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Natural intelligence and the ‘economy’ of social emotions: A connection with AI sentiment analysis

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ABSTRACT

By approaching the concept of Natural Intelligence a new path may be open in a variety of theoretical and applied problems on social emotions. There is no doubt that intelligence emerges as a biological/informational phenomenon, although paradoxically a consistent elaboration of that concept has been missing. Regarding emotions, they have been keeping an unclear status, being often restricted to the anthropological or to ethological approaches closer to the behaviorist paradigm. Herein we propose a different track, centered in the life cycle advancement. The life cycle in its integrity becomes the nucleus of natural intelligence's informational processes, including the consistent expression of emotions along the maximization of fitness occasions. In human societies, the overall ‘economy’ of social emotions is manifest, showing up in the conspicuous interplay between bonding processes and different classes of social emotions. The essential link between natural intelligence, emotions, and the life cycle of individuals may harmonize with current progresses – and blind spots – of artificial intelligence fields such as ‘sentiment analysis.’

1. Introduction: Approaching natural intelligence

One way to initially approach natural intelligence in its relationship with social emotions could be placing a contraposition between the two kinds of intelligence: natural and artificial. In this contraposition, emotions appear as one of the fundamental components of natural intelligence, but at the same time they constitute one of the most cherished targets of socially applied artificial intelligence—the core of the “attention economy (Lanham, 2006). In our approach to social emotions from the point of view of the former, we will largely benefit of recent biological achievements, trying to translate into the human societies a consistent conceptualization based on the cellular life-cycle's interception of information flows. We will show that our informational nature of composite “cellular individuals” involves a parsimonious deployment of emotions in the individual achievement of fitness within the social milieu. The challenge is how to establish a compact narrative that might lead, so to speak, from living cell-cycles to behaving animal brains and human individuals within social structures. That's precisely the central goal of this work.

Let us clarify first what we mean by the rather infrequent term of ‘natural intelligence.’ It may be ascertained, or better intuited, via different multidisciplinary syntheses among a plurality of new fields that have progressively emerged along the biomolecular and computer revolution of recent decades: evolutionary epistemology, autogenesis, autopoiesis, bioinformation, biological cognition, biocybernetics, biosemiosis, natural computation, bioinformatics, biocomputing, bioengineering, synthetic biology, systems biology, and so on. Different synthetic views about some of these fields may be found in (Armitage et al., 2005; Corning, 2020; Marijuán, 2002; Marijuán and Navarro, 2022; Perez Velazquez, 2009; Shklovskiy-Kordi and Igamberdiev, 2022; Slijepcevic, 2018; Timsit and Grégoire, 2021; van Duijn, 2017). Let us note that the term intelligence frequently appears in these works, referred to information processing and often extended to cells, multicellulars, plants, nervous systems, swarms, and animal societies (Calvo, 2016; Gershenson, 2021; Solé et al., 2019; Trewavas, 2017). But the conceptual panorama is far from coherent. Indeed, intelligence participates of the conceptual difficulties of a series of deeply related concepts such as information, meaning, value, and knowledge. In fact, whatever the field, the concept becomes unassailable, and counts like its germane information with multiple pragmatic definitions – too many of them! – related to the traditional fields in which it has been applied: psychology, social science, cognitive science, computer science, etc.

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Pragmatically, intelligence means the ability to flexibly use different tools in the pursuit of some adaptive goals in a changing environment. In the field of AI, as indicated by its pioneers (McCarthy et al., 1955), the interest on intelligence was just pragmatic. They were interested in automatic computers, language programming, neural networks, complexity measurement, abstraction processing, randomness, and creativity. Very soon, however, the success of this venture lead to the "cognitive revolution," which proposed a hexagon of disciplines focused on human cognition and artificial intelligence: linguistics, neuroscience, artificial intelligence, philosophy, anthropology, and psychology. Any biological connections were disregarded; it was a separate kind of intelligence, only anthropocentric and computational.

Nevertheless, as one of the present authors argued long ago, in the early 1980s, the exclusively formal, computer-based schemes of expert and logical systems, perceptrons, neural networks, parallel processing, etc., were far from sufficient. Previously, a reflection on the general phenomenon of intelligence in nature was needed, also taking distances from too anthropocentric approaches in psychology or from behaviorism-oriented ethology. These ideas were developed as a PhD thesis: *"Natural Intelligence: The Evolution of Biological Information Processing"* (Marijuán, 1989). To make a long story short, the scheme of this work was oriented bottom-up, from enzymes as basic processors (molecular automata), coupled with memory banks (nucleic acids), to the informational-intellective scheme of living cells; going then to multicellularity, to the emergence of nervous systems, and to fundamentals of intelligence based on neural processing; ending with an approach to crucial aspects of social intelligence. The commonality of features among highly different, but hierarchically interrelated, forms of intelligence was dubbed as 'natural intelligence' (Marijuán, 1989). This approach pointed to some fundamentals of cellular, neural, and social collective intelligence that, overall, would continue to be applicable and of some theoretical interest, also facilitating the connection with social emotions.

Properly establishing the core of natural intelligence is too complex a multidisciplinary task. Just trying to model or simulate in AI grounds some of its multifarious capabilities does not seem to conduce to the core problems (Bryson, 2015; Gershenson, 2021). Herein, in order to connect with social emotions, we will make a detour around a series of ideas that establish a workable scheme of natural intelligence. It will start, in Section 2, with the cellular world, taking prokaryotic intelligence as the 'fundamental unit (Armitage et al., 2005; Marijuán et al., 2010). An essential point will be advanced: the primacy of the cellular *life cycle* (life story, life course) as the main subject of evolutionary information processing and adaptation (Minelli, 2015). Analyzing the behavioral developments of the cell and its interception of information flows, we will find a curious simile of, say, 'molecular emotions' at the level of gene expression—around the functional hierarchy of *sigma factors*. Parallel considerations around the life cycle of multicellular organisms will guide in our analysis of the adaptive information-processing role of nervous systems. We will register the appearance of true emotions along the evolution of nervous systems, and we will also consider the optimality or 'economy' principles of neuronal information processing (Friston, 2012; Tozzi et al., 2017)—not to forget that it was Santiago Ramón y Cajal (1899) who first proposed 'principles of economy' in nervous system anatomy and physiology.

Previous to the discussion in depth of the human emotional endowment, in Section 3 we will focus on the stringent social adaptation of our species – the 'niche' structure of our own sociality – what can be called the human "sociotype", and the influence that the different relational domains therein would have on our own arrangement of social emotions (Marijuán et al., 2017, 2019). Then, in Section 4, we will approach the Cartesian diagram of emotions, the *circumplex model*, which represents valence and activation (POSNER et al., 2005; Russell, 1980; Russell and Barrett, 1999); other classifications of emotions will be revised but, rather than emphasizing the making of longer and longer all-encompassing emotion lists, we will propose the systematic analysis of the patterns and coalition patterns that trigger off our social emotions. It is an idea that can also be related to the emergence of human "ultrasociality" (Turchin, 2016). The basic or primary emotions involved in processes of *strong bonding*, as well as the secondary emotions involved in intergroup cooperation and *weak bonding*, would be systematically co-opted for the emergence and structural consolidation of ultrasociality. There seems to be a global interrelationship of new bonding processes and appearance of new social emotions, crystallized in very different cultures, social structures, and institutions.

Summing up at the Conclusions Section, and closing the conceptual circle, the whole case of social emotions will be reconsidered in the light of the dichotomy between natural intelligence and artificial intelligence—and their contemporary collision in 'sentiment analysis'.

2. The fundamental unit of natural intelligence

It is important that we clarify the origins of biological/natural intelligence and its cellular 'fundamental unit', which is necessary to set up a consistent rationale along the evolutionary process. In other words, there appears a 'prehistory' of intelligence – and of emotions –which undoubtedly is cellular. Its evolutionary development provides a deep sense and cogency to the social emotions approach.

2.1. The cellular life cycle

Cellular systems (even the simplest ones, prokaryotes) purport an amazing information design. The living cell is a system that constructs itself from environmental material according to an internal blueprint that is separate from the constructive system itself (following von Neumann's self-reproducing automata). All external substances used for self-construction are systematically detected and identified by a dedicated apparatus, the signaling system; then they are selectively imported into the cytoplasm in order to extract their free energy along the ensuing metabolic pathways. So, metaphorically speaking, 'reading' the environment affordances becomes prior to 'eating' them. Or more conventionally, the high-energy, highly valuable energy flows apportioning the materials needed for self-production will be anticipated, detected, and captured by means of the faster and cheaper communication flows tended with the surrounding environment via the cellular signaling system. Recent discoveries in prokaryotic cellular signaling systems have evidenced new important details of this sophisticate relational phenomenon (Galperin, 2005; Grigoroudis et al., 2007; Ulrich et al., 2005). What has been called the "1-2-3 Component Systems" scheme (as coined by Jorge Navarro in (Marijuán et al., 2010) has opened new views on a variety of themes related to the cellular integration of signaling with metabolism and gene transcription—the core of biological intelligence.

An important aspect, looking at the way the bacterium E. coli – the most traditional biomolecular model system – organizes its gene transcription processes, is that a few general states strongly orientate the whole activities: favorable growth conditions, thermal and osmotic stresses, starvation, lack of iron, etc. A few "sigma" factors take care of responding to such specific conditions. In E. coli there are 7 different "sigmas", which are respectively known by their weigh in kDalton. They link RNA polymerases to transcription factors and gene promoters. One of them, Sigma 70, which is constitutively expressed, correlates with favorable growth conditions, and promotes generic translation of around 40% of the genome; the other sigma factors directly promote the expression of around one hundred genes or less. They may cover desiccation, starvation, iron presence, sporulation, SOS system, etc. In all cases, these sigma factors are carefully controlled: anti-sigma proteins and anti-*anti*-sigma proteins take care of detecting specific state variables that determine their gene expression (Gama-Castro et al., 2016; Karp et al., 2007; Salgado et al., 2013).

Let us emphasize that the sigma factors' role in the bacterial life cycle parallels the role of emotions in central nervous systems—propitiating a complete reorientation of cellular behavior by switching towards another aggregate of molecular pathways which are more favorable for the advancement of the life cycle.

If we focus on this continuous relationship with the environment, the adaptive responses that the cell synthesizes may now be contemplated under the prism of what the signal 'invisibly' conveys—its meaning. Meaning emerges from the cell's capability to self-modify its structures in response to external signals, and to inner changes as well. We may state that the meaning of a signal is what is fabricated ad hoc by the receiver cell, essentially via its signaling system and the coupled protein synthesis. This is a universal trait maintained in all the kingdoms of life.

Thus, we advocate the centrality of the cellular signaling system as the genuine source of biological semiosis along the evolutionary process (Marijuán et al., 2018). It is the capability of responding to external signals, changing the own structure via the relatively 'blind' self-production mechanisms, what supports the evolution of more advanced interactions and communicative exchanges—including 'molecular languages and all sort of intercellular codes. A cluster of concepts tightly associated with information and meaning, such as memory, value, and knowledge, all of them integrated within the whole of biological intelligence, may be suitably approached along this way of thinking (Marijuán and Navarro, 2022; Navarro and Marijuán, 2022).

Let us emphasize that while we have described the foundations of cellular intelligence, we have also found a 'protoemotional' system capable of dramatically redirecting the ongoing cellular life cycle towards its most adaptive course.

2.2. Complex multicellular organisms: emergence of new forms of biological intelligence

The different types of intelligence that have evolved in eukaryotic cells, multicellular organisms, fungi, plants, animals, etc. would not depart from the basic phenomenology of prokaryotes: their intellective mechanisms are always in the service of advancing the life cycle. New powerful developments such as symbiosis, signal expansion, cell cycle modularity, differentiation, epigenesis, and the ontogenetic development of metazoans did conduce to evolutionary scenarios of uncanny complexity. Eukaryotic cells developed new tools to control the possible paths of the now far more complex life cycle. It becomes in Borges' terms, "the garden of the forking paths" (Borges, 1941). Now, the functional equivalents of sigma factors are the cellular "checkpoints", where fundamental internal and external pieces of information converge to take the great decisions of a life cycle, which has now become extremely more complex: growth, maintenance, arrest, reproduction, differentiation, specialized function, apoptosis … All these complex checkpoints represent genuine "pattern recognition" devices the mission of which is to maintain or to transform the trajectory of the eukaryotic cell cycle along its most appropriate path. See Fig. 1.

As supracellular organisms come forward, endowed with multiple tissues playing a collective problem-solving game, they are still based on the signaling system capabilities of individual cells and their malleable life cycles. The nervous system is a case in point. It appears as a special electro-molecular tissue capable of orchestrating a new way of 'topodynamic' information processing, providing the body with instant fitness assessment based on increasing varieties of information acquisition (Tozzi et al., 2017). Electricity, ad hoc molecules, and topological mappings become the basic tools of this advanced form of biological

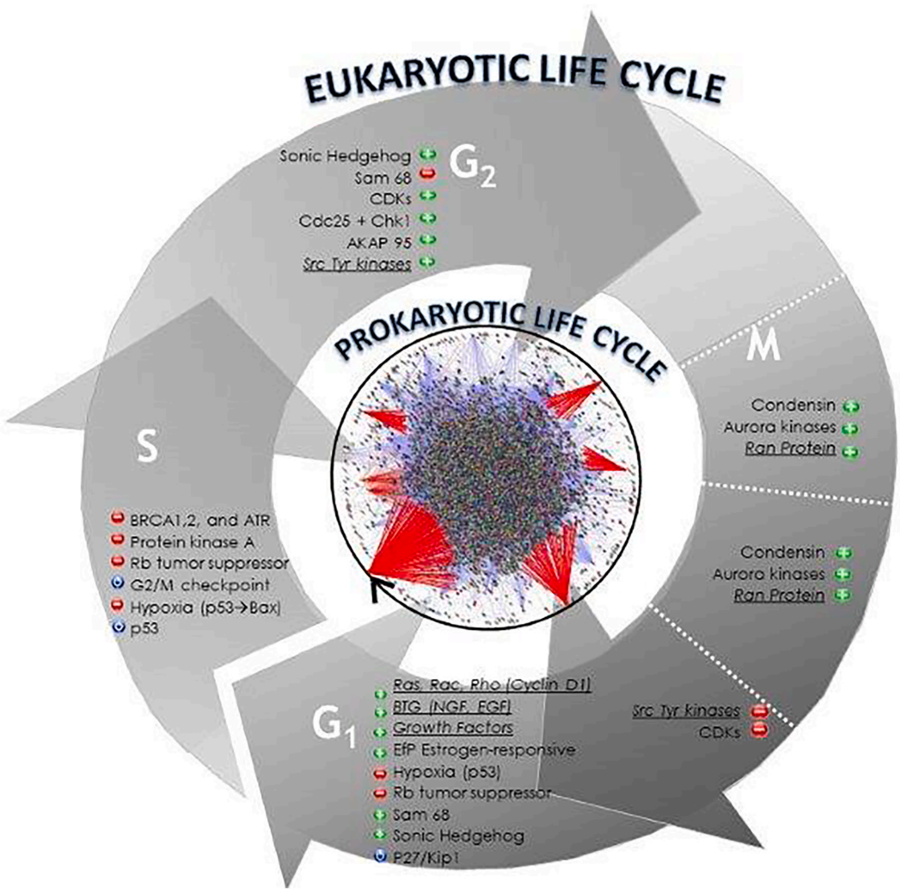

Fig. 1. Eukaryotic and prokaryotic life cycles: A comparative is drawn between prokaryotic sigma factors (fanning red lines in the center of the figure) and eukaryotic checkpoints (represented as dotted signs along the different phases of the life cycle).

intelligence. The evolution of neuronal intelligence has kept pace with the progressive complication and refinement of these nested information flows across the hierarchy levels of organization (Wurtz, 2021). From diffuse neural networks, to ganglia, to cords, to cerebroids, and to the central nervous systems of vertebrates, what we see is an informational crescendo culminating in advanced mammals and anthropoids where individuals may be organized not only into ecosystem-based dispersed networks, but also into coherently bonded societies.

Adaptability defines and sets the scope of natural intelligence. Successful adaptive action, which leads an organism and its genetic partners in the pursuit of long-term fitness, becomes the litmus test for any intelligent behavior. No matter how complex neural processes operate in complex organisms, they must always serve to drive the life cycle ahead, to maximize the organism's fitness. However, what could be the inner equivalent of fitness maximization within this new neuronal realm? A general principle of free energy minimization among the coupled neuronal discharges has been postulated, irrespective of the multiplication of mappings, localizations, and neurotransmitters, in order to organize adaptive behavior (Friston, 2012). An early approach to knowledge automation within central nervous systems, based on entropy minimization, was already proposed by Kenneth Paul Collins (Collins, 1991; Collins and Marijuán, 1997).

Once these complex nervous systems are at work with their sophisticate and ultrafast information processing, the open-ended detection of events coupled with the internal states and the action possibilities all must be integrated to appropriately pursue the fitness occasions. Reflexes, proto-emotions, and emotions are an essential part of the whole integrative process. The implementation mechanisms developed along the evolution of nervous systems basically go from relatively simple "fixed detection-action patterns" to more articulate "flexible" ones, and finally to elaborate "perception-action-reference superstructures" (Csany, 1988). It could remind the complexity jump we have found at the cellular level from sigma factors to cellular checkpoints. As a result of the different pattern recognition devices, either fixed or flexible or superstructural, a battery of neurotransmitters, neuromodulators, and neurohormones with different time scales and providing a variable interconnection among the different cortical areas and basal structures would have the capability to suspend the ongoing minimization processes and focus on the pursuit of the detected new fitness occasions.

We call 'emotions' to these processing superimpositions that interrupt the secondary and enforce the fundamental, always to establish the non-negotiable primacy of the life cycle. Then, the parallel with prokaryotic sigma factors and eukaryotic checkpoints seems appropriate: the ongoing life cycle recalibrates its inner processes and explores a new, more favorable trajectory for the sake of its own advancement. That's the overall mission of the whole mechanisms of natural intelligence: the maximization of fitness occasions, inclusively understood.

Researchers who have worked on the interplay between rationality and emotions in the human case would not be too far from this idea on the emotions' role of extending the information processing of life cycles towards the most adaptive directions (Arbib and Fellous, 2004; Damasio, 1994; Kahneman, 2011; Panksepp, 2015). Cogent rationality requires emotional support, guidance, and regulation (Koole, 2009). So to speak, being a sort of closed 'formal' processing system, the conscious reflective mind (Igamberdiev, 2023) needs to receive its processing goals and evaluations from afar.

The pertinence of this natural intelligence approach to emotions, now assuming all the complexity of human brain evolution and the interrelated social scenarios, will be addressed in the next Section.

3. The social environment of human emotions

The linguistic ability of human species has led our societies down a whole new path. The role of emotions, or better of the newfangled "social emotions", in the context of extended sociality, or even "ultrasociality" (Turchin, 2016), is now mediated by linguistic exchanges in larger and larger groups. Some prior conceptualizations in evolutionary anthropology and evolutionary psychology would be in order.

- The "*social brain*". We have evolved our big brains to cooperate, compete, and communicate in large, but close-knit, "natural groups". There seems to be an average of social networking, with rather ample upper and lower limits, concerning the number and types of bonding relationships that an individual can maintain meaningfully. The empirical finding of networking regularities such as the famous "Dunbar's number" (150–200 individual acquaintances) would make evolutionary and anthropological sense (Dunbar, 2004, 2007). These findings, integrated within the "social brain hypothesis", which was originally known as the Machiavellian intelligence hypothesis (Whiten and Byrne, 1988, Whiten and Byrne, 1989), show an ample clutch on the roots of human sociality and the origins of language. Essentially, this social brain hypothesis has posited that, in primate societies, selection has favored larger brains and more complex cognitive capabilities as a mean to directly cope with the challenges of social life (Allman, 1999; Silk, 2007). Subsequently, the overall cortical conformation and capacity of our species, vastly enlarged regarding other Anthropoidea, would sustain the high number of bonds that, comparatively, human individuals can maintain meaningfully within their oversized groups.
- The "*Sociotype*". As a result of the functioning of our social brain, despite all the existing cultural diversity, there is a great similarity of social relationships that has evolutionary roots ('descended from our genes'). The sociotype would represent our adaptive sociality, a relational whole consisting of a few characteristic sectors in nowadays societies: close family and kin circles, friends, work colleagues, and general acquaintances (Marijuán et al., 2017, 2019; Navarro et al., 2022). In the same way that there is scientific consensus on the validity of the *genotype* and *phenotype* constructs for the human species, notwithstanding their respective degrees of variability, a *sociotype* metrics could also be developed applying to the relative constancy of the social environment to which the individuals of our species would be evolutionarily adapted. The empirical quest by the authors has shown relational results that are relatively similar, and not far away from Dunbar's number in most cases, but with relevant differences (Ji, 2017; Marijuán et al., 2019). There is also a more holistic interpretation of the sociotype covering the influence of cultural backgrounds with a special focus in the individual's mental and physical health (Berry and De Geest, 2012; Berry, 2011). We need instinctive responses to achieve individual adaptation to the different kinds of groups, to achieve and maintain our own sociotype—and to achieve some level of collective "social intelligence" both intragroup and intergroup (Henrich, 2016). And we also need the reflective capabilities of the conscious mind, as outlined by V.A. Lefebvre regarding the use of language for social communication and information interaction (Igamberdiev, 2023).
- *Social emotions.* In a first approach to social emotions, we may consider that the 'big six' emotions traditionally discussed by theorists (Barrett, 2006; Ekman, 1992, 1999) are the most important in terms of their facial and bodily expressions (sadness, happiness, fear, anger, surprise, and disgust), but this does not mean they are most common or significant in our daily lives within the different social environments or in online communication. Rather we may find more often a series of dual sentiments and emotional reactions linked to group situations such as: exclusion vs. inclusion, sympathy vs. antipathy, admiration vs. envy, reward vs. punishment, irritability vs. calmness, excitement vs. composure, etc. We will consider some of these conditions in Section 4, within the new framework we are exploring for social emotions. Further, current AI works on sentiment analysis via lexicons are trying to analyze some of these dual reactions, regularly processing them via different procedures (Turón et al., 2023). The interrelationship of social networks texts with

emotions is also an essential matter for commercial platforms (Zuboff, 2019).

Too many open questions remain. Among them: How social emotions relate with the making and breaking of social bonds (and, particularly, with what kinds of social bonds)? How social emotions could be analyzed and classified in their relationship with different types of social situations? How different emotions may get mixed and combined within successive combinatory levels? How prolonged sentiments and social moods may be established, detected, and changed upon entire communities? Some aspects of these questions will be discussed in the two Sections that follow.

4. Reference frames for social emotions

4.1. Representations of emotions

The discussion on a new frame of reference for these 'small' but frequent social emotions in daily life is one of the aims of our approach. To begin with a general scheme, the well-known Cartesian emotion diagram (POSNER et al., 2005; Russell, 1980; Russell and Barrett, 1999), the "circumplex model" counts with *valence* and *arousal* as the two fundamental dimensions of emotional space. See Fig. 2. This model has the advantage of placing several emotions in very appropriate places relative to each other. Actually, numerous graphical mappings of emotions have been derived from that model, often introducing a third dimension which usually is either *approach/avoidance* or *time*. The model may also provide a visual understanding of emotional trajectories when the valence and activation coordinates of subjects are changed according to the evolution of mental states. Further, the subject's persistence in some emotional state would be tantamount to a permanent displacement of the origin of coordinates so that more – or less – activation would be needed comparatively, or that a bigger – or smaller – increment would be needed regarding valence. The permanence in time of some emotional states is often considered as an instance of 'sentiment', at least in the way AI sentiment analysis is currently practiced, as will be discussed later.

Another relevant model to consider is due to Robert Plutchik (Plutchik, 1980), known as the "emotion wheel", with eight primary emotions grouped on positive versus negative influences and capable of combining to form emotional dyads and triads. This model has been followed by many professionals and counselors on personality disorders and self-improvement. But many other lists and classifications have also been developed, and the number of emotions listed has been steadily increasing as well as their possible combinations (Parrott, 2001). For instance, six axes of emotions each one with another six gradual ranges give a total of 36 emotions (Kort et al., 2001), and the Book of Human Emotions contains a total of 154 emotions and sentiments identifiable in different cultures (Watt Smith, 2021). It is interesting that Ekman's big six emotions were later complemented with another 16 by his research collaborators (Ekman, 1999), most of them social and not necessarily expressed in facial muscles.

Actually, one of the main problems of emotion theorists, at least for the research linked to commercial platforms, is not the compilation of possible emotion lists, but trying to establish a solid emotional underpinning for the most frequent social situations of daily life, either in front of a screen or in face-to-face relationships or in group contexts. Brute force approaches based on big data are useful for direct marketing purposes but not enough for developing a coherent perspective on emotions. As a revealing instance, laughter and crying, so basic emotional states in human close-knit groups and respectively fundamental for supporting the creation of social bonds and for mitigating their destruction (Marijuan and Navarro, 2010; Navarro et al., 2014, 2016), are still missing in almost all compilations of emotions. This absence tells us that relational aspects of importance might not be well solved yet in conventional approaches to emotion. The enigmatic role of laughter along all the stages of human life seems to consist in an indirect but highly efficient tool for bond-making via synaptic reinforcement (Navarro et al., 2016). Intriguingly, laughter appears as a "proto-phenomenon" of our ontogenetic sociality.

According to the previous sections, what natural intelligence would suggest us is the need of looking closely to the human life cycle (or better, the life course), searching for the systemic equivalents of cellular "sigma factors" and "checkpoints", it is to say, the fixed and flexible

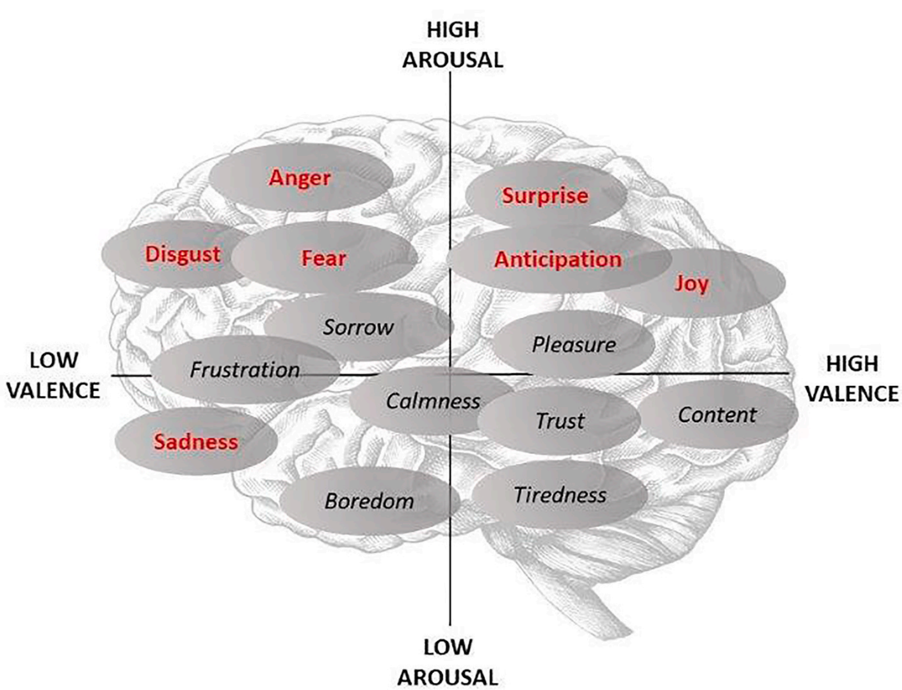

Fig. 2. The circumplex model: This Cartesian representation (arousal vs. valence) includes the eight basic/primary emotions mentioned in the main text (Section 5), in red, and another eight secondary emotions (in italics).

detection-patterns and the superstructural patterns already mentioned that are able to agitate our processing resources and reorient our cognitive mechanisms by means of emotional tools along the life course. An additional idea that the sociotype may convey is that our fundamental adaptation is to a very rich and structured social environment. So, we must try to synthesize what could be the main structural and superstructural patterns triggering our panoply of emotions in the adjustment to a very complex social environment—with remarkable differences along the life course, and with respect to gender, social location, cultures, etc.

4.2. Sociality different scenarios

Trying to separate different emotional domains pertaining to the main relational scenarios of our species, as sketched in the sociotype, we might distinguish the following modalities: (i) survival and self-maintenance; (ii) sex and family nucleus; (iii) friends, colleagues, and general acquaintances; and (iv) ultrasociality & collective identities.

Concerning the survival and self-maintenance drivers, (i) they would be served by the basic emotions, whatever number we may consider. (For instance, Ekman's six basic ones: sadness, happiness, fear, anger, surprise, and disgust.) And concerning sex, marriage, and family life, (ii) they would also be covered by these basic emotions but also by some new specific emotions linked to strong bonding processes, 'almost' exclusively human (for instance: love, affection, lust, play, laughter, curiosity). These six plus six could be considered as our *'primary'* emotions for strong bonding.

Then, we could put together another sector of the sociotype, 'friends', which is somehow intermediate between the nuclear relations and the work colleagues and general acquaintances, considering all of them together under the label of 'interindividual' (iii). In this interindividual domain we have the instinct to make social bonds of weaker nature, more numerous and malleable, implying frequent inclusions/exclusions. In this domain of weak bonds, we must maintain our reputation and personal image, we must cooperate to achieve our best interests with occasional conflicts with other individuals, and we instinctively abide by stringent relational rules, even at very early ages (Tomasello, 2019). This is the genuine territory where Trivers' moralistic emotions are deployed as spontaneous behavioral strategies in the reciprocity game (Pinker, 2009; Trivers, 1985). Another six *'secondary'* emotions would appear, say, in parallel to those primary emotions just mentioned for strong bonding. We would find for weak bonds: resentment, liking, gratitude, sympathy, guilt, and shame. In this point we should remind the important difference in social science between strong bonds and weak bonds, and the centrality of the latter in the establishment of commercial and economic activities (Granovetter, 1973). Weak bonds and their associated emotions would be the main support of civility. So, we can establish an interesting correspondence of bonds with emotions: primary and secondary emotions would respectively be in charge of creating and maintaining strong bonds and weak bonds.

In this interindividual scenario, we propose that in an analogy with the tridimensional approaches of the circumplex model, there would appear tree highly frequent distinctional or 'patterning axes' for the triggering of the emotions, precisely where most group conflicts arise. They would consist of: trust (cooperation) vs. mistrust (conflict); superiority (arrogance) vs. inferiority (humiliation); and inclusion (acceptance) vs. exclusion (rejection), which is highly significant in many cases where being marginalized in a group is tantamount to have really bleak a future. And an additional condition to consider relates to cognitive distance, familiar (close) vs. unfamiliar (distant), which is highly relevant concerning our 'automatic' minimization processing and the subsequent emotional response to the colligated patterns present in these previous axes (Collins, 1991; Collins and Marijuán, 1997). Thereafter, the respective coordinates of the different patterns in this multidimensional space, appropriately transformed by the 'familiar' vs. 'unfamiliar' condition, would call into action different emotions, either of strong bonding – primary – or the others of interindividual nature – secondary – more related to our enlarged prosocial inclination.

And there is also the very important ultrasociality phenomenon (iv). Historically, we have embarked in collective identities of highly variable nature and size. New determinants such as commonality (unity) vs. individualism (discord), freedom (tolerance) vs. oppression (intolerance), and equality (fairness, justice) vs. inequality (unfairness, injustice) represent further important dimensions or patterning axes to allocate our emotional responses regarding collective identities. It somehow echoes the classical political slogan of "*Liberté*, *Égalité*, *Fraternité*." But evolutionarily, the timing of history for this ultrasocial phenomenon has been too short. Quite probably, utrasociality has been using the emotional resources already present in Homo sapiens. So, it would have co-opted a mixing of basic and secondary emotions in the emergence and maintenance of the new social structures—particularly conveyed by means of political, religious, and cultural developments. However, like in the case of reading (Dehaene, 2009) it might well be that the socialization process of individuals, their 'education', provokes the emergence of genuine new emotions derived from the combinatorics among previous emotional reactions, with reactions such as: elation, admiration, awe, adhesion, synchronization, togetherness; as well as rejection, hostility, xenophobia …

In any event, our emotional minds are not organized in watertight compartments. The presence of the previous interindividual axes continues to be inevitable in this new ultrasocial domain too, as is the presence of the basic patterns and emotional reactions related to the close friends and family circle. So, it would be very frequent the overlapping and conflict between opposing emotional occurrences. Displaying these conflicts and showing how they can – or cannot – be solved is the bread and butter of many an artistic discipline (Booker, 2004), and the real substrate of personal wisdom in our social lives. It is in the ultrasocial domain where these conflicts appear more recurrently, given the easy recourse to primary emotions—the appeal to brotherhood or to hatred, or the use of fear as a means of mass control. The emotional mismatch between relational domains is currently amplified in social networks, where the inimical, offensive forms of primary emotions often substitute for the civilized relationships of weak bonds.

Summing up, this approach to social emotions based on natural intelligence and our social nature proposes a different kind of exploration. We do not think, at the time being, that a detailed listing of prosocial emotions taken in isolation would be feasible, or even interesting. Our alternative – complementary– approach based in the detection of patterning axes associated to the different relational domains, rather than being in opposition to Artificial Intelligence fields, could be developed in a fruitful cooperation with them. The basic ideas on Sentiment Analysis in next Section could provide some inkling on how to contribute meaningfully, in an empirical way, to refine and develop the present suggestions.

5. Emotions in AI: sentiment analysis

Emotions have never been alien in AI. Despite the first wave of pragmatic and rationalistic approaches, emotions and emotion-metrics were incorporated to AI relatively soon. From the rudimentary "sentometers" of Manfred Clynes in the 1980s (Clynes, 1988), representatives of the new wave to come, to the "affective computing" research headed by Rosalind Picard in the 1990s (Picard, 1997). Later on, with the growing business interest about the "attention economy", different emotion-detection systems and patents were issued by Facebook, Affectiva, Emoshape, and others, including the design of specific microchips (Zuboff, 2019). An important referent was Eksman's "big six" basic emotions, which became 16 in Facebook research. One of the main orientations was towards automatic visual detection of emotions in images as well as the identification of multiple emotional combinatorics. In another direction, Alex Pentland's "sociometers" were addressed to cover important metrics on social relationships: interactions, bonding processes, real hierarchies, etc.—a sociotype of sorts easily measurable via data from ad hoc wearables and mobiles (Pentland, 2014). Further, the boom of social networks, with their enormous trail of images, videos, and texts, has promoted new types of AI approaches. One of them, sentiment analysis, is the research link we take as a potential way to connect natural intelligence with artificial intelligence regarding social emotions (purposively, we leave aside the 'black box' approaches of machine learning, so fashionables in the new open AI language 'chat' systems).

Sentiment analysis is based on natural language processing. For each text of natural language (after its 'cleaning' and normalization) a global sentiment vector is processed, composed of multiple paragraphs. In each paragraph there is a count of the number of words associated with each basic emotion, taken from an ad hoc lexicon, obtaining the percentage of words associated with each emotion. The lexicon is a list of English words (or of other languages) with their associations with basic emotions (often eight basic emotions are considered: anger, fear, anticipation, trust, surprise, sadness, joy, and disgust). With each word there are two associated 'sentiments' (either negative or positive *valence*), or more values in a larger gradation. Next, from the values of the sentiment vector – the valence of the paragraphs – and the way emotions are distributed in the text, an overall statistical assessment may be obtained. Besides this emotional counting, there appears a valence or sentiment trajectory along the text, which is a plot of the variation of the emotional valence with respect to the narrative time. It is a trajectory graph quite revealing about the overall intentionality and mood of the text.

5.1. Relationship with natural intelligence views

Thereafter, looking for a fruitful interconnection of sentiment analysis methodologies with natural intelligence, what should matter is the possibility of detecting not just the emotions directly in collections of texts, the overall valence, or the trajectory plot, but to distil contextual patterns that may trigger the different emotions. It forms part of the big problem of 'context', plagued with semantic traps for whatever automated analysis. The six patterning axes we have previously identified, three for interindividual cases and another three for collective identities, could be tentatively approached via some of the new bootstrapping and subject classifier methods coupled with deep learning.

In order to facilitate this kind of AI exploration a parsimonious stance is needed. Perhaps, in the same way that "groups shape emotions" and "emotions shape groups" (van Kleef and Fischer, 2016), we may state that "contexts shape emotions" and "emotions shape contexts". This dialectics may be realized via sentiment analysis models endowed with adequate lexicons where emotion-laden words create contexts (which become identified as patterns), and the presence of the contextual patterns helps to recognize further emotional words. Lexicons should be built with more inner complexity, each word projected initially to all the (three or six) axes present, with a more complex valence gradation, and somehow making a reinforcing link with the other emotional words present in the sentence or paragraph. It is a bootstrapping methodology to be designed and implemented via NLP and sentiment analysis. To start with, simpler models related to each patterning-axis polarity could be developed.

In sum, the fast advancement of these new fields of sentiment analysis, opinion mining, affective computing, and emotional AI, as well as their multiple applications in social media, marketing, health care, social surveys, political forecasting, etc., although rather distant from the views herein advocated, could also represent a degree of opportunity for the advancement of new kinds of research on social emotions … Whether the future applications of AI may transcend the present "age of surveillance capitalism" (Zuboff, 2019) or not, may also depend on the relevance of the counterpoised research.

6. Concluding comments

Whatever the domain of life, it is the advancement of the life cycle what guides the informational interaction with the environment. We may consider in a general way that emotions are the inner forces that manipulate the ongoing behavioral (or genetico-molecular) trajectory of the biological system so that the new fitness opportunities in the environment may be properly realized along the life course.

Natural intelligence should study the organization of the "information flow" subtended with the environment, as well as the inner processing resources involved. The molecular tricks inherent in sigma factors, in eukaryotic checkpoints, or in the neuronal circuits of fixed, flexible, or superstructural perception-action patterns, become all of them ad hoc instances of (biological) natural intelligence.

In the approach to social emotions, we want to remark the research interest of the sociotype. Indeed, the genotype and phenotype constructs for the human species, notwithstanding their respective degrees of variability, could well be accompanied by a sociotype metrics, representing the relative constancy of the basic social environment to which the individuals of our species would be evolutionarily adapted.

The differentiated relational domains within the sociotype are important for a more nuanced approach to social emotions. We should emphasize our distinction between primary emotions for the closest relational circle ('strong bonds'), secondary emotions for the interindividual relationships ('weak bonds'), and finally some hypothetical tertiary emotions for the ultrasocial domain. Overall, there is design elegance, a manifest *economy*, in the evolutionary correspondence between groups of emotions and social bonding classes.

Then, as a research strategy, rather than looking for more sophisticate emotion classifications, or for more and more enlarged lists, we have pointed at the contextual patterns guiding our social-emotional adjustment. The interindividual and ultrasocial patterning axes herein proposed are just educated guesses, but via sentiment analysis bootstrap we could start to materialize the dialectical interrelationship contexts/emotions. Thereafter, the refining of classifications and the enlarging of emotion lists could be contemplated and developed in a new light.

Our final approach to sentiment analysis within current artificial intelligence has shown that there might be an effective and efficient connection between research programs of the two branches of intelligence—there is enough research potential to apply the muscle of AI to social emotions and their triggering circumstances. Natural intelligence versus artificial intelligence: what was separated should be reunited.

Data availability statements

The authors report no associated data.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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