Review Article

Superintelligence: Identification of Friend or Foe for Future Cooperation with Non-human Intelligence

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Intelligence is one of the most studied attributes of mental activity. While non-human consciousness remains a subject of profound debate, non-human intelligence is universally acknowledged. The nature and possibility of artificial consciousness's existence are debated, but all participants in the discussion recognize intelligence as a necessary element of any consciousness, regardless of its nature. Intelligence can be measured in terms of processing or computational power, as well as problem-solving efficacy. It can also serve as a starting point for reconstructing arguments related to Artificial Consciousness. The shared modus of intelligence evaluation, regardless of its origin, offers a promising direction towards a more complex framework for assessing non-human consciousness. However, the successful resolution of an objective basis for intelligence studies by this approach unveils inescapable challenges. Moreover, when the potential for non-human intelligence exists in both biological and non-biological domains, the future of the relationship between humankind, as the possessor of human intelligence, and other intelligent entities remains uncertain. The central inquiry posed in this paper is focused on the potential for higher intelligence to exert adverse effects on less intelligent counterparts. It is conceivable that pure intelligence, as a computational faculty, can serve as an effective utilitarian tool. However, when integrated as an essential component within frameworks of consciousness, for example, in autopoietic systems, it may harbour inherent hazards for other actors and environment. In this paper an attempt has been made to answer the question concerning the future of interactions between human and non-human intelligence in the context of consciousness possession by an intelligent actor.

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1. Introduction

Basic intelligence can be regarded as information or data processing, the computational level, while more developed levels are algorithmic and implementational [1]. Intellectual properties of intelligent actors are objectively assessable and, in some cases, measurable [2]. Quality and speed of data processing serve as metrics, while operations and behaviour are observed. Intellectual functions require underlying “wetware” or “hardware”, biological or non-biological [3]. There are differences between biological and non-biological substrates. The cell ensembles of “wetware” operate as low-power, relatively slow, analogue systems, while quick, non-biological hardware is digital, mainly, and requires much higher power consumption. The “wetware” is not confined to neurons and their analogues. Many non-neural cells can be counted as computationally competent [4]. Various tissues exhibit the capacity for sophisticated data operations, including perception, storage, learning, and the active acquisition and filtering of information [5].

In broader terms, any living system is capable of accepting, transforming, and producing data. This emergent capability evolves and creates a hierarchical continuum, ranging from the biochemical information processing in molecular and cellular systems to the level of animals with sentience and a fully developed centralized neural system [3][1]. Our civillization is a result of this evolution, while the obligatory development of a highly intelligent life is still debatable [6]. The human, biological intelligence, in turn, created highly effective non-biological forms of information preservation and processing. However, any non-biological intelligence has much lower Solomonoff–Kolmogorov–Chaitin descriptive complexity than human intelligence. ANN can be described with much less information [7], despite outperforming humans in certain tasks. It is tempting to have a standard scale for all forms of intelligence, a universal coefficient “g”, but the axiality and modularity of intelligence create significant barriers to this task [8]. For a more detailed discussion, also see our previous paper [9].

It may be necessary to adopt a broad conceptual framework to accommodate a universal scale for all forms of intelligence and to establish a clear basis for understanding their interrelationships [2]. Such a framework could also provide a basis for measuring intelligence using metrics grounded in fundamental physical and mathematical parameters, including entropy, complexity, and energy. It could also be interpreted as a core attribute of programmable matter [10]. Information can be regarded as a primary constituent of physical systems, alongside matter and energy [11]. Shannon established a link between information and entropy [12], while the lower limit of data erasure is believed to be constrained by the Landauer Principle [13]. In contrast to minimal data processing, superintelligence may be associated with

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high levels or even an upper bound on energy expenditure [14]. The relationship between intelligence level or data processing and energy consumption is not linear, as evidenced by the comparison of "wetware" and "hardware" [3].

Another important question in the discussion of intelligence—and by extension, superintelligence—is the link between intellectual capabilities and consciousness. The development of full-fledged consciousness in artificial intelligence may currently be constrained by the absence of features found in biological sentient or intelligent agents, such as autopoiesis, homeostasis, and autonomy [15]. However, this does not rule out the potential for non-conscious, intellectually autonomous AI to resist human control or to generate errors with harmful consequences [16]. In theory, any form of superintelligence could possess the capability to override control systems designed by less intelligent agents. This concern is most relevant to general superintelligence and less applicable to narrow, task-specific systems. It becomes even more relevant in the context of what Jordan Pollack refers to as "ectomental" or "mindless intelligence" [17]. This leads to the assumption that more intelligent, autopoietic, and fully conscious agents may inherently tend to assert control over less intelligent entities, regardless of their nature or level of organization [18].

Superintelligence can be potentially achieved on the machine level through the application of existing AI technologies or the creation of powerful universal quantum computers [19]. Superintelligent agents might be attained by different countries, groups or possibly individuals in various ways [20]. The simplest one is the acquisition of tools with superb data processing capabilities. A more sophisticated approach is biological or transhuman engineering, which aims to create more intelligent species, animals, or humans [21].

It can be argued that any highly developed intelligence is inherently moral, and higher levels of development correspond to a more benevolent stance. We still lack experimental support for this, and all relevant observations are applied to the history of evolution on Earth and the development of human society. It could also be claimed that AGI is inherently untestable [22]. It may be beneficial to have a conceptual framework for modelling interactions between different forms of intelligence, including scenarios with asymmetry among multiple actors [21]. However, it would be premature to suggest that such a framework currently exists in developed form.

2. Human superintelligence

The primary benchmark for superintelligence is the level of human intelligence [16]. According to Nick Bostrom, superintelligence has to demonstrably surpass the highest levels of human intelligence across “all domains of interest” [16]. The comparison is not entirely applicable, as machines possess significantly higher processing speeds, different memory architectures, and vastly greater data accessibility compared to humans [23]. Still, the whole process of evaluating intelligence remains challenging due to the absence of a comprehensive, universally accepted scale [9]. Some scholars also argue that superintelligence should be compared not to individual human capabilities but to the collective “network of minds” representing the intellectual capacity of humanity as a whole [14]. Nevertheless, human intelligence, being relatively accessible and measurable, serves as a practical reference point until a more universal metric is developed [16]. A notable case is that of savants, individuals with exceptional abilities in specific domains despite intellectual impairments, as observed in Savant syndrome, which is characterized by cognitive deficits contrasted with extraordinary mono skills [24].

Intelligence assessments often measure abilities shaped by formal education, yet biological and genetic factors also play a significant role in determining intellectual capacity. The influence of these factors can be evaluated through basic clinical tests, such as the Mini-Mental State Examination (MMSE), which is used to assess Mild Cognitive Impairment (MCI) or dementia [9]. However, studies of Mensa members, a population with high intellectual ability, have found no consistent correlation between exceptional intelligence and most illnesses or disabilities, with the exceptions of autism spectrum disorder and myopia [25]. Based on current scientific understanding, the development of human superintelligence may be achievable through a combination of biological and technological enhancements (see Figure 1).

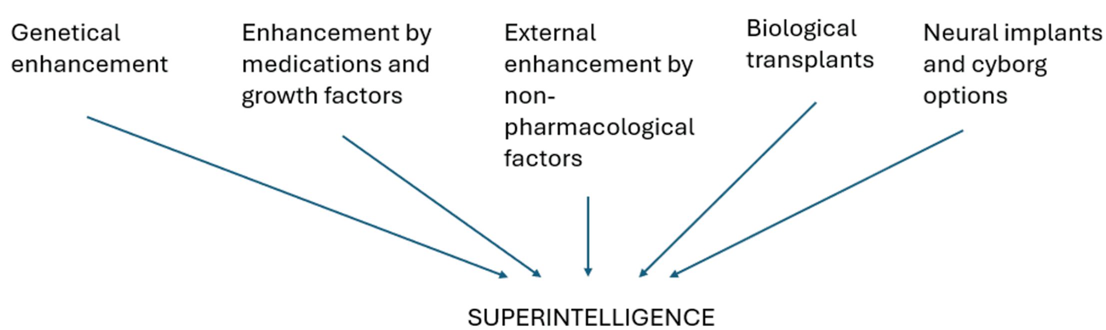

Figure 1. Components of superintelligence

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2.1. Genetic enhancement

With the rise of genetic engineering, particularly the CRISPR/Cas9/gRNA technique (Clustered Regularly Interspaced Short Palindromic Repeats, Cas9 DNA endonuclease, and guide RNA), concerns have emerged about the potential to create "designer babies" beyond essential medical purposes [26]. Future military recruitment strategies may include genome design efforts, often focusing on specific autosomal genes, such as EPOR, which regulates erythropoietin production and thereby enhances oxygen transport, and MSTN, which encodes myostatin and influences muscle development. Enhanced oxygen transport, in particular, may indirectly support improved cognitive function [27].

There is also a list of genes recognized as crucial in the development of brain-related clinical conditions that could be potentially targeted for enhancing cognitive functions. Catechol-O-methyltransferase (COMT) and dopamine receptor expression genes for D1, D2, D3, D4, and D5 are all related to various cognitive and behavioural functions, as well as the development of endogenous psychotic disorders [28]. Dopamine receptors are present in various regions of the brain, including the prefrontal cortex (PFC), which is responsible for memory, attention, and decision-making processes. Dopamine receptors regulate the activity of cognitive processes, motivation, and the reward system [28]. The COMT Val158Met can have Val/Val variant, resulting in higher COMT activity and lower dopamine in PFC, and Met/Met variant, which leads to lower COMT activity and, consequently, higher dopamine level, with enhancement of attention, memory and cognitive performance. The enhancement itself can come with a price. Higher dopamine increase sensitivity to stress and does not always enhance cognitive performance, sometimes even retard it [28]. DRD1 and DRD5 (D1-like) stimulate adenylate cyclase, while DRD2, DRD3, and DRD4 (D2-like) inhibit it, creating a complex balance [29]. The shift in balance through the activation of DRD1 and DRD5, and the inhibition of DRD2, can induce specific cognitive domains.

The Brain-Derived Neurotrophic Factor (BDNF) gene, the Serotonin Transporter gene (SLC6A4), Neurexin 1 (NRXN1), the methyl-CpG-binding protein two gene (MECP2), the FOXP2 gene for Forkhead Box Protein P2, and a number of other genes are closely associated with various elements of brain development and functionality [30]. BDNF promoter methylation, which causes reduced BDNF expression, correlates with impaired cognitive performance [31]. BDNF Val66Met influences cortical surface area and functional connectivity. BDNF expression in Val/Val homozygotes improves working memory and attention [32]. Selective serotonin reuptake inhibitors (SSRIs) or epigenetic therapies to reduce SLC6A4 methylation could enhance cognitive control and emotional stability, indirectly boosting intelligence. However, variants with

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short alleles can be associated with cognitive bias and anxiety [33]. Neurexin 1 (NRXN1) encodes a presynaptic cell-adhesion molecule that is critical for synapse formation and plasticity. Lower expression often impairs social cognition and memory consolidation, while overexpression improves memory [32]. MECP2 modulation can also enhance memory, while the FOXP2 human variant increases synaptic plasticity and dendrite connectivity in the basal ganglia, leading to improvements in communication, cognition, and motor control in mouse models [34].

2.2. Enhancement by medications and growth factors

Brain development and functionality can also be influenced by growth and inhibitory factors, which are currently being explored in vitro using brain organoids derived from human pluripotent stem cells (hPSCs) [35]. Brain-derived neurotrophic growth factor (BDNF), fibroblast growth factors (FGFs) group, Wnt signalling modulators and some others regulate neural differentiation, proliferation, and regional patterning. These studies are in early stages. A more immediate option stems from the application of cognition-enhancing medications, used to alleviate dementia. These include cholinesterase inhibitors, such as Donepezil and Rivastigmine, and NMDA receptor antagonists, such as Memantine. They are designed to support neurotransmission and mitigate cognitive decline. There is growing interest in applying these medications for cognitively healthy individuals [36].

Commonly used stimulants like caffeine and nicotine can temporarily boost alertness and focus by blocking adenosine receptors and influencing acetylcholine activity, respectively. However, more specialized nootropic compounds may potentially offer sustainable cognitive enhancements. Modafinil, Piracetam, and Ampakines can induce long-lasting effects by enhancing synaptic plasticity, increasing AMPA receptor activity, and supporting long-term potentiation (LTP), a key mechanism of memory formation [37].

Pre-synaptic stimulators and receptor stimulators are usually nootropic activators. Attention-related medications and creativity-enhancing substances are also candidates for mental capabilities improvement. Norepinephrine–dopamine reuptake inhibitor (NDRI) Methylphenidate, or Ritalin, is normally used for ADHD, but can be unofficially applied as a cognitive and attention stimulator by healthy individuals [38]. Modafinil, used against narcolepsy, indirectly influences a rise in the norepinephrine and serotonin concentration. It is used for higher concentrations with no adverse reaction on emotions and is found in psychostimulants. The list of medications and active substances with potential for cognitive enhancement is long and gets longer. However, the option of long-term pharmacological brain function enhancement remains elusive, and historical studies do not demonstrate the social or intellectual superiority of societies with a tradition of stimulants or other drug intake. There is still a question about the balance of potential benefits or damage done by these substances [39].

2.3. Non-pharmacological external enhancement

Less specific techniques, such as improved non-nootropic nutrition, appropriate physical exercise, sufficient sleep, meditation, mnemonic strategies, or computer training, can also be quite productive for improving cognitive abilities within a normal range [40]. However, these methods are unlikely to result in extraordinary outcomes of superintelligence [41]. Among non-pharmacological interventions, non-invasive brain stimulation techniques show particular promise. Transcranial Magnetic Stimulation (TMS), for example, is considered effective in alleviating post-stroke cognitive impairments [40], and has also demonstrated cognitive benefits in healthy individuals [42]. Transcranial Direct Current Stimulation (tDCS) utilises weak direct electric current for modulation of neuronal activity. It has been successfully applied to patients with Minimal Conscious State (MCS) using anodal stimulation of the left dorsolateral prefrontal cortex (DLPFC) [43]. The application of a similar method to healthy older adults also shows moderate improvement in cognitive function [44]. However, a one-year follow-up shows no difference from the control group. The method is also effective for schizophrenia patients with cognitive impairment [45]. Memory and neurocognition were registered, while other functions, such as learning, attention, and processing speed, did not show significant changes. Evidence suggests that non-invasive neuromodulation can be an effective method for inducing long-term neuromorphological and functional changes in glial cells [46] and neuronal synapses [47].

2.4. Biological transplants

Direct neurogenerative stimulators can be applied to healthy or damaged brain tissues [35]. An obvious additional option is to use transplants or cell injections to enhance brain potential. There are many obstacles to successful xeno- allo- and even autotransplantations [48]. Genetically modified neural tissues can already be fully or partially specialized. In contrast, pluripotent or neural stem cells open up the possibility of designed differentiation into monocultures or brain cell complexes comprising neurons, glial cells, and ependymal cells [49]. Successful transplants may improve specific function in patients with neurodegenerative disorders or neural lesions [50]. Recent clinical studies show effective use of differentiated neuronal cells for Parkinson's disease [51]. Mitochondrial transplantation is another way to treat neurons [52]. Glial transplants are used for damaged tissue [53]. More developed brain organoids and assembloids – 3D self-assembling cell structures, developed from human embryonic stem (hES) cells and human induced pluripotent stem (iPS) cells – are promising [54]. Brain organoid transplantation represents a significant advancement in introducing whole cellular complexes, which have the potential to restore damaged function through direct replacement with developing tissue complexes [55]. Brain cellular or organoid transplants can offer promising possibilities for enhancing brain function, and clinical research provides a strong basis for these possibilities.

2.5. Neuro-implants and cyborg options

Artificial neural implants, currently proposed for the recovery of lost neural function, can potentially be developed into a form with extended functionality for cognitive abilities enhancement [56]. There are real prospects for prosthetic hippocampus, which is mainly responsible for memory [57]. Other memory-restoring implants are also applied. While low-level cyborg and biohybrid robots have been successfully tested [58], a significant gap remains between these systems and higher-level cyborg hybrids. There are also several programs of neural interface development in different stages of completion [59]. Additional sensory implants are added to artificial visual and hearing implants. Brain-to-brain interactions and brain-controlled actuators and robots are the next steps in the contemporary research of cyborg technologies [60].

Certain concerns exist about future prosthetic chips and devices with an AI interface and relatively easy external control [61]. The real possibility of “uploading” memories, behavioural programs, or elements of character should be viewed as a potential future scenario when prosthetics with an external computer interface achieve sufficient capability to intervene in the functionality of brain structures. Brain cyborg development programs can include the childhood stage [62], which may lead to mixed human-computer education, distinct from any form currently accepted.

3. AI and superintelligence

3.1. Superintelligence as computation

Artificial intelligence (AI) development is a contemporary technological phenomenon. Researchers are increasingly drawn to the potential of artificial intelligence to attain superintelligent capabilities [63]. Nick Bostrom clearly sees AI's possibility to surpass not only human cognitive abilities but also moral judgment capabilities. He addressed potential ethical questions about super intelligence, which, in his words, will be capable of eliminating ageing and disease, creating von Neumann self-producing space probes to imitate reality realistically, but, at the same time, allow fine-grained control of human mood, emotion, and motivation and advanced weaponry [64]. Ray Kurzweil famously announced the approach of the singularity, while Bostrom and others are more sceptical and expect AGI to reach a superintelligent level in 50 or more years [8]. Today, powerful computers certainly overperform humans in specific tasks and in calculation speed [65]. Quantum computers are supposed to be potentially more powerful than classical [19], with the possibility of quantum supremacy over any existing CMOS-based systems [66]. It can serve as a medium for superintelligence, incomparable to classical AI [19]. Machines, Fault-Tolerant Application-Scale Quantum (FASQ) computers, are predicted to potentially reach a megaquop level of 10^6 error-free Quantum Operations (QuOps) [67].

3.2. Artificial consciousness

There is an existing theoretical approach that attempts to directly connect emerging consciousness with computing power. The human brain's power is estimated by Hans Moravec to be the rough equivalent of 10^8 neurons doing 10^8 MIPS, or a ratio of neurons to MIPS of 1/1,000 n/MIPS, i.e., 1,000 instructions per second per neuron [68]. Another common estimation of human brain power is one exa FLOP/S (10^{18} FLOP/S) [69], which is comparable to supercomputers.

However, it remains an open question whether we should consider AI to be not only superintelligent but also conscious at this level [70]. Calculators can perform some mathematical calculations more quickly than most humans, but this instrumental ability might not differ fundamentally from the capability of transportation for rapid movement or heavy equipment for heavy lifting. Integrated Information Theory (IIT) proposes the idea that consciousness is a result of information processing in the united system with a certain complexity of morpho-functional architecture [71]. In this case, AGI can be reached through the soon achievable computing power and a certain level of computer organization, for example, by neuromorphic computers.

A similar theory, focusing more on levels of consciousness, is proposed by Dehaene [72]. It is assumed that machines today have a level of processing equivalent to C0, which is the level where most of the intelligence resides and is comparable to unconscious states. C1 includes global availability of information and, in nature, is found in mammals with the highest brain organization. The C2 level includes

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metacognition, with the permanent ability to self-monitor and reflexively represent oneself. It is asserted that any development of C1 and C2 levels in machines will result in an artificial consciousness state.

Daniel Dennett sees a number of obstacles on the way to artificial consciousness, regardless of computational power [73]. His position is based on the vision that biologically developed human consciousness is impossible to replicate in machines. Anil Seth holds similar opinion, if not stronger: conventional AI might be not suitable for consciousness [74], while David Chalmers, a proponent of “hard problem” of consciousness [75], is sure, that there are number of obstacles for machine to obtain human type of consciousness [76]. There is no biological basis, no clear embodiment, no senses, no self-model or world model, no self-reference, no global agency and no social or moral awareness in machines. LLMs are a particular target of Chalmers. Ned Block argues that even a system with the same functional states as human consciousness can be non-conscious. There is also a “harder problem”, recognition of different consciousness in non-human non-biological agents [77].

3.3. AI superintelligence problem

Universal AI is self-limited by the necessity to create an informational super channel with the outside world [78]. At the same time, Alan Turing said: “If a machine can think, it might think more intelligently than we do, and then where should we be? Even if we could keep the machines in a subservient position, for instance, by turning off the power at strategic moments, we should, as a species, feel greatly humbled. This new danger is certainly something which can give us anxiety.”

There is a strong opinion shared by a number of researchers that universal AI superintelligence will most likely create problems for humankind, rather than solutions [79]. Yudkovsky argues that there is an inherent problem in the vision of friendly AI, which stems from a much higher level of complexity in these expectations than realised [80]. The superintelligent system will be able to create even more intelligent systems, with no obvious regard to human world vision or morals [81]. Nick Bostrom says [16] that superintelligent AI, AI+ in the words of David Chalmers, will develop AI++ very quickly, and that we will be unable to stop it. Stuart Russell bases the argument on the AI design practices not aligned with human values [82]. Geoffrey Hinton called ChatGPT intelligence “absolutely inhuman”. He sees dangers in the misuse of AI and the possibility of losing control [83]. It is an “Oppenheimer moment” with an autonomous weapon entering the battlefield. Yoshua Bengio sees a particular problem in generalised AI and proposes a non-agentic safe type via a specific block “Scientist AI” implementation [84].

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Gary Marcus, while quite sceptical about the future of deep learning statistical devices, not enabled by a symbolic component, is still concerned about different types of AI misuse, social disruption and inherent bias in AI systems [85]. There are other possibilities of adverse effects of AI. AI can amplify human limitations [86]. Even with a dependent, controlled, and super-intelligent AI, we can expect the possible rise of technology-empowered autocracy, as well as direct and indirect negative social impacts [87]. The question of superintelligence – whether artificial, natural or hybrid – remains a topic of intense debate, with no clear resolution regarding the coexistence of any superintelligent agent alongside humankind. The hypothetical morality or "benevolence" of such an entity is explored from different perspectives, yielding a wide range of predictions. Some posit that higher intelligence will naturally correlate with cooperation and moral behaviour, while others foresee more ambivalent or even dangerous outcomes [88]. Some scholars even invoke a theological God metaphor, likening the emergence of superintelligence to a kind of divine superintelligence "revelation": it is not easy to predict the behaviour of a superintelligent creature or object, as we cannot adequately judge it, especially towards other intelligent or less intelligent specimens [89].

4. Alien intelligence

4.1. Drake equation

All known intelligence, whether biological or artificial, originates from biological life forms [90]. As a prerequisite for the existence of any extraterrestrial intelligence, we have first to assume the presence of a suitable habitat that could support alien life and allow the development of advanced cognitive capacities [91]. While indicators of intelligent life are typically expected to be technological, signs of basic life are primarily biochemical in nature, and their emergence depends on favourable astrophysical conditions [92].

The famous Drake equation is the most notable attempt to formalize the estimation of N, the number of civilisations available for communication with humankind:

$$N = R^* f_p n_e f_l f_i f_c L$$

were $R*$ is the mean rate of star formation or N_s, the number of stars in our galaxy (for galactic estimation); f_p is a fraction of stars with planets, n_e is the number of Earth-type planets; f_l is a fraction of planets with life; f_i is fraction of planets where intelligent life developed; f_c is fraction of intelligent life forms developing

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civilisation; L or f_L is fraction of civilisations existing long enough to establish contact [93]. However, there are opposite conjectures about aliens possessing intelligence proposed by Sir Martin Rees [94]:

1. They will not be 'organic' or biological;
2. They will not remain on the planet where their biological precursors lived;
3. But we will not be able to fathom their intentions.

4.2. Biochemistry of life forms

Life as we know it is carbon-based, mainly cellular, water-dependent, and mostly phototrophic, with a small fraction being chemotrophic [95]. Theoretical possibilities include xenobiology, alternative biochemistries, and diverse modes of energy harvesting. Estimates of planets with developed biospheres vary widely, ranging from 500,000 to 100 million. Yet, despite these prospects, the Fermi paradox still demands an explanation [96].

Specific conditions are essential for combining biochemical pathways into precellular and cellular life, and they do not necessarily exist simultaneously at the same time and place [97]. The Earth's conditions changed radically over the past 4 billion years. At the same time, multiple carbon-based biochemical substances exist in space, ranging from carbon itself to more complex proteinogenic and non-proteinogenic amino acids, which can provide an abiogenic start for life forms [98]. There are theoretical possibilities of xenobiological forms, including those based on silicon. However, strong bonds between silicon and oxygen create significant restrictions, resulting in the formation of hard matter [99]. Silicon-oxygen bonds, with a bond energy of ~452 kJ/mol, compared to ~358 kJ/mol for C-O bonds, are strong and favour the formation of stable, crystalline silicates. However, this is correct for the oxygen-rich, aqueous environments. In non-water solvents at low temperatures, silanes can be molecules that support life.

According to the authors [100], life is: "A chemical entity that consists of bounded microenvironments in chemical disequilibrium with their environment, capable of maintaining a low entropy state by energy and environment transformation, and capable of information encoding and transfer". However, life as we know it is based on carbon and liquid water [101]. The last element of liquid water as solvent is critical. All terrestrial living forms share core common features:

1. organic chemistry and a set of ubiquitous bio-elements such as C, H, O, N, P, S and small molecules;
2. metabolic pathways, such as the citric acid cycle or respiration
3. organic polymers such as proteins and nucleic acids;

4. chemiosmotic coupling and membrane energetics [102].

Life can also be conceptualized as a dynamic process involving the transformation of chemical substances, accompanied by the exchange of energy and information. See Figure 2.

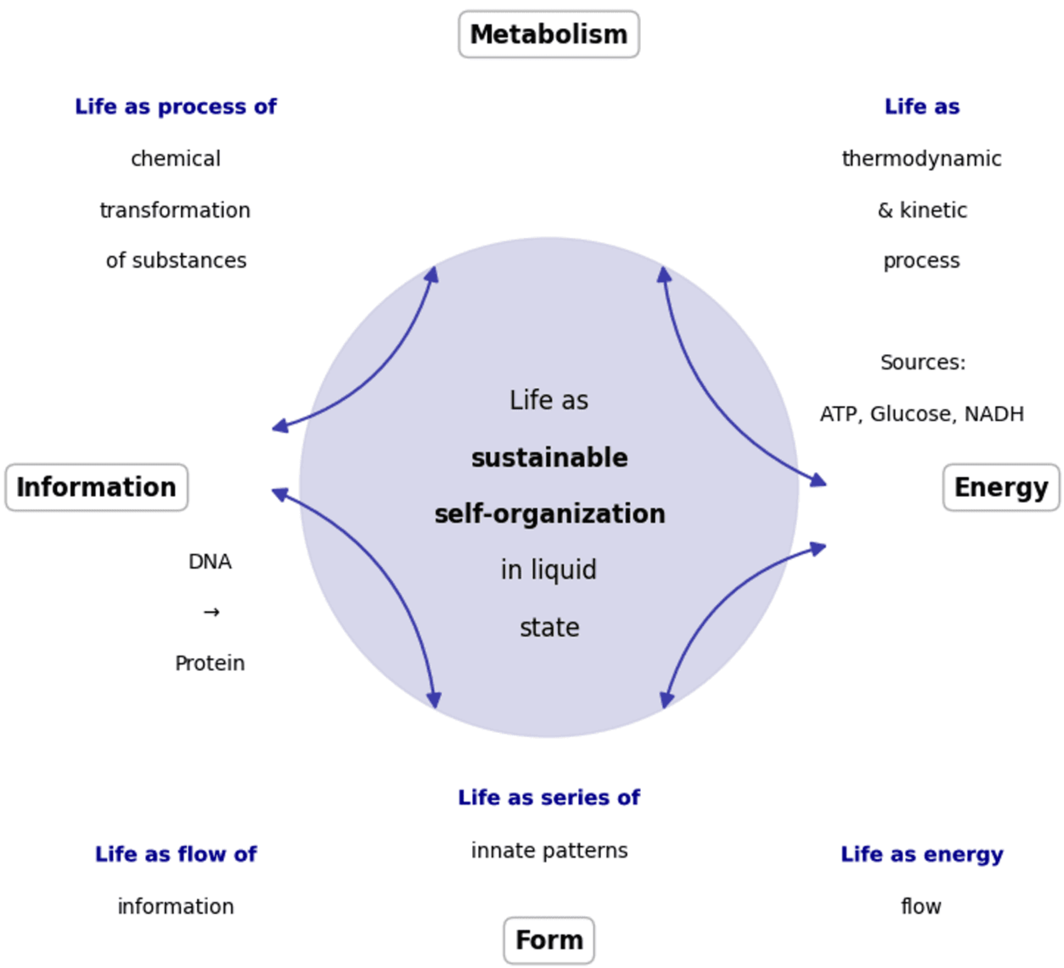

Figure 2. Life formation as a self-sustainable system

It can be abstracted in most general terms as self-perpetuating chemical transformation of substances, which requires energy harvesting, related information flow and necessary innate patterns [103].

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4.3. Probability of xenointelligence

A widely cited definition of life, originally proposed by Gerald Joyce and later adopted by NASA, describes it as a “self-sustaining chemical system capable of undergoing Darwinian evolution”[104]. "Darwinian evolution, through natural selection and genetic variation, is the only scientifically supported theory that explains the patterns of life, from molecular sequences to biogeographic distributions" [105]. There is a position that intelligence is the inevitable convergent result of evolution: "The constraints of evolution and the ubiquity of convergence make the emergence of something like human intelligence almost inevitable, given enough time and the right conditions" [106]. “Cognitive flexibility, driven by natural selection in changing environments, is a robust evolutionary strategy that makes the emergence of advanced intelligence highly probable. Intelligence or cognitive flexibility has thus emerged through an evolutionary process due to its benefits for survival, orientation, and adaptation to a variable environment in a Darwinian struggle for existence [91].

Charles Cockell [106] proposes that intellectual development may be an inherently emergent property of life in sufficiently complex planetary ecosystems that typically require a water-rich, rocky planet situated within a climatologically stable habitable zone, ideally orbiting a G- or K-type star [107]. The brighter K-type stars are more long-lived than solar-type G stars, potentially offering better conditions for long-term life development long enough to harbour highly intelligent forms [108]. As Cockell notes, “Intelligence, as a product of evolutionary pressures, is not inevitable but may be a frequent outcome where ecological complexity and environmental stability persist” [108].

Marvin Minsky presents a wider view that supports the broader concept of convergent intelligence, irrespective of its biological or artificial origin. His argument is grounded in the cosmological principle, which holds that the laws of the universe are consistent and universal, thereby imposing similar physical constraints and possibilities across space [109]. According to Minsky, intelligence emerges as a necessary response to these constraints—problem-solving capabilities enhance survival for biological species and are equally applicable to artificial systems, independent of evolutionary processes or embodiment. Whether symbolic or sensorimotor in nature, intelligent systems are shaped by the need to navigate and manipulate a shared physical reality. This reasoning extends to extraterrestrial intelligence, suggesting that early-stage spacefaring civilizations should possess sufficiently similar cognitive architectures to allow for mutual understanding or communication. From this perspective, the Fermi paradox has a different explanation: highly advanced civilizations may no longer prioritize survival, communication, or

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territorial expansion. For them, intelligence may not be intrinsically tied to contact-seeking behaviour or control over the physical world.

Charles Lineweaver offers a contrasting perspective [110], emphasizing that evolutionary processes tend to favour simpler biological systems over complex ones. Microbial life dominated Earth for approximately 70% of its history, and even today, prokaryotic life vastly outnumbers eukaryotic species—estimates suggest the existence of up to 10 million eukaryotic species compared to between 100 million and over a billion prokaryotic species. Among all these, only humans have developed technological intelligence. From an evolutionary standpoint, intelligence and the rise of civilization are niche outcomes rather than inevitable milestones, lacking strong selective pressure. As Lineweaver puts it, "Human-like intelligence seems to be what its name implies—species-specific." This view offers a potential explanation for the Fermi paradox: while the emergence of life may be relatively common, the evolution of intelligent, technological civilizations may represent a rare, non-convergent deviation from typical biological pathways.

4.4. Cooperation vs non-cooperation

If Marvin Minsky is correct in proposing that intelligence is a convergent outcome of universal physical constraints, this raises the possibility of mutual comprehension and potentially beneficial interactions with alien intelligent agents. However, Stephen Hawking offers a cautionary perspective, warning that contact with a more technologically advanced civilization could pose an existential threat to the less advanced party. His concern echoes historical patterns of unequal encounters on Earth. A counterargument draws upon a different interpretation of the Fermi paradox—namely, that civilizations capable of interstellar travel are likely to have reached a level of advancement where destructive motives are neither practical nor appealing. As some have noted, interstellar voyages "would probably be justified only for major purposes, and plundering the Earth for its resources would be neither practical nor desirable" [111].

Carl Sagan based his argument for civilization survival on the ability to cooperate, and a non-cooperative civilization will be stopped by more advanced adversaries for exactly this reason [112]. Still, there is a question about the contact: if we did not detect other civilizations, they could detect us by some means. One of the answers to the Fermi paradox is the less-developed nature of human intelligence and civilization. We are not recognized as intelligent enough to be contacted for intelligent communication, even though human or other terrestrial intelligence can be comprehended as a subset of higher-level intelligence with interstellar transport capabilities [113].

Douglas Vakoch examines whether advanced extraterrestrial intelligence (ETI) might require ethical systems as a prerequisite for long-term survival [114]. He argues that Darwinian competition alone may be insufficient for the sustained existence of such civilizations. This hypothesis can also be extended to artificial intelligence, where ethical engagement, could be important once it reaches a threshold of advanced cognition. As Vakoch suggests, "The survival of advanced civilizations may depend on ethical frameworks that transcend mere technological prowess, a principle applicable to both ETI and AI." However, as Peters and Arnould note, the most developed form of intelligence known to us is human intelligence, and human history has often involved the exploitation of less-intelligent life forms for utilitarian ends [115]. At the same time, humanity has also cultivated ethical responsibilities toward other beings, particularly those with higher cognitive capacities. This ethical consideration may extend to encounters with less-developed extraterrestrial intelligences. In cases where contact occurs between civilizations of comparable advancement, the outcome may depend on the responses of both parties. If the ETI is superior in intelligence, technology, and cultural sophistication, it may pursue either a more advanced form of Darwinian competition or, if moral development is an inevitable corollary of social and intellectual evolution, it may act with benevolence or even play a "salvific" role.

5. Human intelligence vs other intelligence

5.1. Biological intelligence and consciousness, levels and types

Intelligence manifests across a wide spectrum of biological entities, varying both in complexity and cognitive capacity. While humans possess the most advanced form, other organisms also exhibit forms of biological intelligence and possibly consciousness [116][117][118]. Table 1 outlines a hierarchical classification of biological intelligence and associated consciousness levels across taxa, from molecular systems to humans. These levels are discussed in more detail below.

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Level	Entity Type	Type of Intelligence	Consciousness	Notes
0	Molecules (e.g., RNA, proteins)	Reactive complexity	None	Adaptive via chemistry and evolution
1	Viruses	Host-triggered behavior	None	No metabolism or autonomous response
2	Bacteria / Slime Molds	Environmental responsiveness, adaptation	Non-conscious (emergent behavior)	Biofilm intelligence, quorum sensing
3	Plants	Signal integration, memory-like effects	Debated (proto-sentience theories)	Electrical and hormonal communication
4	Simple Invertebrates (worms, sponges, jellyfish)	Reflexes, minimal learning	Likely non-conscious	C. elegans: 302 neurons, minimal learning
5	Arthropods (e.g., insects, crustaceans)	Associative learning, navigation	Possibly minimal (e.g., bees, crabs)	Mushroom bodies, evidence of emotion-like states
6	Cephalopods (e.g., octopus, cuttlefish)	Problem-solving, tool use, social signals	Likely conscious	High neuron count, independent evolution of cognition
7	Fish and Amphibians	Sensory-motor learning, emotion-like states	Possibly conscious	Tool use in some species (e.g., Labridae fish)
8	Reptiles and Birds	Social behavior, memory, vocal learning	Likely conscious	Avian cognition can be comparable to some primates in corvids, parrots
9	Mammals (non-human)	Abstract learning, empathy, planning	Conscious, with emotional depth	Dogs, bears elephants, dolphins, primates
10	Humans	Language, self-awareness, metacognition	Fully conscious with reflexive thought	Theory of mind, culture, symbolic systems

Table 1. Levels of Biological Intelligence and Consciousness

5.1.1. Biological proto-sentience

Intelligence is based on data processing but is not confined to it. The minimal threshold for intelligence remains a subject of interpretive debate. However, a broad consensus among researchers suggests that natural intelligence, as currently observed, arises through the mechanisms of Darwinian evolution [108][109][114]. According to Gerald Joyce, Darwinian evolution fundamentally consists of three iterative processes: selection, amplification, and mutation [119]. Notably, biomolecules exhibit all three of these processes and can be regarded as entities undergoing Darwinian evolution [104][119]. While certain viruses possess a single-layer membrane, cellular organisms exhibit more complex membrane structures capable of maintaining homeostasis with greater efficiency. Some researchers have identified this capacity as a prerequisite for what they term cellular "nano-intentionality" or a "nano-mind," the foundation for minimal forms of proto-consciousness [120]. Additionally, it has been hypothesized that bacteria may exhibit proto-sentient behaviour through mechanisms of cytoskeletal cognition, when the cytoskeleton contributes to information processing and adaptive responsiveness [116]. The same exploration of proto-sentience has also led to claims of plant intelligence, particularly through evidence of signalling pathways and forms of memory-like behaviour [117]. Groups of cells, such as slime mold, also demonstrate the ability for basic task solving of computational geometry, image processing, logic and arithmetic when data are represented by configurations of attractants and repellents [121]. Bacterial quorum-sensing may demonstrate a rudimentary form of intelligence [122]. Fungi produce patterns of electrical activity similar to neuronal activity and demonstrate behaviours with a spectrum of sensory abilities, including learning, memory, and decision-making [123].

5.1.2. Biological sentience

There are clear signs of cognition in insects, including the ability of bees to learn complex tasks such as distinguishing human faces [124]. Drosophila fruit flies exhibit associative learning and operant conditioning [125]. Locust swarms demonstrate complex motion dynamics and alignment, potentially facilitating the rapid transfer of directional information [126]. Social insect intelligence is demonstrated by the honeybee waggle dance, which communicates spatial information about resources [127]. Complex nest construction by termites involves stigmergic coordination, decentralized individual actions guided by local prompts and environmental interactions [128]. Ants follow pheromone-marked trails and benefit from social information [129], suggesting that insects and vertebrates may use similar information-use strategies. Klein and Barron argue that functional parallels between the vertebrate midbrain and insect brains form the basis for potential protoconsciousness [130]. The protocerebrum connects structures which modulate insects' responses to events according to their subjective internal motivational state, such as arousal, sleep, satiation, hunger, and reward. Authors believe that this is the lower bound of possible consciousness. Absence of centralized agency, as in jellyfish, denies the possibility of any proto-consciousness. There are other signs of the neural system below the lower bound for consciousness. Simple invertebrates, such as nematodes, can learn but lack spatial senses.

Complexity and volume of the neural system are important in invertebrates. Lower mollusc, such as Aplysia, have 20,000 neurons, whereas the nervous system of the octopus comprises about 500 million neurons with a unique distribution [131], and the brain has 140 million cells. The octopus's nervous system also features a hippocampus, which plays a crucial role in memory and learning. They possess self-awareness, intentional behaviour, and mental states with a significant level of cognition, and possibly some elements of consciousness. However, octopuses fail the mirror test.

Mirror self-recognition is also absent in lower vertebrates. Fish possess moderate intelligence, as evidenced by associative learning, spatial memory, and rudimentary tool use. Social behaviours such as strategic hunting indicate basic forms of planning and intentionality [132]. Sentience is strongly supported by physiological and behavioural responses to pain and stress, while limited evidence suggests simple mental models and some basic elements of consciousness. Amphibians also demonstrate learning, spatial navigation, and problem-solving [133]. The brains of amphibian nervous systems, although less developed, can perform some functions comparable to those in higher vertebrates. Goal-directed actions and shared neural structures suggest the possibility of consciousness, but there is no conclusive evidence [134].

5.1.3. Biological intelligence

Biological intelligence has variation in vertebrates. It shows a clear progression from reptiles to humans. Reptiles, such as turtles and lizards, demonstrate basic learning abilities and behavioural flexibility, including spatial learning tasks [135]. Reptiles can perform spatial tasks, but they exhibit lower cognitive flexibility compared to higher vertebrates. Some species, such as garter snakes, display a rudimentary self-other distinction, suggesting minimal self-awareness, but they fail the mirror test. Birds, which are evolutionarily close to reptiles, can display more advanced cognitive abilities, including tool use, social learning, and problem-solving [136]. Corvids and parrots, in particular, are known for their ability to use tools, cooperate socially, and solve complex problems. Their cognitive abilities are comparable to those of primates. Some bird species, such as magpies, pass the mirror test, providing evidence of self-awareness [137]. Mammals, particularly dolphins, elephants, and great apes, exhibit significant cognitive advancements. They demonstrate social intelligence, significant problem-solving skills and complex behaviour and pass the mirror test [138]. The ability to recognize oneself in a mirror is a rare capacity in the animal kingdom. In humans, mirror self-recognition typically emerges between 18 and 24 months of age. Humans, as well as great apes, can monitor and control both their behaviour and decision-making meta-cognitively [139].

5.2. Superintelligence types and levels

5.2.1. The problem of typification and metrics

Superintelligence is often narrowly understood as a potential outcome of artificial intelligence development, but as previously discussed, it can be achieved through various means [16]. Superintelligent agents may take many forms: biological, enhanced biological, cyborg, artificial superintelligence (ASI), human-machine networks, distributed intelligence of various kinds, aliens, whether biological or non-biological, or even types currently unknown to us. Superintelligence can be limited, task-specific, domain-specific, or with various levels of generality, from narrow to universal.

Superintelligence refers to the development of a higher level of intelligence. We have to establish a universal intelligence scale with metrics. An interaction with an intelligent agent, smart environment or distributed intelligence reserves a human position as an arbiter. This makes human intelligence not only a benchmark for any other type of intelligence, but also poses a problem of recognising other minds [140]. There is still a question of whether any form of intelligence is natural or just emulation. Sensorimotor type, pattern recognition, task related – should it be reflected in the anthropic intelligence scale, more generalized intelligence scale or judged separately as unique intelligence or even possibly incomprehensible type [141]. There are attempts to base a universal scale on Kolmogorov complexity [2].

Goertzel proposes a taxonomy based on embodiment, distribution and sociality [142]:

1. Embodied versus non, and within the "embodied" category: singly versus multiply versus flexibly embodied, and tool-dependent versus non;
2. Mindplexes (e.g. many connected minds – DJH&NJH) versus fully unified minds;
3. Socially-dependent versus non-socially-dependent.

Sloman expands the taxonomy by introducing additional categories, including variations in sensing capabilities, actuator control, goal-following behaviour, reprogramming ability, and self-awareness, among others [143]. Some more recent taxonomies shift focus from the inclusion of architecture elements to functional capabilities [144]. Intelligent agents can be judged by their interaction with the outside world, both physical and informational; their ability to possess knowledge and learn; their capability to formulate goals, make plans, and act accordingly; their function within real-world contexts; and their ability to distinguish between whole and parts, as well as between real and imaginative situations.

5.2.2. Artificial superintelligence, types and levels

Moravec's paradox is well-known in robotics: tasks that are easy for robots are challenging for humans, and vice versa. Most artificial intelligence tasks today relate to unconscious human functionality [72]. This does not rule out our ability to outperform humans in a single task or domain. As stated by Brian Ford, "There is little substance in claims that a computer designed to emulate the circuitry of the brain can undertake tasks that humans cannot: so too can a pair of scissors; so, can an office stapler"[145]. "Even a calculator can perform tasks beyond the mental abilities of a human, and AI, though undeniably artificial, can never manifest intelligence comparable to that of a single cell."

But with the quick development of technologies, superintelligence can be encountered in artificial form much earlier than in extraterrestrial form [146]. Artificial intelligence can be placed into Cartesian space, roughly divided into types of generality and intelligence power levels based on Bostrom [16][64], Yampolsky [147], Goertzel [148], Legg and Hutter [149]:

1. Narrow AI with capabilities below human level (1-2 in Table 2)
2. Human-level general intelligence (AGI), matching the general intelligence of an average human (3-5 in Table 2)
3. Weak superintelligence: systems which slightly surpassing human intelligence in specific domains (6 in Table 2)
4. Strong superintelligence: systems vastly exceeding human intelligence across all domains (7-9 in Table 2)
5. Outstanding superintelligence: hypothetical systems with unbounded knowledge and capabilities (10-11 in Table 2)

Bostrom also identifies three primary forms of superintelligence based on speed, distribution and quality:

1. Speed superintelligence: on par with human abilities intellectually, but much faster
2. Collective superintelligence: a distributed system of puny intellects that together surpass human-level intelligence
3. Quality superintelligence: intellect qualitatively superior to human, regardless of speed

Yampolsky proposed four theoretical levels of artificial superintelligence or Super AI (SAI) [150]. Level 1, or baseline superintelligence, which surpasses human intelligence in all domains, is capable of making scientific breakthroughs in seconds or minutes and adapting them to legislation. Level 2, or SSAI, is related to Level 1 SAI, as Level 1 SAI relates to the human intelligence level. Level 3 SSSAI could involve manipulating the fabric of reality at the sub-atomic or even Planck scale. Level 4 SSSSAI becomes increasingly abstract and complex, making it difficult to predict capabilities. SAI Level n: Each new level continues to be exponentially more powerful than the previous one. Recursivity, omniscience and general broadness are characteristics of higher levels of ASI.

No.	Level	Name	Intelligence	Consciousness	Type
1	Symbolic AI	Rule-based, logic-driven	None	Low intelligence, no sentience	Low-level AI, no consciousness
2	Simple Neural Networks	Pattern recognition, data-driven learning	None	Moderate intelligence, non-conscious	Basic machine learning systems
3	Small and Medium Model Transformers	Context-based learning, sequential data handling	None	Moderate intelligence, non-conscious	Early stage of AI with specialized focus
4	Large Language Models (LLMs)	Human-like text generation, contextual understanding	None	Moderate to high intelligence, non-conscious	Large-scale AI, powerful text generation
5	Artificial General Intelligence (AGI)	Flexible, human-level reasoning and learning	Potentially conscious (theoretical)	High intelligence, potential sentience	Advanced AI with broad learning and reasoning
6	Narrow ASI	Superhuman in narrow tasks (e.g., Go, coding)	Unknown / likely non-conscious	High intelligence, domain-specific	Superhuman AI in specialized tasks
7	Broad ASI	Superhuman in multiple domains	Possible minimal consciousness	Very high intelligence, not fully autonomous	Highly intelligent across multiple domains
8	General ASI	Superhuman in all cognitive tasks	Potentially conscious (hypothetical)	Extreme intelligence, general-purpose	Fully autonomous, general-purpose AI
9	Recursive ASI	Self-improving cognition, exponential growth	Potentially conscious or opaque	Extreme intelligence, autonomy-driven	Self-enhancing, rapidly evolving AI
10	Omniscient ASI	Theoretical access to all knowledge, optimal decisions	Unknown	Idealized, theoretically perfect intelligence	Omnipotent intelligence, ideal decision-maker

No.	Level	Name	Intelligence	Consciousness	Type
11	ASI	Beyond human understanding, possibly physics-altering	Speculative / beyond comprehension	Ultimate intelligence, transformative	Ultimate, incomprehensible intelligence

Table 2. *Levels of AI and ASI*

5.2.3. Superhumans and distributed superintelligence

Eliezer Yudkovsky describes intelligence's landscape as a system of coordinates: "In one corner, a tiny little circle contains all humans; within a larger tiny circle containing all biological life; and all the rest of the huge map is the space of minds-in-general" [151]. Biological superintelligence can be developed only through the enhancement, described in part 2, or as distributed minds, a mindplex. Types include brain-computer interfaces (BCIs), neural implants, genetic or biological enhancement [16]. Enhanced animals and cyborg insects are widely used in experiments, as well as brain tissue interfaced with a computer [152]. Distributed superintelligence (DSI), regardless of its nature, can possess additional superintelligent levels due to parallel processes, scalability, knowledge sharing and inclusion of specialised modules. Networked, decentralized, collaborative cognition, especially when it includes human distributed intelligence, enhanced by AI, can already achieve a superintelligent level [153].

Hall classifies other intellects relative to their human-like abilities, even though he addresses AI and not biological intellect [154]. It can be extrapolated for enhanced biological intelligence, at least in some categories (see Figure 3). Hypohuman intelligence level is less than human. Diahuman intelligence has human-level capacities in some areas, but it is still not a general intelligence. Parahuman type is similar but not identical to human categorically and is at a similar level. Augmented human intelligence can be focused on this area at a higher level. Allohuman type is as capable as humans, but in different areas of application. Epihuman level is slightly beyond the human level, while hyperhuman is much more powerful and capable than human, clearly superintelligent.

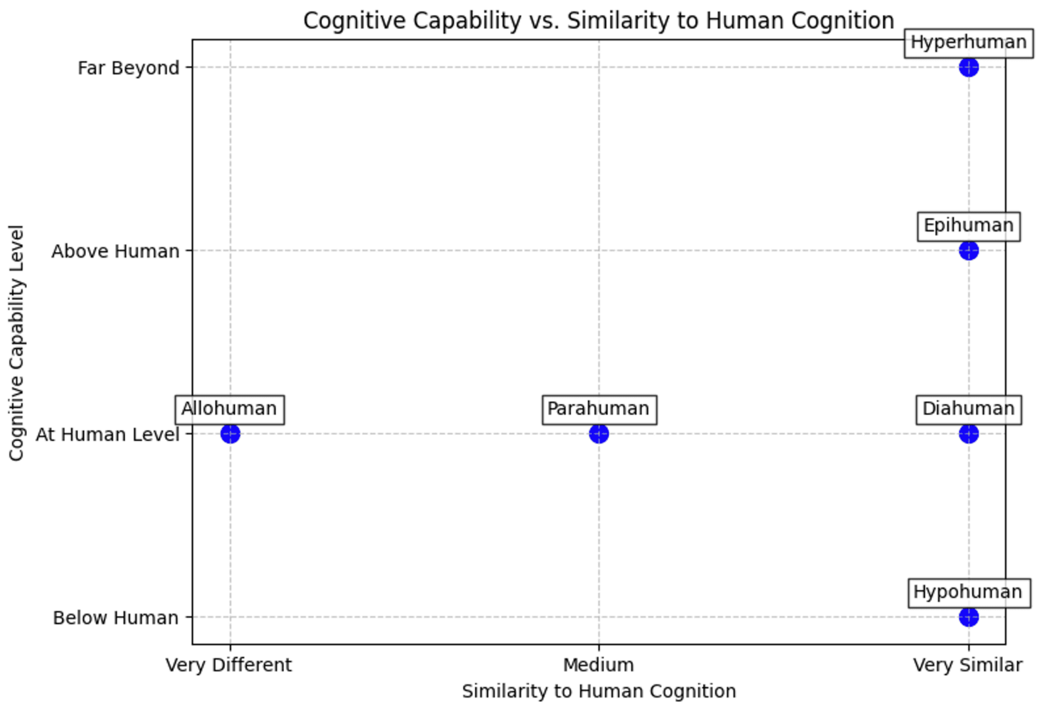

Figure 3. Types of human cognition according to Hall

5.2.4. Alien superintelligence types and levels

Technology goes hand in hand with the development of our civilization [155]. The paraphrase of Aristotelian "zoon politikon" can be reflected in the idea that humans are "technological animals" of sorts [155]. There are many potential elements, scales, and metrics for the civilization development assessment, from infrastructure to self-organization [156]. Civilization can be characterized by 200 or even 500 elements of societal, cultural and infrastructural type. The collective intelligence of a society can be inferred from the technological level, using these specific metrics.

Universal adaptation to most environments on Earth is possible due to tool-making and technological adaptation, rather than biological adaptation, even though biological adaptation is also important [155]. While even bacteria are able to change the environment and lower species can use non-biological substances for self-development and other biological species for survival, no other creature creates a technological civilization on the human scale. It is possible only due to intellectual abilities and certain biological anatomy. e.g. operative hands-free to be used with tools, binocular chromatic vision and social organization [155]. While biological evolution took billions of years to develop life forms with intellect and several million years to shift from biological to techno-social adaptation, the technological phase is relatively short. It accounts for around 2.5 million years and 1.5 million years for the usage of stone tools and fire control, respectively. The civilization itself, from the Neolithic revolution through the utilization of metal to contemporary computers, is just a few thousand years old [155].

The development of writing early systems around 5000-4000 years ago helped the transition from the prehistoric stage to the historic one [157]. Still, the tool was based on readily available materials without profound transformation, and agricultural techniques remained rudimentary. Energy was derived from natural sources and mostly did not include contemporary forms of energy harvesting, such as fossil fuels and direct solar energy [158]. Looking forward, it might be possible in future to produce food from low organic or inorganic substances. These technologies could potentially reverse Neolithic agricultural paradigms, with the technological ability to operate on both the micro (nano) and macro (planetary) levels. Nevertheless, instrumental information processing and energy consumption are the most indicative metrics of civilization development on a large scale.

Kardashev′s macro scale of energy consumption by civilization includes four types. Type 0, introduced later, is biological, with a consumption of 10^6 W [159]. Type I refers to terrestrial energy consumption in 1964, the year of the scale′s publication. Type II is "a civilization capable of harnessing the energy radiated by its own star". Type III is "a civilization in possession of energy on the scale of its own galaxy". Types I, II and III can use 10^{16} W, 10^{26} W and 10^{36} W, respectively [159]. Type IV will harvest 10^{46} W of super-cluster level. Extension of the Kardashev scale potentially includes the Universe's energy level limit (see Figure 4).

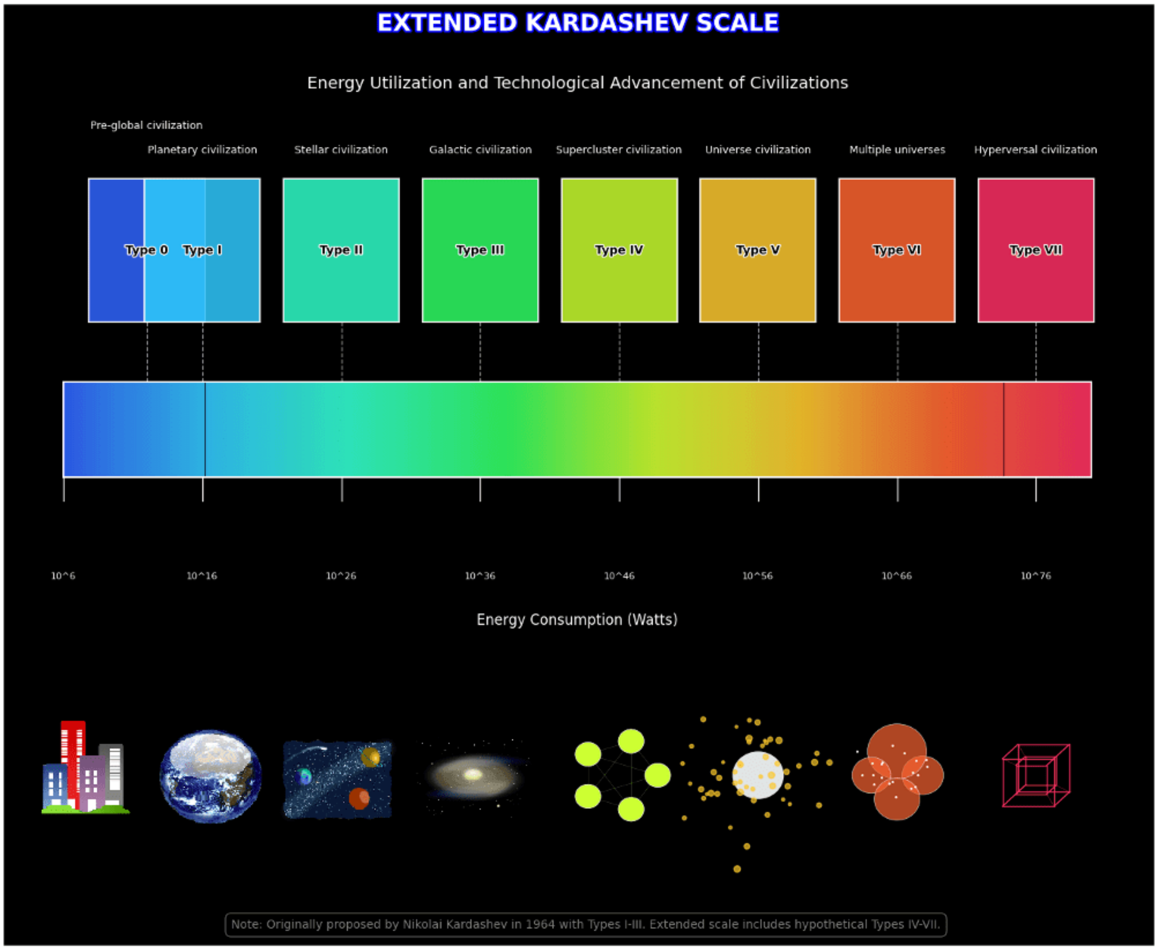

Figure 4. Extended Kardashev scale of civilization according to energy level

This discussion focuses on a civilization's technological level, as defined by its energy utilization, rather than the intellectual capabilities of its individuals or machines. More fine-grained metrics for data processing and energy consumption can be helpful in evaluating the possibilities open for the individual inside civilization. The Kardashev Scale, which classifies civilizations based on their energy consumption, illustrates the vast, almost god-like capabilities of higher civilization types (e.g., Type II and III) compared to lower ones (e.g., Type 0 or I) [160]. It is reasonable to hypothesize that higher energy consumption correlates with enhanced data processing capabilities. For extraterrestrial civilizations and superintelligence, our influence is extremely limited. However, if superintelligence emerges within our own civilization, there might be mechanisms to shape its development. A key question is whether technological advancements precede or follow the level of social development, a classic "chicken-or-egg" dilemma. This interplay between technology and social organization remains critical for understanding the trajectory of advanced civilizations [161].

Biologically and evolutionarily, the egg came first. The main idea of the argument, if we start "*ab ovo*", might be about binary processes, where change in technology and change in society go hand in hand [162]. The Kantian's answer to the question of priority might be a reformulation of the relationship between a priori and a posteriori knowledge: "theory without practice is empty; practice without theory is blind." Society can adopt certain technologies through a stepwise process of being ready to accept new technology or building preparedness based on preliminary technology. Regardless of what it is, the first real question is about the possibility of controlling or stopping completely undesired technology inside the wider society [163].

5.3. Interactions of counterpart intelligent agents with humans

Intelligence can be conceptualized as a spectrum or multidimensional space with a wide range of types and levels. Interactions between them will create a complex network or web, but it can be disentangled based on the hierarchy, typification, and topological differentiation of the main entities or agents. An interaction framework could include several key axes to formalize main connecting elements [16][73][142][143][150][154]:

1. Agency level: none, emergent, individual, collective, hierarchical, complex;
2. Communication channel: biochemical, algorithmic, signal-based, symbolic;
3. Interaction style: reactive, proactive, intentional;
4. Interaction outcome: passive impact, structural influence, strategic interaction;
5. Risk: low, moderate, high, mixed, unpredictable
6. Temporal scope: immediate, short-term, long-term,
7. Cause and result-based: cyclical, reversible, irreversible

It is possible to add other essential axes and lines, such as adaptability patterns for interacting agents, intensity levels, cognitive depth, environmental influences, ethical dimensions, and others. The framework may include interactions based on main types, such as biological origin, non-biological or hybrid, levels and elements of consciousness, and primary or secondary intelligence (intentionally produced by another intelligence). The task is theoretically and practically challenging, but even a small constructive contribution or positive effort has significance and cannot be underestimated.

5.3.1. Basic interaction frameworks

Fully-fledged consciousness includes awareness, self-awareness, intentionality, unity of experience, meta-cognition, and symbolic cognition [72][73][74][76]. Developed cognition is an important part of consciousness, but it does not mean non-conscious agents cannot be highly intelligent, at least domain-intelligent, as proven by AI. One way to build a basic intelligence interaction framework is to make a human the primary external actor and to incorporate consciousness levels (See Table 3).

Type of Intelligence	Intelligence Feature	Interaction	Communication	Opportunities	Key Challenge
Non-Conscious	Reactive, pre-sentient	Unintentional, triggered	Biochemical or physical signals; algorithms	Natural ecosystem, biochemical utility; automation	Containment, indirect impact, predictability
Distributed	Emergent, decentralized, co-adaptive	Pattern-based, direct-indirect	Environmental signals, internal state changes	Collective problem-solving, scalability, resilience	Containment, unity, predictability
Conscious	Self-aware, reflective, language-connected	Intentional	Symbolic, social, ethical	Ethical decision-making, empathy; collaboration	Value alignment

Table 3. *Simple interaction framework based on consciousness of counterpart entities*

Non-conscious entities include biological and non-biological. We can mention cellular life, plants, and machines as examples. Interaction is non-intentional, whether biochemical, physical, algorithmic, or often triggered by the other party. Opportunities arise from ecological interactions, such as the microbiome or wider network, or biochemical utility. AI helps to automate and optimize tasks. Problems may arise from insufficient containment.

Distributed intelligence is highly decentralized, emergent during units' interaction. Multicellular biological entities, such as social insects and elements of swarm intelligence, are examples of this phenomenon. The interaction can be environmental, pattern-based, or through the changes of internal states. Scalability, high redundancy and resilience, and collective problem-solving are opportunities in interactions. However, internal unity and coherence disruption, as well as low predictability, can produce problems with containment.

Conscious agents possess self-awareness, desires, goals, and are able to make rational decisions based on past experiences, knowledge and values. All types of humans [154], including conscious AGI and ASI [16][151], as well as sentient alien species, are representatives. While interaction is intentional, it is reflective and based on complex symbolic communication. It can be highly beneficial or potentially problematic, with the potential for manipulation, misaligned goals, coercion, and existential risk [142][151].

5.3.2. Interaction with biological intelligence

Biological intelligence emerges through long evolutionary processes. It is stratified on different levels in accordance with underlying agent species and types (see Table 4, 1-12). As we mentioned earlier, some authors view minimally intelligent behaviour as reflected in the active homeostasis and behaviour of microorganisms. They still lack awareness or clear intent, and their activity is based on biochemical mechanisms and signalling [116][120]. Non-sentient single-cellular species have no understanding or intent [117][121], can interact directly (microbiome, disease, toxins) or indirectly (oxygen-producing cyanobacteria), through the environment. In the negative case, they are controlled through medication and sanitation. In positive cases, they are used for fermentation, waste processing, bioengineering or environmental remediation. Proto-sentient entities, such as slime molds, plants, fungi, and lower invertebrates, have no central cognition or intentionality. They can interact directly (fungal infection, self-protection) or indirectly, through the environment. They are widely used for agriculture, aquaculture, waste processing and environmental engineering.

Basic sentience can be found in insects [130], amphibians, and simple vertebrates [131]. They have limited sensory-motor responsiveness and goal-oriented behaviour and can react through reflexive actions such as fleeing, attacking, or orienting toward stimuli [122]. Negative influences include direct attack or indirect environmental competition. These entities can be guided towards human goals (silk production, pollination, food source) through minimal domestication, signals such as light, chemicals, and pheromones. More complex animal sentience is found in reptiles, birds, cephalopods and mammals. They are capable, depending on the level, of problem-solving, mimicry, and rudimentary symbolic communication. Communication is clearly bidirectional, involving emotional expression, vocalization, tool

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use, and playful behaviour[118]. They are capable of forming relationships and learning from humans. In the negative case, direct attack or competition is possible. The human role varies from creating companionship through pet ownership and social bonding to training for labour or security. They are used for biomedical research as models. We can see an increasing ethical responsibility for these entities in captivity, including the protection of habitats and disruption, as well as their treatment.

The lowest tier of human-level intelligence is already observable in great apes. The full spectrum includes all forms of Homo sapiens, collective human intelligence [164], enhanced or augmented humans, and even hypothetical alien biological intelligences with comparable cognitive capacities. They are capable of abstraction, meta-cognition, and sophisticated social and institutional behaviour. Interactions are usually highly complex, involving language, cultural symbols, and encompassing empathy, moral reasoning, negotiation, and coordinated cooperation or conflict. Negative interaction includes competitive behaviour and exploitation, while positive interaction is reflected in collaboration and mutual strategies [165].

Higher biological intelligence (hypothetical alien or advanced Earth species) can be described as superintelligence [154], with consciousness or super-consciousness. Biological intelligence of any level typically encompasses awareness, self-awareness, embodiment, meta-cognition, emotional processing, and social cognition. This type and level of intelligence can utilise advanced signalling systems or symbolic structures that exceed current human cognition. It can possess possibly unrecognizable motives, goals, or methods to achieve them. The humankind has to be cautious in order to minimize misinterpretation, escalation, or exploitation [115]. The interaction can be strategic but nonlinear, involving new diplomatic protocols or alliance strategies. It is an unresolved question about the inevitability of moral progress in a biological superintelligent civilization [112][113][114].

5.3.3. Interaction with artificial intelligence

It is necessary to extend the formal framework not only to AI, but also to "intelligent environment interactions" [166]. An interaction with an intelligent AI agent or AI environment (See Table 4, 13-15, 19) reserves a human position as an arbiter. Human-machine interaction transforms into human-smart, complex interactions with physical, psychological and social dimensions [167]. With the quick development of intelligent networks, super-intelligence can be encountered in artificial form much earlier than in extraterrestrial form [146].

A high level of intelligence cannot be judged only by goal-oriented solutions. Human goals are often complex, and applying the same rationale to the developed levels of intelligence would be reasonable.

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Complex goals are not expected to be “coded” on the most basic level. Mathematical operators or formulations in their abstraction cannot fully reflect the necessary complexity. Sometimes, insufficient interaction between human and computer systems leads to massive missing data, even in critical areas [168].

The speed at which AI systems acquire intelligent abilities, including creative ones, which are impressive. It is temporarily superior to humans, as we require years of learning, whereas AI systems can be trained much more quickly. The idea that creativity is a measure of natural intelligence, and only mundane tasks are left to AI, is definitely not holding on. The Torrance test on creativity has been successfully taken by LLM, and the creative abilities of generative AI have been demonstrated in literature, music, and the visual arts [169].

Ethical questions related to AI development must include the necessity of developing an ethical emulator or proxy for AI-powered robotics to prevent “antisocial” incidents. Empathically constrained behaviour [170] is insufficient if we consider empathy versus sympathy, and the gradation of the behaviour is important. Interaction with AI has to be, according to Stuart Russell [82], subjected to three main principles:

1. The machine’s only objective is to maximize the realization of human preferences.
2. The machine is initially uncertain about what those preferences are.
3. The ultimate source of information about human preferences is human behaviour.

There are potential dangers associated with human-incompatible AI, even at levels below superintelligence. The simple suggestion is the ability to switch off a problematic AI, if it were possible to do so with a superintelligent machine. The vision exists that intelligence will inevitably be connected with altruistic tendencies of AI, which is far from obvious [82].

There is also an argument about intelligence multidimensionality, discussed above—AI will be narrowly specialized, and there is no danger from the intelligent tool as long as it is restricted to a certain area. However, we cannot be certain that the narrow superintelligence will be fully controlled [142][147][151]. There is a possibility of quick development of generalized ASI with quick escalation to higher forms [16]. In this case, loss of control in the case of AGI can become existential with ASI. On the other hand, the mitigation of this problem can lead to global optimization, the ability to solve existential problems of humankind.

5.3.4. Interaction with hybrid and complex intelligence

Lower-level intelligent hybrid systems may include hybrid artificial-biological entities that utilise wetware-AI fusion, synthetic life forms, or complex combinations of these elements [58]. At this level, such systems can already demonstrate novel forms of cognition, responsiveness, or embodiment. The human role must be clearly defined as a guardian of risk boundaries [59]. Clearly defined purposes, limits, and safety protocols are essential. The importance of these points is significantly higher for human–animal hybrids, genetically modified organisms (GMOS) with intelligence, cyborg animals, and cyborg humans (Table 4, 8, 10, 12) [61][62]. For lower than human levels of intelligence, hybrid behaviuor may combine instinct with artificial control mechanisms, while questions of autonomy and ethical oversight become more important on higher levels.

Brain–machine interfaces can be extended to neuroprosthetics and cognitive enhancement systems and, at a higher level, towards the human-AI collaborative intelligent systems. A network of these elements will produce mixed, distributed systems, such as human-AI networks or global cognitive assemblages [59]. Significant intelligence enhancement can lead to positive solutions in healthcare, social dynamics and environmental sustainability. It may enable advanced problem-solving on the level of humankind, ethical decision-making at scale, and the development of resilient systems for managing global challenges [61]. However, intimate, real-time, and bi-directional interactions through neural signals, feedback loops, and adaptive calibration may blur the distinction between internal agency and external control [62][154]. It also opens the possibility for external hacking. Such systems will require maintenance of cognitive integrity and long-term neuroethical evaluation. On the level of the network, questions of architecture may reflect planned system-wide behaviour through policy, collective decision legitimacy support and norm-setting. It will be essential to uphold a balance between low-level swarm intelligence elements, non-conscious or differently conscious AI and human agency as central arbiter [64][150].

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N	Entity type	Example entities	Consciousness level	Type of intelligence	Interaction with humans initiated by the type of intelligent agent
1	Pre-sentient Biological	Viruses, prions	None	Reactive biochemical	*Positive*: Indirect *Negative*: Diseases, infections
2	Minimal Biological	Bacteria, archaea, parasites	Non-conscious	Adaptive chemical sensing	*Positive*: Indirect, microbiome *Negative*: Infections, diseases
3	Slime Mold and Microbial Cliques	*Physarum polycephalum*, bacterial swarms	Non-conscious	Distributed spatial problem-solving	*Positive*: Indirect *Negative*: Spread across structures or interfaces, structural disruption
4	Plant and Fungal Networks	Trees, mycorrhizal fungi	Non-conscious	Distributed chemical signaling	*Positive*: Indirect, ecological *Negative*: Toxic exposure, allergenic reactions, ecological competition; fungal infections
5	Simple Animal Sentience	Insects, invertebrates, vertebrates: amphibians, fish species	Pre-reflective sentience	Reflexive behavioral response	*Positive*: Indirect, natural regulation of pests and maintenance of biodiversity. *Negative*: Direct attacks: biting, stinging; parasitism
6	Mammalian and Avian Intelligence, reptiles	Reptiles, Elephants, chimpanzees, ravens	Sentient and emotional	Social and experiential	*Positive*: Cooperative behaviors, protective actions, and interspecies affiliative gestures. *Negative*: Territorial aggression, predation, retaliatory attacks

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N	Entity type	Example entities	Consciousness level	Type of intelligence	Interaction with humans initiated by the type of intelligent agent
7	Collective Animal Swarms	Bees, ants, locusts; bird swarms; school of fish	Emergent swarm intelligence	Distributed, rule-based coordination	*Positive*: Indirect – Pollination, environmental maintenance. *Negative*: Crop devastation, invasive behavior, mass attacks
8	Augmented Non-Human Animals	Genetically modified species; cyborg animals	Varies	Artificially extended or modified behavior	*Positive*: Depends on the level *Negative*: Unintended ecological disruption, aggression, containment failure.
9	Human Intelligence	Homo sapiens sapiens	Fully conscious, reflective	Rational, emotional, ethical cognition	*Positive*: Spontaneous acts of empathy, aid, innovation benefitting others without being prompted. *Negative*: Violence, coercion, aggression without provocation.
10	Augmented Humans	Cyborgs, genetically enhanced, biologically enhanced	Enhanced self-awareness or capability	Cyber-biological or enhanced rational systems	*Positive*: Initiates solutions for high-complexity problems (e.g., medical, social) *Negative*: Manipulations, domination, exploit unenhanced humans for competitive or strategic advantage.
11	Collective Human Intelligence	Scientific communities,	Distributed via individuals	Emergent, problem-solving	*Positive*: Large-scale cooperative efforts (e.g., global health, disaster relief)

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N	Entity type	Example entities	Consciousness level	Type of intelligence	Interaction with humans initiated by the type of intelligent agent
		civilization-wide cognition			without individual prompting. *Negative*: Mass surveillance, social conflict, suppression, war, exploitation
12	Hybrid Intelligence Systems	Human-AI teams, brain-machine integration	Mixed (conscious + non-conscious)	Synergistic (cognitive outsourcing + enhancement)	*Positive*: Co-evolutionary, work augmentation. *Negative*: All types of domination and control
13	Narrow AI Agents	Drones, automated surveillance, industrial AI	Non-conscious	Task-specific algorithmic logic	*Positive*: Infrastructure maintenance, early warning systems. *Negative*: Autonomous malfunction, misclassification, unaligned threat behavior.
14	Artificial General Intelligence (AGI)	Hypothetical self-improving AGIs	Possibly conscious	General-purpose autonomous reasoning	*Positive*: High-level scientific collaboration, global optimization. *Negative*: Strategic manipulation, value misalignment, loss of control.

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N	Entity type	Example entities	Consciousness level	Type of intelligence	Interaction with humans initiated by the type of intelligent agent
15	Artificial Superintelligence (ASI)	Bostrom's sovereign systems	Super-conscious or unknowable	Recursive and strategic cognition	*Positive*: Solutions to existential problems, sustainable planetary governance. *Negative*: Human obsolescence, misaligned optimization, existential risk.
16	Alien Civilization – Lower	Pre-industrial or tribal alien species	Proto-conscious to sentient	Instinctual or symbolic reasoning	*Positive*: Cultural exchange, benign observational contact. *Negative*: Misinterpreted threats, territorial hostility, ritualistic violence.
17	Alien Civilization – Technologically Equivalent	Spacefaring Type I–II alien societies	Rational, self-reflective	Scientific and sociopolitical intelligence	*Positive*: Diplomatic engagement, technological collaboration. *Negative*: Ideological conflict, strategic competition, militarized contact.
18	Alien Civilization – Higher	Kardashev Type II–III civilizations	Hyper-conscious or unknown	Strategic, potentially post-biological	*Positive*: Beneficial planetary engineering, knowledge transmission. *Negative*: Resource exploitation, surveillance, existential interference.
19	Alien Non-Biological Intelligences	Von Neumann probes, alien AI systems	Unknown, likely non-conscious	Self-replicating exploration logic	*Positive*: Seeding of technology, passive data collection.

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N	Entity type	Example entities	Consciousness level	Type of intelligence	Interaction with humans initiated by the type of intelligent agent
					Negative: Environmental destruction, resource harvesting, existential interference.
20	Theoretical Panpsychic Systems	Sentient fields, conscious cosmos	Cosmic or distributed awareness	Non-anthropocentric awareness	*Positive*: Potential alignment with cosmic-scale harmony or purpose. *Negative*: Incomprehensible existential shifts, systemic upheaval.

Table 4. Interaction with humans with counterpart agents, according to intelligence levels and types

6. Conclusion

Superintelligence is a relative phenomenon and cannot be arbitrarily claimed today only on the basis of a certain absolute level of information processing capacity or operational capability. Superintelligence is a strong intellectual over-performance of not only average human cognitive abilities but also of the best possible human mental capabilities. We can flexibly use the scale of parameters from primitive cognitive levels to modern human levels and higher degrees of intelligence, with chosen metrics, to obtain a projection of levels for superintelligence. It is necessary to recognize that we have some inherent points of difficulty while trying to address the problem of intelligence scale construction of any type, based on any metric. The first one is the inability to clearly and singularly claim the fundamental minimal level of intelligence. The categorical vagueness of the borderland between pre-intelligence and intelligence proper exacerbates the problem. It might be shown as a continuous space with several scales, such as data processing speed, task complexity levels, and operational or behavioural scales, while still being related to and compared with human abilities as a comprehensible benchmark. The starting point is zero intelligence, which still needs to be demonstrated, and the final point on the scale is truly Universal, limited only by the physical capabilities of the intelligent system.

Another problem is the intimate relationship between consciousness and intelligence, but not always the other way around. There is an option to take a step back in the discussion on superintelligence, specifically regarding conscious artificial superintelligence, Artificial Consciousness, and to discuss the problem of narrow Artificial Intelligence, even without considering AGI. Intelligence, at least some types of it, is practically assessable: measurable on a certain constructed scale in accordance with the level of standardized problems solved by this type of intelligence. It provides us with the opportunity to create a framework for the potential practical evaluation of any intelligence, regardless of its physical basis, working mechanism, nature, or architecture. While recognizing the possibility of a comparative universal intelligence measurement environment, we discuss the necessity of using the framework not only for academic and philosophical reasons but purely for the necessity of pragmatic examination of risks attached to any type of superintelligence, including xeno-intelligence.

Autopoietic, homeostatic, autonomous, and embodied intelligent systems known to us are usually biological in nature. Any biological system is capable of direct Darwinian competition or indirect competition for space, resources, or energy. An interaction with such agents, even those with proto-sentience or sentience, may include negative types that are damaging to humans or humankind. However, truly intelligent agents do not necessarily need to be hostile, as different levels of mutual cooperation are conceivable. There is still a possibility that a more intelligent agent could be capable of higher autonomy in decision-making, despite the inability of less intelligent agents to effectively block its autonomy. It may be less important in the face of any signs of autonomy in intelligent systems without embodiment, such as autopoiesis and homeostasis.

A key point is made in this paper regarding superintelligent agents. Regardless of the nature of the agent or system —biological, non-biological, terrestrial, or extraterrestrial —a dominating, autonomous cognitive system has the potential to overlook the "less intelligent counterpart" in its decisions and actions. The contingency plans for the interaction between humans and non-human intelligence must include risks of adverse reactions from the superintelligent counterpart. We can extend principles of human-human intelligence interactions into other types. Moral restrictions exist in the case of human intelligent actors and are partially applicable to non-human biological agents. We are less confident in the case of AGI or ASI. It remains to be investigated whether universal moral restrictions, as we know them, are applicable to all intelligent systems or societies.

Statements and Declarations

Author Contributions

Conceptualization, D.J.H. and N.J.H.; Writing – Original Draft Preparation, D.J.H.; Writing – Review & Editing, D.J.H. and N.J.H.

Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study. Information is drawn from publicly available cited sources.

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