Value co-creation 'gradients': enabling human-machine interactions through AI-based DSS

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Abstract. Artificial Intelligence-based Decision Support Systems (AI-based DSS) are becoming increasingly important in many contexts. This work aims to define a type of human-machine interactions for new value co-creation processes' ranks, to help identify factors that can stimulate value co-creation in human-machine interactions. To understand if the outcome of a man-machine interaction can contribute to the co-creation of value, and in what way, the work carried out is epistemological and typological, also based on System Thinking. A matrix of novel gradients of the relationships between humans and non-humans has been created, and the typology of human-machine interactions has been identified for the new degrees of value co-creation processes, as well as the new specific scale of skills, in terms of language, learning, know-how, level of trust and endowment of knowledge, as a whole. The main implications concern the need to customize Decision Support Systems (DSS), to enhance different levels of intensity of relationships, and to identify insights for Decision Making AI - based users.

1. Introduction

When humans and machines (including AI solutions) (we can intend as 'machine') and humans work together, they can really achieve higher levels of effectiveness [1], even if AI solutions efficacy is depending on humans' involvement [2]. Humans seem to have always a central role in interacting with AI, since computers plus humans do better than either one alone [3]. However, AI could also determine ineffective outcomes and value co-destruction [4]. As well, as sub-optimal performances may occur, as assessed at different levels than the one of the Human-Machine Interactions (HMIs), also due to emergent consequences [5][6]. HMIs are fostered by AI solutions even more, as they are progressing at a high-speed pace, showing abilities to perceive words, develop cognition, build relationship, and fill roles. However, many questions on how AI should be developed and used by humans arise [7], for example in values-oriented design and ethics for users [8].

Today, decision-making processes are increasingly data-driven, decisions are more "informed", the exchange of information happens fast, it can be precise, punctual, efficient, and valid. Nevertheless, the risk of data-deluge and the difficulty of having useful elements

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is very high, while the possibility of making quick, accurate, thoughtful decisions becomes more and more necessary, indeed fundamental, so this study is 'desk' and affects the need to update and integrate modern Decision Support Systems for new strategies that managers ought to plan and follow, inside the uncertainty conditions in which business organizations continuously operate today. The motivation for this work lies in the need to investigate how the functioning of AI systems (for AI-based DSS), and the ways in which they are designed and implemented, can impact human-machine interactions, and therefore have effects in terms of value co-creation. Up to date, this examination is not, particularly in-depth in the literature.

To solve nowadays issues, the emerging scenarios can place human and machine in an alternative position and develop in two different directions [9]. First option may concern technology as a tool adopted by humans to achieve objectives, where human-decision-maker fully assumes risks derived from any fallacy in the solution provided by the trusted AI. Second, based on the ability to produce patterns of solutions, AI can also place the decision-maker in a subordinate position with the risk to associate the machine's solutions only to machine's errors [9], with huge effects on continuity of any activity. All these lead to focus on the evolution in HMIs, when a platform-based vision is majorly integrated in nowadays decision-making processes. This is because sometimes the use of IT-based tools (like AI, DSS, chatbots) to make appropriate decisions appears not successful and effectively supportive, nor for humans (e.g., not performing/wrongly performing the task) nor for the not-humans (e.g., not learning/wrongly learning from the human interaction). This aspect is influencing the generation of value somehow, as well as the perceived value. According to nowadays worldwide literature, first in the Service, every interaction cannot be co-creative if it does not involve man.

Instead, a machine even providing more appropriate schemes, and gathering more information, sometimes interacting emotionally with the most active subjects of the interaction (i.e., humanoid robots or animated SW agents recognizing human affective intentions and producing also emotive facial expression like disgust or happiness), soon seems to not completely give till-now a personal interpretative key or introduce the approaches needed for the effective co-generation of the value. This is exactly the aim to outperform here.

This paper highlights some preliminary insights capable of motivating the research question (Section 2) and then working on a type of HMI for the new ranks of value co-creation processes (Section 3), highlighting structural pre-conditions and systems determinants. By using the categories thus identified from the structural (static) and systemic (dynamic) point of view, we will build the basis for the matrix of the relations of the new gradients and the taxonomy of the HMI, as well as the spectrum of the HMI in terms of co-creation of value and the final ranks of co-creation (Section. 4). Afterwards, the discussion of the obtained results in presented in Section 5. The main implications for future research directions and final considerations are outlined in Section 6.

2. Hunting main insights to motivate the Research Question

To properly frame the topic under discussion here, it's fundamental to start from the pillars of value co-creation historically stated in the past 20 years in terms of interactions among entities, as well as the pathway the observed phenomena happen within.

Prahalad and Ramaswamy [10] firstly listed four general building blocks for co-creating value, by highlighting such main 'moments' insightfully characterizing it, as in the following: the 'dialogue' at every stage of interaction encouraging not just knowledge sharing, but, even more importantly, the understanding between involved organizations; the 'access' at multiple points of exchange to broaden their view of the business opportunities

creating good experiences (overcoming the ownership's concept and significance); the 'risk reduction' through getting providers and users to become co-creators of value; the 'transparency' of information required to create the trust between institutions and individuals. In parallel, Maglio et al. [11] specifically focused on approaching human-computer interaction, by pointing out the role of usability, user experience, and intuitiveness of technology in creating natural user interfaces; there, the term 'natural' referred to interactions that are like those people have with one another, even if not exploring yet human-not human co-creative interactions. Accordingly, Prahalad and Ramaswamy [12] has confirmed that the role of comfortable interfaces in motivating customers to involve in value co-creation activities is essential. This is especially important in dialogical situations where both parties are active in a learning process and influence each other's perceptions and actions. In this sense, co-creation of value inherently requires participation of more than one entity, and it happens through integration and application of resources made available during the exchange, as argued by Vargo et al. [13].

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Insight n.1: Here the point, not yet outlined, is if all participants are really 'active', if resources (every kind) are basically 'available', 'expendable' or 'usable' when requested during interactions, if interested entities (individuals, organization or whatever) are surely ready, prepared, educated and motivated in doing things; probably, the answer could be: not always, not everyone.

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Grönroos [14] started in querying how the supplier's involvement in its customers' usage processes is relevant during interactions, by directly working with the customers and actively influencing the flow and outcome of their value-generating processes. In this sense, Payne et al. [15] questioned how co-creation opportunities, that suppliers and users have thanks to interactions, are strategic options for creating value. Furthermore, the role of technology was particularly introduced in this discussion. Ostrom et al. [16] opened the issue that technology-enabled value co-creation processes remain largely unexplored, while understanding the performance implications of ICT remains a key challenge. Moreover, Glückler and Hammer [17] expressed that though terminology varies, the common denominator is the high level of ICT-mediated interpersonal interaction between human economic actors. This aspect differentiates technology enabled value co-creation from other ICT-driven interactions (such as self-service), which do not rely on human-to-human exchange. From that, few answers have been shared till now, and soon only concerning the bridge between human actors. Other scholars went around the topic but never through. Ramaswamy [18] specified that co-creation is the process by which mutual value is expanded together, where value to participating individuals is a function of their experiences, both their engagement experiences on the platform, and productive and meaningful human experiences that result. Edvardsson et al. [19] fostered that value co-creation is shaped by social forces, is reproduced in social structures, and can be asymmetric for the involved actors. Grönroos and Voima [20] confirmed that co-creation only occurs if provider and beneficiary interact in the joint sphere.

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Insight n.2: These mean just that value co-creation can happen when some conditions are respected and appropriately allow useful interactions between parties. This do not happen always consequently, and not in a mandatory way. It seems that everything is personal, experiential, and some doubt that could occur anytime strongly arise, at least not the same for all, not the same at all. Lastly, the distinction between human and not human appears evident, first from the interactive point of view.

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Later, the worldwide progress in technology and the global culture of high-tech new possibilities influenced international literature in a very clear mode. Lusch and Nambisan

[21] has begun to give a special role of digital service platforms, intended as value co-creation enablers by ensuring "resource liquefaction and resource density". Breidbach and Maglio [22] widely stressed this issue, by proposing that, ultimately, resource scarcity in technology-enabled value co-creation processes is likely not driven by a single aspect, but results from the complex interplay of multiple factors, including the quantity and quality of interactions, trust, and reciprocity, as well as role clarity and the structure of exchange networks. Technology-enabled value co-creation processes can be also intended as complex interactions between interdependent actors who perform several distinct roles, and the nature of technology-enabled value co-creation processes implies that interactions between service provider and customer are dominated by ICT [22]. Accordingly, Breidbach and Ranjan [23] have identified some practices that help in understanding of how platforms facilitate value co-creation processes. Nevertheless, Nenonen and Storbacka [24] argued that the comprehension of such digital interaction and engagement is still unfolding and requires refinement of the very nature of value co-creation. Schüritz et al. [25] raised the need for a more nuanced conceptualization of value co-creation in the context of data-driven services, addressing the use of data and analytics by a provider to support a customer's decision-making process, with the intent to create value for the customer. In detail, when actors co-create value using data-driven services, this context is shared between a provider and a beneficiary and the design of the service defines what activities are conducted by which actor, such as collection of data, preprocessing of data, the application of analytics on this data to derive insights, and even decision making and resultant action [25]. More recently, the topic has been approached more specifically, whereas when humans can flexibly cope with unexpected inputs from the customer and still co-create value, while IT technology is inherently limited to dealing within the range of inputs and requests it was designed to do. Hodapp et al. [26] stated that value co-creation in nascent platform ecosystems places significant challenges on building trust and implementing value capture mechanisms. Buhalis et al. [27] synthesized somehow prevailing theories of co-creation, service ecosystems, networks, and technology disruption with emerging technological developments, highlighting the areas of likely future disruption in service experiences that may benefit from immediate attention as extra-sensory experiences, hyper-personalized experiences and beyond-automation experiences. For Durall et al. [28] quite often, the different understandings of co-creation are left implicit and accepted without further problematization. In fact, digital ecosystem business environments challenge dyadic approaches to value co-creation [29]. Moreover, digital technologies are transforming human relations, interactions, and experiences in the business landscape. Whilst a great potential of AI in the service industries is predicted, the concrete influence of AI on customer experiences remains little understood [30]. Sjodin et al. [31] suggested that value co-creation in digital servitization is best managed through an agile micro-service innovation approach (not always, not everywhere). Finally, machine-age technologies, including automation and robotics, are profoundly expanding the variety of service interfaces and therefore the possible ways that customers and firms can interact across customer journeys, and this expansion challenges service firms' capabilities to deliver coherent streams of interactions for effective customer engagement [32]. Indeed, Hollebeek et al. [33] concluded that while co-creation research proliferates, existing studies fail to isolate its manifestation through digital (vs non-digital) platforms and explored how consumer digital co-created value (CDCV) reflects the consumer-perceived value by interacting, collaborating, or communicating with or through digital platforms (H2HPs - social media; H2MPs - a) robotic process automation-based platforms, call centers; b) machine/deep learning-based platforms, service robots).

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Insight n.3: From all of this, it seems that technological tools, digital platforms (just classified), data analytics and similar instruments can enable (only enable) value co-

creation. Interactions are intended as complex and still not well understood. The deriving indeterminacy characterizes a huge quantity of possible effects in interactions (maybe infinitive, probably not always co-creative, or at least to be explored and not surely defined to be like). HMIs are not deepened at all in the logic of value co-creation, even if the evolution in technology allow many reflections on A.I. determinant contribution.

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Starting from these main insights and following the logic of theory adaptation to cope some aspects missing from the domain theory [34], we may start to analyze in depth the possible co-creative interactions among humans and not-human entities, to understand how co-creative those interactions could be, if and when. In managerial studies, HMIs are dealt with too few, first in terms of value co-creation; so human-machine co-creative interactions deserve to be much more investigated. To this aim, hereafter an attempt to type them has been done, with a precise link to the definition criteria to identify types of co-creation in HMIs (as sort of spectrum's shades), when the 'moment' of co-creation takes place.

3. Working on a *Typology* of HMI for new value co-creation processes' ranks

As Huang and Rust [35] synthetized, and Polese et al. [6] raised up, four are the types of intelligence needed to perform tasks: i) mechanical (as the social robot, equipped with facial, recognition capabilities); ii) analytical (based on data); iii) intuitive (based on understanding); iv) empathetic (based on experience). Similarly, Davenport and Kirby [36] framed four levels of AI, focusing particularly on: i) support for humans (recommendation systems for decision making); ii) repetitive task automation (in which humans only monitor performances and fine-tune algorithms); iii) context awareness and learning (based on data coming from the field/the user); iv) self-awareness (super AI). Storbacka et al. [37] stated that actors have been seen not only as humans, but also machines, or collections of humans and machines capable of "action, interaction, and engagement required for effective resource integration and value creation", by listing multiple types of actors (Human-H and-&/to-2 Machine-M) combination, such as H2H, H2M, M2M, H2M&H, and so on. It means that several perspectives can be used to approach HMIs and a lens is needed to face with this effectively. To make a good overview of all possible situation concerning HMIs, and properly type/classify them, in a logic of value co-creation never fully exploited before, the System Thinking (ST) can be really supportive. Indeed, systems perspective is fundamental to create a realistic understanding of how technology can shape value co-creation [38], as well as interpretative models, DSS, managerial tools and instruments, inevitably concern viability mechanisms in market systems [39].

According to ST main assumptions and dichotomies, recently summarized by Polese [40], it can be assumed that any systems interaction (involving entities of any kind) is based on "structural preconditions" and "systems determinants". Successful value co-creation depends on structural and behavioral enablers. Structural preconditions are the prerequisites to establish a common structural basis for exchanges in terms of shared capabilities and background, whereas systems determinants concern factors fostering the emergence of synergic and effective interactions in terms of shared purposes.

Using the ST lens and new technologies literature, an attempt to outpoint factors that may be considered as HMIs' structural (static) preconditions and systems (dynamic) determinants has been done hereafter. It was possible by comparing such features of each side (human and not-human) interacting with each-other, as they can emerge before, while and after actors interact.

3.1 Outpointing "structural pre-conditions"

Hereafter, this analysis follows the basic structural 'consonance' conceptualization and the need to 'match' the own basic elements of each involved actor, exposed for A4A relationships [41], fully based on ST and applicable for humans and not-humans. Trying to compare similar aspects of each side, sure in not exhaustive way, preconditions for value co-creation may concern:

- *Personal predisposition through technological sensitivity*

The commitment underlying everything is not necessarily a consequence of external stimuli or incentives [42][43]. From ST we know that the commitment is often due to the personal belief of wanting to do well: «I participate because I share its usefulness», «I interact because I have an interest in it»; relationships (and exchanges in general) are always and only bijective [44]. In this sense, one can think that inter-systemic relationships in such a context are not only A2A [45]. That is, to do something towards someone else, but also to consider A4A relationships, or to do something for someone, for the benefit of someone, in the interest of someone else first [46]. This win-win logic is best expressed by a relationship 'in favor of' [47][48]. From this point of view, the concepts of co-creation, sharing of resources, equifinality take on a different, deeper, more direct meaning. This should meet with the level of sensitiveness of technology, because of its capacity to estimate to personal tendency to interact. It's normal to think that this could be a successful match or a poor mismatch or something else in between, not only in a stated moment but during the time.

- *People education through machine training*

Today, people are ready to appreciate the huge contribution from technology in increasing the levels of performances in doing things. The comprehension of the potentiality of this kind of interactions isn't enough because users are many and different and the machine training is limited. To face with all of this, using the ST lens, every organization needs to use their personal three levels of 'information variety' (i.e., general information units, filtering interpretation schemes, categorical values as strong beliefs) helping in understanding what is really going on [49]. As ST has taught, that is personal, subjective, and origins from specific background, previous lessons learnt, and the individual ability to catch and elaborate new info, to be properly used in future decisions [50]. That is heuristic too, due to the individual's own capacity to focus on strategic issues by using an intuitive and epistemological approach and delving to the deep significance of things.

- *Individual learning through algorithm readiness*

The knowledge necessary to define the characteristics of any solution to be proposed on the market (intended as value propositions), improves the satisfaction of its future users, and allows you to launch a positive message of participation and system openness that is always highly appreciated, as we have learnt from ST [50]. The learning plays a fundamental role in efficacy of any interaction, but not everything is positive, not everything works, not everything resists over time. As in the case of value co-destruction [51], A4A relationships can also fail; having correctly set up an approach, involvement and cooperation strategy may not be enough; the reason why we initially cooperate could fade (as happens in dispersive systems), therefore, also, for this reason, it is important not only to be aligned when starting an A4A relationship, but also to find and renew stimuli right for a long-term talk [41]. This can contrast with the readiness of technology, the immediate response it can propose, the different modes in action to get users more prepared and able to practice the received suggestions.

- *Known language used through instructions' availability and disposal*

To foster success, organizations can 'teach' the value they promise, by engaging actors in dialogic interactions to define new value codes. Hereby, the teaching metaphor is conceived as related to multi-actor ongoing interactions in which participants (machines and humans) share resources for creating new, ever updated, valuable knowledge. Shah et al. [52] empirically investigated teaching value, linking it to the participation at the so-called wisdom of the crowd. From ST we know that Actors need to dynamically change and adapt their mode in action [53], focusing on the evolution of the communication channels (online special events, direct experiences, influencers' presentations), product distinctive features (tutorials, evidences' demonstrations, normal people testimonials), users' inclusive participation (immersive advertising, free proof testing, flexible agreements, easy and self-instructions), codes and languages (millennials' codes, slangs, social rhythms, today gender rules) or similar [54]. To enable this, a dynamic approach is needed to actually involve actors (all kind), is inherently related to subjective perception and makes them able to participate in a continuous and mutual learning process, which lead them to gain helpful competences and skills in a lean way [55]. In A4A, the will to get users able to appreciate the value of offered proposals leads providers to pay more attention on all of these aspects, to be competitive over time [41]. To understand value and how it can be communicated or 'taught', individual dimensions of firms cannot be ignored. Thus, their structure, history, culture, and values shape the way they conceive the value they promise and the way they try to communicate and support stakeholders in learning value and usability. The point is that not always everything is available at the disposal of user, nor all users can easily understand related instructions. Many different levels of comprehension are here (such as, intuitive, expressed, tacit, self-explaining), all depending on available and codified tools/instruments for sharing knowledge.

- *Finality and cognitive alignment through technological embeddedness*

Collectivism enhances the collective intentionality, the iterative paths, the shared purpose - the Community above all - and involves interested behavior, if inserted in a community, with a huge sense of aggregation [56]. In A4A, and carrying on from ST nudges, the systems consonance between Actors (interested in a given situation or an exchange and with a role, whatever, in the context of reference) is understood as a "condition" or a status parameter that can arise from changes in the individual information variety [42] and represents the compatibility that exists between a given subject and the embedded environment within which it interacts [57], nowadays powered by last advances in technologies. The shared purpose allows to transform systems consonance into resonance [49], harmonizing objectives, aligning perspectives, perfecting processes, optimizing the use of resources, ultimately obtaining better results [58]. It also becomes easier to understand that you are part of a whole, by which each organization is immersed in its context, as subjectively perceived, as a function of the extension of the relationships activated with the various actors more directly involved in the same value generation process [49]. In this sense under the ST umbrella, it is possible to define a particular 'social individualism', based on the recognition of a shared purpose among the actors, in which the ECO version prevails over the EGO version [44][59], in which awareness of the collective utility of one's participation (of information, resources, results) contributes to improving the system as a whole. Of course, this depends on the awareness of each involved Actor, on the understanding to be 'part of' and the ability to 'activate' relationships defining the boundaries within which it operates.

- *Users' acceptance through set up appropriateness*

Each actor usually operates following his interest (such as competitiveness for business organizations) to survive in the long term. But when immersed in a given context, his individualistic behavior, however competitive, does not concern exclusively selfish purposes

[60], leading to a different and not opportunistic way of doing. In A4A, the commitment does not only concern a generic psychological involvement of the actors; it also identifies the intention to share a purpose to be pursued in a specific way, with certain personal participation and acceptance of what it concerns [41]. From ST, when there is a high sensitivity to collective realization, the alignment of strategies in the planning phase increases, as does systems viability [61]. These effects could be allowed by an appropriate organization of technology (not warrantied) since the action of any subject often draws inspiration from an inspiring principle, capable of accelerating a latent trend or already in action or stimulate towards a more or less profound modification of organizational relationships and even of value categories.

- *Contextualization (human side) through context-driven technology (not-human side)*

Actor feels involved and 'engaged' in a given relationship and, in some way, expresses its will to be part of it [62]. Once this 'connection' has taken place, it is possible to witness continuous interactions, activated thanks to the harmony between the parties [63]. As stated in ST, working in a context populated by other actors, whose behavior directly or indirectly influences (in a reciprocal way) the work of others, allows to acquire the right awareness of being part of a whole [64]. At this point, empathy and trust encourage involvement, nurture harmony, and bring goals closer (which, in this way, become common), exactly as in A4A relationships, and allow cooperating in a more convinced and happier way, with mutual satisfaction (actual or latent) and desired margins of collective growth [65]. This positive condition is the foundation for any form of exchange and the sharing of resources deemed most critical and strategic [66]. By continuing pursuing this type of system dynamics continuously, a virtuous circuit is sustained by context-driven technologies, which can be both sustainable and long-lasting or not.

3.2 Outpointing 'systems determinants'

According to ST, the application in real life is affected by the finalization of planned actions. In this sense, the effects of observed HMIs have to be studied and analyzed based on main aims of involved entities. Here, system determinants, always not in exhaustive way, could concern:

- *Continuity through reliability*

Today, users expect to resolve issues by themselves, before reaching out to customer service representatives, ultimately becoming a central element of service production as co-creators of value. However, AI-powered interactions can also fail in reliability, potentially leading to anger, confusion, and customer dissatisfaction, largely attributing the problems they experience to resource mis-integration by service providers [67]. Streamlining HMIs from the point of view of data management, using cloud-computing for information sharing, AI helps the correct interpretation by available data and the generation of new ones, as well as machine learning, data mining, and sentiment analysis. This can foster the right systems continuity, as ST proposed, but can also show some criticalities in protocols' activation, data-sources integration and management support of queries, schedules, layers, overlaps, alerts, availabilities, delays, recoveries, retrieval/revival and even privacy/security [68].

- *Relevance through completeness*

Characteristics of the data can be acquired (data-acquire/disclose), aggregated/combined (data-manipulation) and used (data-consume) in the business processes; for this purpose, the 10V of big-data (Volume, Velocity, Variety, Veracity, Value, Validity, Variability, Venue, Vocabulary, Vagueness) will be taken into consideration, to understand how new knowledge

(and therefore awareness) is generated in service, and how much the decision-making processes are consequently influenced, with particular reference to the possible advantages of meta-dating, data-modeling/architecture, data-integration [69]. ST suggested that decision-making techniques (cost-benefits, grid-analysis, paired-comparison, compensatory strategies, etc.) face with the conditions of uncertainty due to, for example: systematic errors, cognitive biases, risk situations, external distortions, information asymmetries, legal aspects, technological crashes, or even only weak signals escaped, somatic markers, negative contingencies, and so on [41]. These aspects, harbingers of increasing complexity, difficult to be complete, often take on a decisive influence in areas where an emergency is often faced.

- *Engagement through understandability*

A common commitment to carry out activities for the reciprocal benefit, can be based on positive energies, mutual loyalty, widespread quality, sustainable relationships [70]. Being able to enhance the static relationships characteristic of belonging to common structures allows you to benefit from dynamic interactions typical of the systems that arise from individual and collective engaged actions giving value to the exchange of resources [71][72][73]. From ST, what emerges is a shared system of values, an interrelated system of actors, a living and evolving system, whose boundaries are dictated by behavioral dynamics and are not pre-constituted [74]. Existent research predominantly explores the co-creation process (vs. its outcome of co-created value), which therefore merits further scrutiny, particularly in the digital context. This reflects the consumer-perceived value that arises by interacting, collaborating, or communicating with or through digital platforms (touchpoints) [33]. Perception inevitably implies comprehension, and some difficulties can occur, invalidating or altering results and disregarding user expectations. This can influence the engagement somehow and do not warrant the fullest possible cooperation.

- *Congruence through speed*

From ST studies we know that in every dynamic system, the achieved balance is maintained with repeated behaviors, which represents the historical memory of the interaction, and which are not cancelled out on the occasion of the modifications that may in the meantime congruently take place [75]. An interactive system does not start from scratch every time but maintains the cyclically acquired achievements even when it must seek other balances [75]. Working timely and providing real-time reaction should foster the capacity to catch results coherently with the aim of the involved users; however, it depends on contingences occurring time-to-time [76], making each cycle different from others.

- *Participation through digital divide avoidance*

Through a strategic behavior of aggregation, integration, and cooperation, any work can be carried out more efficiently and effectively and the objectives can be achieved with greater satisfaction than that which can be obtained independently and, above all, of common benefit, as ST suggested [65]. This approach, if carried out systematically and consciously, can favor more global governance, which enhances resources and relationships, and promotes essential synergies for the survival of a system, especially of an enterprise system [55]. Pursuing the system perspective gives the incentive to make available what you have (information, time, experience, skills) with a view to full sharing for a greater participation [41]. This is allowed by a very functional arrangement of digital toolkit, by avoiding any digital divide; as well-known, not all difficulties are always overcome, and this make various the scenarios to work and interact within.

4 The 'need' to have a *Gradients*' matrix of relationships among humans and not humans

In practice, it is possible to use the categories mentioned above, detected through an in-depth study of ST and of new technologies and innovation, find out a new way to interpret HMIs with greater accuracy.

So, hereafter the bases for novel gradients' matrix of relationships and HMIs taxonomy have been explained, as well as the spectrum of HMIs in terms of value co-creation and the final ranks of co-creation.

4.1 HMI's taxonomy

Summarizing the above discussion, we can say that HMIs work not only for simple approaches to solve problems, but also to express lots of other issues showing a huge variety and variability of possible scenarios. Comparing features from human and not-human side as detailed before, it could be possible to understand that gradients in HMIs are needed to properly investigate them, just because of the richness of elements in their relationships (Table 1).

Table 1. HMI's structural preconditions

From human side	From not-human side
personal predisposition/tendency	technological instrument sensitivity
people education, experiences and background	machine training
individual learning ability	algorithm elements' readiness
known language used	instructions' availability and disposal
finality and cognitive alignment	embeddedness (integration / rooting)
user role (at a stated moment)	variety/variability management through ICT
user acceptance capacity	set up and connectivity appropriateness
contextualization (human side)	context-driven technology (not-human side)

Figure 1 presents the comparison between the positive/negative measures of structural preconditions selected from the human side and non-human side. Personal predisposition is the structural precondition on the human side and the availability and disposal of instructions is the structural precondition on the non-human side taken as examples.

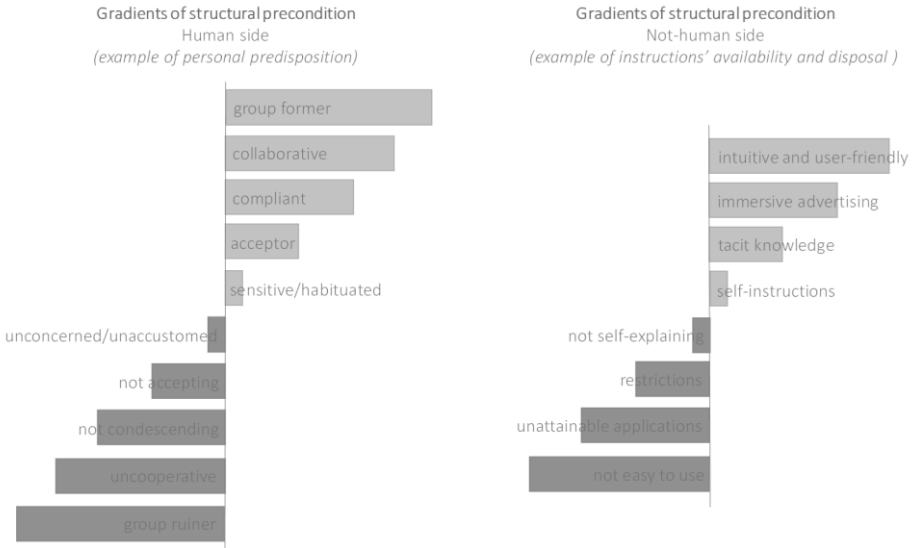

Fig.1. Examples of gradients in HMI's structural preconditions

For each side, considering that the vertical axis corresponds to 0 position, each characteristic is distributed in a range of different shades; we not only have two dichotomy values (max/min) but infinite records in between. For both sides, it is thus possible to define any gradients. This makes it clear that in this path one can find correspondences of different conditions. This is replicable for each structural precondition identified.

Finally, a comparison on taxonomic hypotheses and visualizations can be explored (scaling, types, grids, etc.), to deal with that.

To this aim, the classification of HMIs (Figure 2) could follow these common rules (from macro to micro groupings):

- Class, (-) no interaction – (+) effective occurred interaction.
- Order, (-) negative conditions for good interactions – (+) positive conditions.
- Family group, (-) not evolving and static situations – (+) evolving and dynamic situations.
- Gender, (-) no feature's clusters from human and not-human sides – (+) many clusters.
- Species, (-) only one feature from human and not-human sides – (+) many features for both.

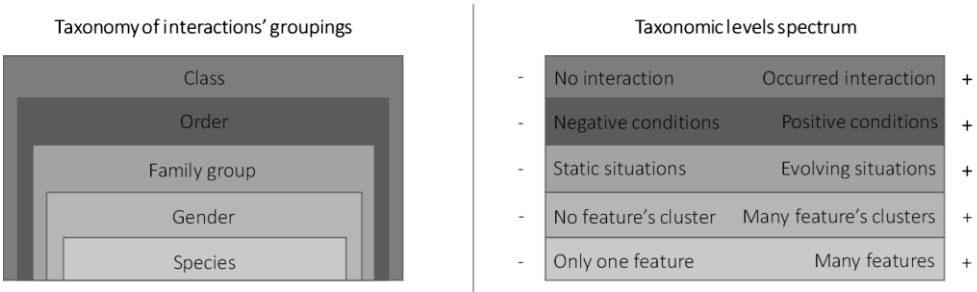

Fig.2. Main taxonomy of HMI

In this way, we can scale the type of any interaction including. Concerning taxonomy of interactions' grouping, for instance, the possibility to count in occurred interaction (class) a changing level of acceptance from people to effectively receive and take advantage (order) from machines' suggestions (family group), in a defined context to reach the own final goal (gender), regarding an appropriate set up or the presence of helpful and usable instructions (species).

A different taxonomic level spectrum can be linked to each element of the taxonomic interactions' grouping side. It indicates the different intensity with which each element can be realized, its dynamics. An interaction (class) can occur or not, it can incorporate negative or positive conditions (order), which in turn underlie static or evolving situations (family group), due to no features' cluster or many features' clusters (gender), in turn conditioned by only one feature or many (species).

This, with appropriate scales, helps in shaping all interactions, precisely, distinguishing and identifying them anytime.

So, to properly analyze HMIs, we need to count several different gradients in between. For example, from the human-side, the individual knowledge of a such specific language needed to comprehend machine' suggestions are not the same for all, even if it refers not to idioms but to technical directives.

4.2 HMI's spectrum

In the same way, the acquired experiences in interacting with machines (learning by doing and/or failing) could be different in every person and evolving during the time for everyone. Dynamically, HMIs differ a lot. From the not-human-side, the different level of effective integration (perfect, not perfect, working, not-working, etc.) could affect the level of performances and make the evaluation more difficult. The same holds for the machine sensitivity, its on-going training or readiness. This allows to explore systems' determinants that power HMIs both from human and not-human sides (Table 2).

Table 2. HMI's systems determinants

From human side	From not-human side
continuity	reliability
relevance	completeness
engagement	speed, real time (timely)
coherence (congruence)	understandability
participation, pro-activity	digital divide avoidance

As seen, the exploration and exploitation of cultural/cognitive bias in HMIs at all levels show possible misalignments, conflicts, frictions, as well as AI not performing/performing the wrong performing the required task. This affects the dynamic side of every interaction, including human-machine ones. For instance, from the human-side, the level of personal engagement can vary from one to one, as well as each real participation. From the not-human-side, reliability or speed can be influences and consequently differ for many reasons. Starting from this, we should rank the emerging interactions among humans and not-humans somehow (Figure 3).

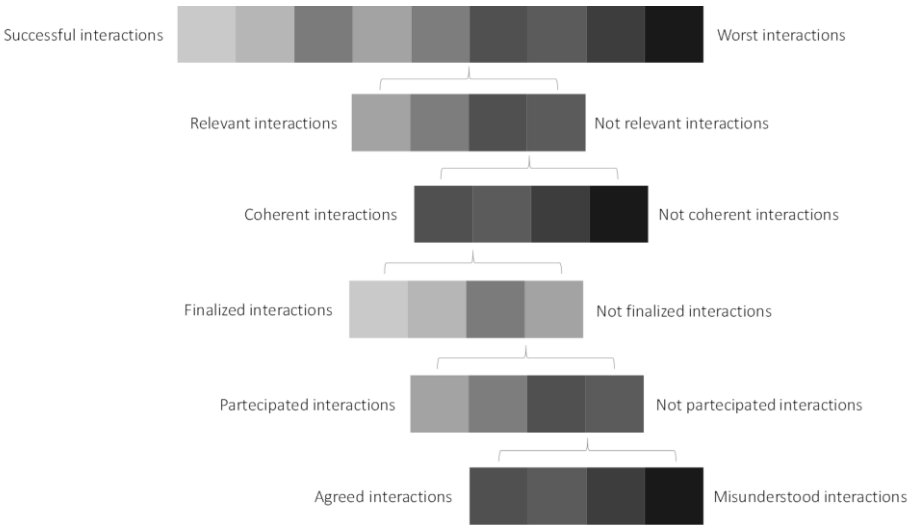

Fig.3. Spectrum of HMI in terms of value co-creation

To this aim, the ranks could be organized in sub-levels architecture, as follows:

1. successful interactions (value co-created) - worst interactions (value co-destructed);
1.1 relevant interactions – not relevant (not crucial) interactions;
1.1.1 coherent interactions – not coherent interactions (adherent to the final aim);
1.1.1.a finalized interactions – not finalized interactions (not at all);
1.1.1.a/a participated interactions – not fully participated interactions (mono-directed);
1.1.1.a/a/a agreed/understood interactions – mis-understood interactions (not comprehensible).

To explain the importance to outpoint scales but without aiming to precisely describe them, figure 3 shows that between two dichotomous situations such as, for example successful interactions through which value is co-created or worst interactions through which value is co-destructed, there are different possible intermediate conditions (represented for this reason by a grayscale) which can more or less affect the final goal (the co-creation of value). Actors have to understand these intermediate situations existence to more or less manipulated in favor of the desired result.

Figure 3 also shows that, in the context of the intermediate positions of a variable, further linked factors can be investigated (with further intermediate positions): for example, an attempt can be made to understand if an occurred interaction is relevant or not, and whether a more or less relevant interaction can be more or less coherent; not only, if, among the intermediate positions of the latter, a more or less finalized interaction can be detected, whether an interaction that tends to be less finalized can be participated or not, and whether an interaction that tends to be less participatory can, in any case, be agreed or not.

In this sense, now we can categorize HMIs according to the specific level of awareness of involved parties (1.1.1.a/a/a), their effective participation (1.1.1.a/a), to obtain a defined goal (1.1.1.a), in line with the vision to cope (1.1.1), with a certain level of significance (1.1) to really co-create value (level 1). The infinitive combination of these elements allows us in understanding that the value is not always co-created, not always in the same way or with the same satisfaction level of co-creators.

There are such of gradients of several and various options to be included, with lots of effects in terms of operations, strategies, plans, results, outcomes, etc. (Figure 4).

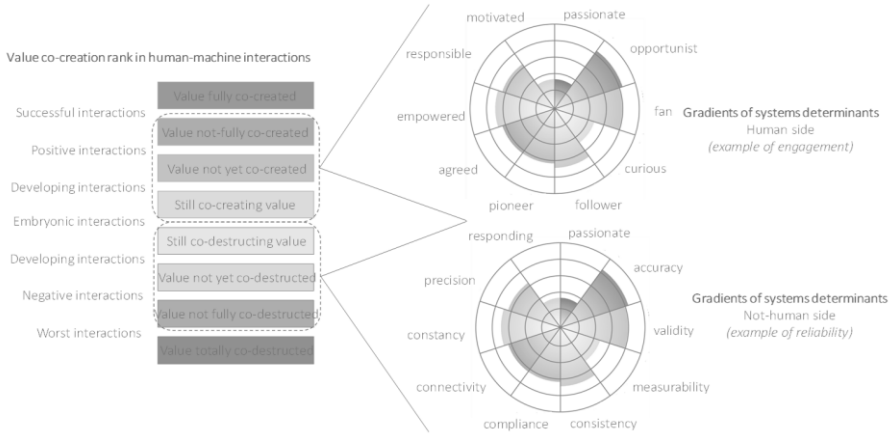

Fig.4. Rank of value co-creation in HMI

In the example, we consider two systems determinants by the human and non-human sides. The engagement (human side) is taken into consideration and different engagement gradients are identified: motivated, passionate, opportunist, fan, curious, follower, pioneer, agreed, empowered, responsible.

The reliability (non-human side) is considered and its possible gradients are highlighted: accuracy, validity, measurability, consistency, compliance, connectivity, constancy, precision, responding, passionate.

The figure shows how the grades of engagement can match/mismatch with the grades of reliability. Each identified gradient can, with a different intensity degree, contribute or not to the emergence of value co-creation phenomena.

HMIs can take on different characteristics, depending on the different gradients involved. It can be a successful, positive, developing, embryonic, negative or worst interaction, with various possible effects in terms of co-creation or co-destruction of value.

5. Discussion

Value co-creation cannot be identified in the same way in all the interactions between humans and machines. Not everyone has the same capacity to effectively understand what is going on and how that can be relevant or crucial for their mode in actions. The differences in perceptions can be the reason why some organizations will be able to 'continue' their activity and survive over time and some other not. This confirms the need to investigate the ability of actors to be dynamic and acting to avoid mistakes, gaps in communications, interpretation failures and similarities. This helps to bridge the gap between the potential value and the effective one [77], overcoming trap risks and value wasting. Actors involved in a value co-creation have better opportunity in building a positive value understanding process; in this context, machines solutions emerge as actors' stimulators, and occurring misunderstanding could be reduced thanks to humans' attitude to be dynamic and open to the change, while machines can act as relevant actors able to share openness, flexibility, and reaction to change. But disturbances, misalignment, disregarded expectations, and divergences can reduce the power of a new solution, allowing a misunderstood value effect and a distorted misuse consequently. This is due to differences in languages, emerging perceptions, new interpretative habits, unexpected contingencies, and personal beliefs, which influence

communication. Therefore, machines and humans bent to join valuable interactions. When individual perception of value is based on wrong interpretations, it can lead to misunderstand it. Soon, actors' dynamism (both from human and not-human side) can boost the engagement and the active participation, which lead them to grasp value and agree on its meaning as it has been experienced.

Comparing the existing instructions with specifically performed teaching actions, it is fundamental to check if teaching is not yet activated or instructions are not well understood and diffused. Indeed, even if high-tech tools and instruments could appear as 'actors' in any examined process, lots of artificial practices are predefined, set up, programmed, and *a priori* structured, nor spontaneous or impulsive. As seen, open issues on value co-creation, regarding resource integration, institutional arrangements, system dynamics in Service are not well clarified about different possible layers of co-generation; these gaps are in general for every interaction between actors, mostly if observed between humans and machines. AI deals with technological systems that attempt to emulate human intelligence to perform complicated tasks. Such understanding can pave the way to feedback improvements to AI development/adoption projects to assure AI can be both effective and trustworthy (in terms of robustness, fairness, explainability / interpretability, and lineage).

The need to define a gradients' matrix of relationships and a HMIs taxonomy, as well as the spectrum of HMIs in terms of value co-creation and the final ranks of co-creation are then all well motivated [78]. The will to investigate structural/systemic conditions due to HMIs derives from the need to provide insights for value co-creation outcome, not obvious, not surely predictable, not easy to understand and completely simple to grasp. Interactions are not binary, the richness of possible combinations of preconditions and determinants that are shown before allowing to define and distinguish a huge variety and variability of situations to face with, as well as the rather fast evolution of AI in value co-creation. Here we confirm that it is thanks to the engaged multi-part contribution, as powered by a multi-cultural approach [79] because everything is based on several conditions that need to properly match.

7. First conclusions and future research

The main findings of this work address the definition of a novel gradients' matrix evaluating the relationships among humans (individuals involved in crucial decision making actions) and not-humans (machines, algorithms, AI cognitive computing, neuronal networks, chat-bot, etc.). It is used for demonstrating which kind of interaction helps in overcoming the simple search of efficiency or standardized indicators and checks (typical of artificialities). Sometimes empathy and harmony between humans and not-humans (if properly simulated) take place, and sometimes not (mostly of cases). Furthermore, a first desk proposition of a typology of human-machine interactions for new value co-creation processes ranks is formulated.

This study highlights several incipient practical implications, on the managerial side and on the educational side. These insights must be further explored in future research. First, the managerial implications on decision-making can be formulated in two aspects: i) for DSS, as they need to be much more customized to valorize different layers of relationships intensity; and ii) insights identification for Decision Making AI – based users (such as managers, employees, human resource recruiters). Second, some educational implications on T-shaped programs and MBAs may be formulated: the identification of insights in HMI for users (managers, employees, human resource recruiters, etc.) definitively should foster new proposals of worker re-skilling [80].

Future research should find useful to investigate the factors that allow human-machine interactions to be efficient and effective for the co-creation of value. Among these, the role of transparency in artificial intelligence could be investigated. de Fine Licht and de Fine Licht

[81] show that a certain resistance in the full adoption of AI systems is based on the fear that it can produce and provide an inadequate output, thus invalidating the decision-making processes of the actors who use it. The possibility of opening the "black box" of the AI decision-making process and making it more transparent, to ensure high quality, fair and reliable decisions by acting in terms of transparency and explainability of the systems of AI could improve human-machine interactions, to favor a better predisposition of the actors to integrate resources for the co-creation of value.

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