are likely to significantly change the nature of technology and its relationship to the human form (58, 99). Consequently, the next generation of revolutionary technologies could include not only "wearable computing" but also "internal computing" that allows us to significantly modify our cellular structure and our basic biological nature (23). In this sense the future of technology could take both the forms and functions that has been traditionally occupied by organic nature (48). Furthermore, given these technologies potential capability to increase our perceptions, improve our memories, and extend our lifespan, we should expect them to diffuse and become widely adopted within the coming decades. If such technologies are incorporated into the human form they will help humans interface with the GB as virtual medium and potentially enable us to form higher level cognitive associations.

3.11 How will future technological developments change human nature and our physical composition?

There are incredible difficulties predicting how human nature will change as a result of merger with advanced technology in the domains of genetics, nanotechnology, and robotics (48). Nano-computing could enable us to communicate our thoughts and share information more efficiently, augment our reality from within our own nervous system, dramatically increase our memory storage capacity, and enhance our cognitive capabilities generally. However, just as it is possible that we will start to supplant biological processes with technological processes, we may also opt to enhance our biology with technology (99). This means biological structures could become intelligently modified by our own intelligent design, as opposed to natural selections (unintelligent) design (23). From this perspective we could "hack the body" by re-programming our genetic code, enhancing our basic structure towards forms that we desire. Of course, both the potentiality of synthetic biology and nanotechnology stretch the imagination to its limits. Consequently, this makes it difficult to discern what a GB landscape would look like if it were composed of billions of biologically enhanced and technologically modified human beings (neuronal nodes).

3.12 Does the Internet have infinite growth potential?

The Internet is currently in an accelerated growth phase, spreading to every region of the planet and incorporating ever more domains of social, economic, and political activity into its total architecture. This early growth phase is dramatically extending the power of distributed intelligence and changing the basic infrastructure of society (2, 41, 45). However, this process of growth will not continue indefinitely but eventually reach a new level of stability and maturity (3, 21). Of course, regardless of how we quantify Internet growth,

there are a limited number of people that can connect online and a limited number of processes that the Internet can integrate. Thus, we may conceptualize this growth phase, not as a process of infinite exponential growth, but instead as a classical S-curve or logistic growth process (100).

3.13 What is collective intelligence?

Collective intelligence is a phenomenon of higher-level problem solving that emerges in social groups as a cumulative consequence of local autonomous interactions occurring in parallel (1). Throughout the historical process the human species has exhibited a wide-range of collective intelligence which manifests in a large variety of activities (e.g. voting systems, mass peer review, crowdsourcing, social media, etc.) (7). In the future GB the resource of collective intelligence could be harnessed to solve increasingly complex societal problems if Internet mechanisms such as wikis, social networks, collaborative filters, and online markets continue to develop and start to dominate older centralized-hierarchal structures (101). As a consequence of increasing our species-level collective intelligence we should be able to help guide the development of the information age towards increased diversity and democracy and away from homogeneity and totalitarianism (102, 103).

4.0 Global Brain Technology:

4.1 What technologies are being developed to build a Global Brain?

There are a number of emerging technologies that will be necessary for the healthy maturation of the Global Brain. These technologies include the semantic web, neural networks, artificial intelligence, recommender systems, massively online open courses (MOOCs), personally online open courses (POEMs), smart phones, wearable computing, augmented virtual reality, brain-computer interface devices, Internet of Things (IoT), robotics, infinite computing/cloud computing, and 3D/4D printing (6). However, the social inscription of these technologies is just as if not more important than the specific technologies themselves (104). The major features of a healthy GB environment that maximizes distributed intelligence would include: peer to peer structure, security, privacy, anonymity, transparency, open source, data integrity, ensured trust, and a high degree of open-ended intelligence (105).

4.2 How quickly can these technologies become a reality?

Many of the technologies listed above already exist but because they are in their early growth phase their functionality is not yet optimal and their cost is still relatively high (48). In the coming decades we should expect technologies related to wearable computing, cloud computing, 3D printing, and brain-machine interface devices to progress through exponential phases of growth improving their basic functionality and reducing their cost resulting in widespread distribution (106). We may expect these growth phases to mirror the growth phases of personal computing in the 1990s-2000s or smart phones in the 2000s-2010s. For

technologies that require major software advances, like artificial intelligence and the semantic web, it is harder to predict when exactly they will become a reality and how they will impact the structure of society considering that both will require fundamental theoretical breakthroughs.

4.3 What is the ultimate role of the Internet/World-Wide Web?

The emergence of a GB requires a sophisticated planetary interaction channel that enables the interconnection of every person and object into a universal medium. The Internet gives the appearance of potentially becoming such a universal medium (2). Thus, the Internet's ultimate role is to facilitate the integration of the human superorganism into one global totality capable of mediating the interactions of all people and machines and stabilising a new level of evolutionary process (6). From this perspective the most important aspect of the Internet is not necessarily technological but instead its capability to change human social life as it allows for new levels of cultural sharing and conscious reflection.

4.4 What is the relationship between the Internet of Things and the Global Brain?

The Internet of Things (IoT) is currently used as a concept to describe a diversifying Internet infrastructure that is not just about connecting personal computers but about connecting every object to every other object (104). In 2015 approximately 15 billion objects were connected to the IoT, but by 2020 that number should reach approximately 50 billion objects (107). The goal of such a project is to improve the efficiency of production lines and logistics networks consequently changing the operations of businesses, homes, schools, governments, transportation, and society in general (44, 47). Thus, the IoT creates increasingly smart environments that are responsive to human needs and desires. Consequently, the relationship of the IoT to the GB should straightforward: there could be no GB without first developing a IoT. The IoT provides a structural scaffolding or framework for the next level of societal self-organization and distributed intelligence.

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