Positive Artificial Intelligence

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Abstract

Positive Psychology has been developed as a complement to traditional Psychology, in order to cater for positive components of personality which can lead to sustainable satisfaction, happiness and well-being. Positive *Technologies* have been developed to build technological tools to support Positive Psychology. Artificial Intelligence research has focused on the development of artefacts to relieve humans from undesired tasks, with lesser focus on artefacts to promote positive components towards well-being and happiness. In this article, the concept of *Positive Artificial Intelligence* is proposed as a counterpart in Artificial Intelligence in general to the role Positive Psychology has played to Psychology.

Keywords

Positive Technologies, AI for Good, Ageing Society

1. Introduction

Douglas Engelbart (1925-2013) and John McCarthy (1927-2011) are two engineers whose works are of fundamental importance for the development of computer technology. Engelbart was born in the rural state of Oregon, northwestern US; McCarthy was born in industrialised Massachusetts, northeastern US. Both developed most of their careers in California, southwestern US. Even though their work seems, in retrospect, interconnected and interrelated, there are no historical indications that they ever worked together, despite being active at the same time and in the same region.

Engelbart had an epiphany in 1950 when he decided that he would design and engineer devices to augment human capabilities, so that humans could work collectively to solve complex problems and build a better world [1]. In 1957 he started to work at SRI International, where he started the *Augmentation Research Centre – ARC*, devoted to the development of methods, techniques and artefacts to broaden the spectrum of possibilities for human action and expression. Engelbart is considered one of the creators of the field of *Human-Machine Interaction*, and an advocate of computer technologies as means to promote human collaboration.

McCarthy organised the *Dartmouth Conference* in 1956, together with several other scholars, as a two-months discussion aiming at the definition and structuring of a new research area coined *Artificial Intelligence*. Soon after the Dartmouth Conference, he moved to work at the MIT and, in 1962, he moved to become full professor at Stanford University, where he started the *Stanford AI Laboratory – SAIL*. Artificial Intelligence has been since its inception a

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multifaceted endeavour. Several initiatives target the development of methods and techniques to reconstruct intelligent behaviour in artefacts which could, ultimately, relieve humans from unwanted activities which can be repetitive, strenuous and/or potentially harmful.

This brief review of the work of these founders of important areas in computer science and technology has the purpose of highlighting two complementary approaches to design technologies that support human actions and interactions: a *positive* approach, focusing on desired human capabilities to be enhanced *in* and *for the benefit of humans*, and a *negative* approach, focusing on undesired human tasks and traits to be *retracted from humans*, also *for the benefit of humans*. It resonates with – and furthers – arguments presented by Winograd [2], suggesting that the design of intelligent systems can be refined by accounting for both negative and positive approaches.

The appropriateness of adoption of methodologies that encompass negative as well as positive approaches to design has been considered in different domains. In *Positive Psychology*, similar arguments ground the proposition that a *negative* approach – focusing on treatment of undesired psychological traits – should be complemented by a *positive* approach – focusing on strengthening of desired potentialities. *Positive Technologies* are an offspring of Positive Psychology and encompass research about the development of artefacts to support the flourishing of desired potentialities.

In the present article the concept of *Positive Artificial Intelligence* is proposed as a complement to existing practices to design intelligent systems. The article also brings forward the proposition that regulatory bodies concerned with safety and ethical issues related to Artificial Intelligence should include strong requirements related to Positive Artificial Intelligence in regulations, in order to ensure that intelligent systems are not only harmless, but also useful.

Section 2 contains a brief rendition of *Positive Psychology*. Section 3 contains a discussion about *Positive Technologies*. Section 4 contains a brief presentation of intelligent agents, highlighting how they could be enhanced by a positive approach to their design. Section 5 brings forward the proposed concept of *Positive Artificial Intelligence*, including illustrative scenarios to characterise our proposition. Finally, section 6 contains some conclusions, discussion and proposed future work.

2. Positive Psychology

Positive Psychology has been developed since the 90s to contrast with "conventional psychology" – i.e. psychological methods based on psychoanalysis and treatment of hallmarks – by focusing on well being, happiness and positivity [3]. It has been characterised as a branch of Psychology since the late 90s, although with roots in Humanistic Psychology [4], Logotherapy [5], Jungian analysis and ancient Greek and Eastern philosophies [6, 7, 8].

Very briefly, Positive Psychology is grounded on the *PERMA* Theory proposed by Seligman and the *Flow* Theory proposed by Csikszentmihalyi. *PERMA* is an acronym for ***P***ositive emotions, ***E***ngagement, ***R***elationships, ***M***eaning and ***A***chievement, which are identified as the five factors influencing the path towards a life of fulfilment, happiness and meaning. *Flow* is a state of awareness of inner and external events which leads to pleasure, satisfaction and effectiveness in goal seeking. A *state of Flow* is reached and sustained via the dynamic balance of perceived

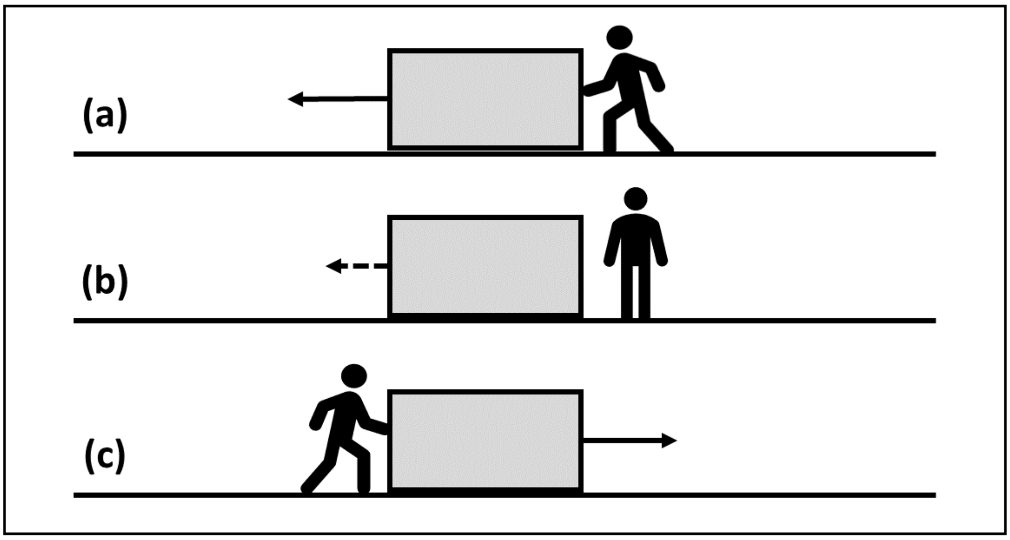

Figure 1: Negative psychological traits move the individual (depicted as a block in this image) to one direction (a). In order to change direction of movement, it is necessary (1) to neutralise the negative traits (b), and also (2) to add enough energy to positive potentialities in order to overcome inertia and move to a new direction (c).

challenge and skills, which must be informed to the individual through feedback about inner and external events and progress towards self determined goals.

Seligman and Csikszentmihalyi proposed a "Calculus of Well being" to clarify how "negative" and "positive" psychology should be balanced. Resorting to a simplistic analogy with Newtonian mechanics, retraction of undesired psychological traits can neutralise acceleration of a patient towards an unwanted direction in life, but actual movement in a new direction can only be achieved by adding energy to potentialities that can overcome inertia and lead to a desired direction (Figure 2).

Seligman and Csikszentmihalyi, together with other scholars in Positive Psychology, have also clarified the difference between *hedonic* and *eudaimonic* states, in order to highlight the importance of the latter over the former: hedonic forces – which relate to momentary pleasure, contentment and satisfaction – are not self sustained and require permanent extrinsic reinforcement, in contrast with eudaimonic forces – which relate to sensations of prosperity, blessedness and happiness, and are perennial or, at least, longlasting. Resorting to the same analogy with Newtonian mechanics, hedonic forces can change direction of movement of oneself but cannot alter friction that works to stop that movement in the long run, whereas eudaimonic forces change direction of movement *and* reduce friction towards zero.

A challenge to Positive Psychology has been the development of methods and techniques for effective interventions and assessment of results related to the strengthening of positive potentialities. *Positive Technologies* have been proposed as tools to enable controlled interventions and assessment methods.

3. Positive Technologies

Positive Technologies have been proposed to support Positive Psychology through artefact mediated, tangible and measurable actions and effects. In broad terms, Positive Technologies have addressed [9]:

- Mental health: promotion of Positive Psychology components in
  - patients in vulnerable situations;
  - patients presenting symptoms such as depression, eating disorders and other observable behaviours;
  - patients requiring emotion regulation.
- Neuro-rehabilitation: support to treatment of
  - patients with visuospatial partial disabilities;
  - patients in motor-cognitive neuro-rehabilitation;
  - patients with partial disabilities related to ageing.
- Empathy and pro-social behaviour: support to
  - patients with partial disabilities in development of empathy;
  - patients with partial learning disabilities;
  - scenarios in which cross-cultural integration is required.
- Self-transcendence: promotion of experiences that generate a state of *awe*.

Generally speaking, Positive Technologies must stand on three pillars:

1. Intervention: technology mediated construction of experiences that can induce states that promote Positive Psychology components.
2. Monitoring: (possibly quantified) assessment of effectiveness of intervention, through measurable surrogate markers such as
   - fluctuations in hemodynamic parameters [10],
   - occurrence and intensity of goosebumps [11, 12],
   - monitoring and classification of micro-expressions, posture and gesture patterns [13].
3. Assessment: interpretation of monitored values and fluctuations based on theories grounded on Positive Psychology, often based on correlations between observations of values of markers and answers to standardised questionnaires such as Self-Regulation Questionnaires [14, 15], Emotion-Regulation Questionnaires [16] and Technology-based Experience of Need Satisfaction Questionnaires [17].

An artefact whose design is based on these three pillars is capable of interventions which can be expected to help in the flourishing of Positive Psychology components, as validated by monitoring and empirical assessment.

If an artefact is comprised of technology to feature intelligent behaviour, it is called an *Intelligent Agent*. Intelligent Agents whose design is based on the three pillars of Positive Technology characterise Positive Artificial Intelligence. The following section contains a brief review of the concept of Intelligent Agents, as a final ingredient for the presentation of Positive Artificial Intelligence.

4. Intelligent Agents

Following the general literature about Artificial Intelligence [18, 19], the field of Artificial Intelligence can be summarised as the scientific and technological development to build systems which can be organised according to two attributes:

1. *Structural / Imitative intelligence:*
   - Systems that are *inherently* intelligent by featuring structural organisation which aligns with explanatory theories of intelligence applicable to biological agents *versus*
   - Systems that are capable of *imitating* intelligent behaviour, regardless of their organisation; and
2. *Human / Mathematically defined rationality:*
   - Systems that adopt as reference for intelligence/intelligent behaviour human (or other biological) agents *versus*
   - Systems that adopt as reference some theory of rationality that characterises "optimal" intelligence in terms of efficiency in goal seeking.

The combination of possibilities builds four alternatives:

1. Systems that are approximately *intelligent as humans* (or other biological entities);
2. Systems that provide good approximate *imitations of intelligent behaviour* as observed in *humans* (or other biological entities);
3. Systems that are close to optimally aligned with *mathematical theories of rationality*; and
4. Systems that can generate outputs that are good approximations of what is determined by *mathematical theories of rationality*.

From an engineering standpoint, the focus in this article is on the second and fourth alternatives. Instead of considering them as a dichotomy, however, the consideration of a spectrum of possibilities is suggested, in which these attributes can be combined in different ways.

Mathematical theories of rationality are based on optimisation: how to optimally reach a (possibly multi-attribute) goal, maximising reward and minimising use of resources. When dealing with complex systems, it is frequently required to deal with incomplete mathematical models, in which equations and rules are not completely known or may not be analytically solvable. In such cases, surrogate systems must be developed, which are capable of *imitating* input-output behaviour of the complex systems being studied. Artificial Intelligence considering the fourth alternative above is about building such surrogate systems, which can be called *intelligent rational agents*.

Models of human behaviour are based on psychological theories and empirical data, which identify patterns in human behaviour and align these patterns with explanatory models. Artificial Intelligence considering the second alternative above is about building surrogate systems which are capable of *imitating* the behaviour of human agents when facing similar scenarios and stimuli. Such systems can be called *intelligent imitative agents*.

In general, these attributes are independent, and an intelligent agent can be better or worse as either an intelligent rational agent or an intelligent imitative agent. In some rare scenarios and problems, these attributes can be conflicting (e.g. when humans whose behaviour must be imitated show pathological self-destructive tendencies). In such cases, a choice must be made about giving priority to one of the attributes.

In both cases, another dimension for analysis and design of intelligent agents can be considered, which is coined here *degree of awareness of social interactions* and relates to the extent to which a designed agent includes consideration about relations with other agents – which can be other intelligent agents or humans (or other biological entities). In order to make the presentation clear, the spectrum of possibilities of awareness of social interactions is reduced to four values:

1. *Egocentric agents*, which only account for their own goals and resources and consider any other entity and event in the environment as either resources to be exploited or barriers to be overcome. Such agents correspond to what was considered during the pioneering development of Artificial Intelligence.
2. *Strategic agents*, which are aware of the existence of other agents, which also have goals and resources of their own, but still give full priority to management of their own resources to reach their own goals. These agents assume that the other agents will behave similarly, and build strategies which, in order to optimise their own goals and use of resources, may be mutually beneficial to other agents. Such agents correspond to what is considered in Classical Economics and Mathematical Game Theory [19].
3. *Social agents*, which take into account collective goals and resources and act to optimise them, considering long term goals that may outlive the agents themselves. Such agents consider the benefit of the collectivity and of future generations as well as their own.
4. *Empathic agents*, which are capable of "wearing other agents' shoes", balance the importance of their own goals with respect to those of other agents and decide for actions based on social emotions [20].

In this spectrum, each value adds to the previous one on refinement and, as a consequence, complexity of modelling of agent interactions: strategic agents are egocentric agents *plus* awareness of existence of other agents; social agents are strategic agents *plus* awareness of collective goals; and empathic agents are social agents *plus* awareness of (or "sensitivity" to) motivations based on social emotions.

Increased awareness of social interactions makes room for the design and development of intelligent agents capable of more effective human-agent interactions, which is fundamental to build intelligent agents as Positive Technologies – hence, *Positive Artificial Intelligence.*

5. Positive Artificial Intelligence

Ultimately, intelligent agents are designed and developed to serve human needs, hence – directly or indirectly – intelligent agents exist to interact with humans.

In some cases the interactions are more evident, e.g. when agents interact with humans as artefacts designed for end users. In all cases, consideration of the widest possible spectrum of consequences of interactions with intelligent agents is advised, and has become object of attention of scholars and regulatory agencies.

The ACM and the IEEE have prepared general Codes of Ethics for professionals in Computer Science and Engineering, catering specifically for autonomous and intelligent agents in specialised sections [21, 22], and specialised institutes and laboratories connected to well established universities have been structured to work on topics related to how to ensure that intelligent agents are used to promote well-being following carefully crafted ethics guidelines (see e.g. *Positive Computing* http://www.positivecomputing.org/ and the *AI Now Institute* https://ainowinstitute.org/).

Adopting a terminology suggested by Peters et al. [23], there has been an imbalance towards *"nonmaleficence"* over *beneficence* in the design of intelligent agents, i.e. codes and regulations have focused on what should be avoided to prevent harmful interactions, instead of what should be ensured to promote positive interactions (an important exception to this trend being the work of Peters et al. [17, 23]).

Priority to "nonmaleficence" seems to be prevalent for certification and quality assurance, with regulations focusing on risk mitigation to avoid undesired behaviour of systems (see e.g. the preliminary proposal developed by the FDA – U.S. Food and Drugs Administration – to regulate *Artificial Intelligence and Machine Learning in Software as a Medical Device* [24]). This seems necessary, although not sufficient for interactive systems, and regulations must be complemented by requirements to ensure beneficence as well as "nonmaleficence".

The fundamental proposition in this article is precisely that, in order for intelligent agents that interact directly with end users to be certified by regulatory bodies, these agents should be required not only to ensure that all measures were taken to mitigate risks and avoid undesired issues, but also that interactions were designed following strict guidelines to ensure that positive outcomes are likely to result to users.

As a common reference to characterise the practice of inclusion of attributes in intelligent agents to promote positive outcomes from interactions, the framework of *Blue Zones* is adopted [25, 26]. Blue Zones are communities around the world which share empirically observable characteristics in their citizens: longevity, high sense of satisfaction with respect to life as a whole, good health and well-being. Interestingly, these communities also share patterns in everyday habits, culture, family structure and social interactions, although disguised according to local culture and traditions. The first four Blue Zones that were studied are located in disparate locations such as Okinawa (Japan), Ogliastra (Sardinia, Italy), Loma Linda (Californa, US) and Nicoya (Costa Rica).

The common patterns in all Blue Zones produce observable hallmarks which can be assessed as markers of the "Blue Zone effect". These hallmarks can be summarised as:

- Having a physically active everyday life;
- Having frequent, small and well-balanced meals;
- Having a sense of community belonging such as those that you get by surrounding yourself with friends, families and neighbours; and
- Finding a sense of purpose.

It is interesting to notice the correlation between these hallmarks and the *PERMA* Theory of Positive Psychology:

- A physically active life can bring a sense of ***A***chievement, promote ***E***ngagement and foster ***P***ositive emotions;
- Similarly, carefully managed meals can leverage on a sense of ***A***chievement, ***E***ngagement and ***P***ositive emotions;
- A sense of community belonging is directly related to ***E***ngagement and ***R***elationships;
- Finding a sense of purpose directly relates to finding ***M***eaning, which directly relates to ***P***ositive emotions, ***E***ngagement, ***R***elationships and ***A***chievement.

In the following paragraphs this proposition is illustrated with concrete scenarios, taking into account designed actions of intelligent agents which are potentially capable of leveraging these hallmarks.

5.1. Illustrative Scenario I: improvements in walking experience for elderly pedestrians in urban roads

Two important trends can be observed globally: urbanisation and ageing (see e.g. https://ourworldindata.org/ for up to date statistical data). Therefore, it is important to develop technologies to improve the quality of experience of elderly citizens as pedestrians in urban environments.

Several projects have been developed to study the behaviour of pedestrians in specific contexts [27, 28], and several of these projects focus on the ageing population [29, 30, 31]. Most projects focus on safety issues and how to improve safety through smart design and interactions with intelligent agents.

These are important issues, which nevertheless should be complemented with design practices and features in intelligent agents to cater for positive components [32, 33, 34, 35, 36]. Some aspects that can be considered are:

- Route optimisation taking into account physical activity, e.g. by suggesting alternative routes including short detours along pleasant neighbourhoods. The identification of what neighbourhoods and routes can be pleasant must be personalised, hence intelligent agents designed for this task must be prepared to adapt to individual taste and preferences.

- Identification of opportunities for action that can bring utility to other individuals and the community as a whole while *en route*, this way strengthening a personal sense of purpose as well as community belonging. The identification of what actions to suggest, and in which moments and how frequently to make suggestions, must also be personalised.

Personalisation, in this case, refers to psychological traits and values such as taste, preferences (which can be based on aesthetics, personal history, values, tradition etc.) and perceived capabilities, potentialities, scale of values and sense of community belonging. All these aspects are highly dynamic and directly related to the dynamics of interactions between individuals, individuals and society, as well as individuals and artefacts comprising intelligent agents. Hence, contrasting with intelligent agents that are built considering only safety – which can be developed based on different possibilities in the spectrum of awareness of social interactions – the design of agents to interact with humans accounting for positive components *requires* empathy, which encompasses all other possibilities in the spectrum.

Design practices such as the ones sketched in the previous paragraphs, together with design patterns that can enable them, can be clearly characterised. Our strong claim in this article is that organisations devoted to the development of rules and regulations for certification of intelligent systems *should add* to their already existing norms specific design rules catering for positive components, and explicitly verify and require alignment with these rules for certification.

5.2. Illustrative Scenario II: extended interaction with medical devices for treatment of noncommunicable diseases

Traditional medicine in China was centred around the *village doctors*, also referred to as *barefoot doctors* (see e.g. https://www.who.int/bulletin/volumes/86/12/08-021208/en/). An interesting practice which is now withering away is to have village doctors remunerated by healthy villagers – citizens who fell sick would stop contributing to the remuneration of the doctor, and only start contributing again when they were again fit for work. This way, village doctors would focus on healthcare, instead of treatment, contrasting with Western practice.

In recent years, there has been growing interest in *Precision Medicine*, which has proven to be relevant particularly for patients who may be sensitive to the side effects of medications and treatments, e.g. older adults with cancer, who may need treatment based on radiotherapy and chemotherapy, which can cause longstanding, highly debilitating side effects and be aggressive to any patient, particularly to elderly individuals [37, 38].

This specific scenario illustrates a situation in which conventional Western medicine (which is *negative* in the sense of Positive Psychology) is obviously important but, also, clearly not sufficient. Novel technologies for Precision Medicine *should include, as a requirement from regulatory agencies*, functionalities to cater for *positive* components of well-being for patients.

Two concrete examples which illustrate possibilities in this direction are:

1. An innovative medical device has been developed to treat specific types of cancer using electromagnetic fields to promote well-being and decelerate the growth of tumours, which are calibrated for individual patients based on a database of previous treatments and Machine Learning techniques that classify patients by similarity with previous patients with respect to specific physiological response to stimuli [39]. Even though this initiative

is still aligned with the perspective of Western medicine, the proposed measurement of success of treatment is based on a *Quality of Life Index*, instead of simplistic measurements such as growth ratio of tumours.
2. More directly to the point, studies have been developed to assess how technologies based on virtual reality, tele-presence and interaction with intelligent agents can be employed as Positive Technologies during treatment of patients with COVID-19 [40].

Possible convergence of these two initiatives could lead to enriched devices and treatment protocols which can complement therapies with decreased harmful side effects with immediate, medium and long term interventions such as:

- Incorporation of ludified and gamified experiences during treatment sessions, e.g. based on virtual reality that can promote ***P***ositive emotions related to a sense of ***A***chievement and ***E***ngagement, as well as resources based on tele-presence that can promote ***R***elationships and a sense of community belonging during treatments;
- Incorporation of followup experiences to manage diet, physical activities and long term outpatient treatment, which can also be ludified and gamified and promote ***P***ositive emotions, ***E***ngagement, ***R***elationships, and a sense of ***A***chievement;
- Incorporation of resources to promote participation in communities of support which can encourage proper management of treatment, reintroduction in social and professional activities – including support for self reinvention – and induction to transition from passive to active participation in such communities, therefore promoting a renovated sense of ***M***eaning for recovered patients.

Functionalities to ensure positive components as the ones suggested in the previous paragraphs can be characterised based on design principles, which should be included by regulatory bodies as requirements for certification of novel devices and protocols for treatment of patients. This would bring Western medicine closer to a holistic and hence more effective approach to treatment, moving from *Precision Medicine* to *Precision Health and Care* [41, 42].

6. Conclusion

In this article the concept of *Positive Artificial Intelligence* has been introduced, based on a particular view about the evolution of Artificial Intelligence and how the design of intelligent agents can be improved to include features that can promote Positive Psychology components.

This concept is illustrated with sketches of agent design which are *feasible, viable* and *desirable* [41]. The article brings forward the proposition that regulatory bodies in charge of certification of systems that embed intelligent agents should include explicit requirements catering for Positive Psychology components for certification.

Planned future work shall follow at least two lines:

1. Experimental design of intelligent agents focusing on Positive Psychology components, to build evidence of feasibility of what is proposed here; and
2. Development of concrete propositions of requirements that could be incorporated in existing standards and norms for certification of systems.

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