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ORIGINAL ARTICLE

Coping with Descartes' error in information systems

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Abstract
Coming from Hubert Dreyfus' recent book ''Retrieving Realism'' (together with Charles Taylor), the paper presents embodied pre-conceptual perception and representational cognition as two contrasting perspectives on accessing the world. It further characterises the 'different forms of knowledge emerging from these perspectives and how they dynamically relate to each other. Taking up the Peircean theory of signs and abductive reasoning as methods of discovery, computers are analysed as semiotic machines that formally model and objectify explicit knowledge about social practices and that can be embedded in the sign processes of thereby restructured practices. This practice theoretical perspective allows for both, understanding the limits of AI and pointing to options for productively combining the performance of ''cognitive artifacts'' with the tacit skills of knowledge workers.

Keywords Abductive reasoning · Artificial intelligence · Implicit experiential knowledge · Explicit propositional knowledge · Semiosis · Semiotic machine

1 Introduction: taking up Dreyfus' legacy

In his most recent book ''Retrieving Realism'' (2015; together with Charles Taylor), Hubert Dreyfus reminded us again of two fundamentally different thought traditions on how we get access to the world around us: the ''contact'' theoretical perspective of ''being-in-the-world'' which we make sense of through skillfully interacting and coping with it, on the one hand, and the representational perspective of conceptually mediated world recognition, on the other. While Dreyfus argues for the relevance of the first view particularly referring to Wittgenstein's (2009) ''language-games'', Heidegger's (1962) ontology in ''Being and Time'', and Merleau-Ponty's (1962) ''phenomenology of perception'', the latter has dominantly influenced Western thinking since the days of Descartes' dualism separating mind from matter.

Both, the contact theoretical and the representational world view, have been propagated for a long time in isolation and opposition with each other. Moreover, both correlate with two fundamentally different types of knowledge being characterized as implicit and embodied or experiential knowledge, on the one hand, as opposed to explicit and conceptual or propositional knowledge, on the other [cf., e.g., ''knowing how'' versus ''knowing that'' (Ryle 1949) or the ''tacit dimension'' (Polanyi 1966)]. Both views can claim to be based on sound evidence, and it seems impossible to refute one or the other.

The long lasting controversy between both perspectives is, however, by far not an idle dispute among academics but rather of particular relevance for social practices dealing with complex computing machinery. It forms the epistemological background for designing, evaluating, and appropriating this specific semiotic type of machinery operating signs as distinct from energy or material transforming machinery operating with forces. In particular, the representational view seduces the creators of so called artificial ''intelligence'' (AI) or ''smart'' machines to claim to either mimic [''weak AI'', as assessed by the ''Turing test'' (Turing 1950)] or even represent human intelligence [''cognition is computation'' (Pylyshyn 1984), ''strong AI'']. If all our knowledge would lastly be explicit and propositional, it in fact might also be represented by algorithms and implemented as a computing machine, either by logical or functional programming or by machine ''learning''.

Against this background, the paper will shortly present both epistemological perspectives to investigate their actual dynamic interrelationship: regarding humans primarily as bodily and socially embedded actors dealing

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with the world around them, they are seen as being able to primarily gain an immediate, pre-reflexive perception of the world through their interaction driven by needs. It is implicit, embodied knowledge, a tacit skill private to the actors, and it normally is sufficient to cope with the world and the things ‘‘present-at-hand”. Driven by curiosity to explore the world or when actions lead to irritation, surprise or failure it might become necessary to reflect on the specific situation by conceptually reconstructing the underlying actions and processes. In this reflective stance, by conceptualizing, both by self-observation or observation by others—i.e., by distinction and designation—explicit or propositional knowledge about practices is being created.

This conceptual knowledge about practices is secondary and representational, hence, it is necessarily incomplete and partial, and it is error-prone (rightly evoking Cartesian doubts). Moreover, this theoretical knowledge needs to be appropriated again for situated practical use to become actually effective. Appropriation is work to make explicit knowledge (or knowledge-based artifacts) work, an effort which, on his part, enriches the implicit or tacit practical knowledge. With this dynamic interrelationship in mind, Descartes’ error does not consist in expressing his doubts about the certainty of propositional knowledge, but rather in regarding this representational cognition as the primary and only way of perceiving the world.

The practice theoretical perspective with its focus on the dynamics of explicating successful social practices as conceptual knowledge and of appropriating such knowledge as enhanced tacit knowledge and practical skill is of particular relevance to understand the persisting problems with conventional approaches to designing and appropriating complex computing machinery for use in organizations and the productivity paradox associated with them. It points to the need for understanding the semiotic nature of computing systems and the limits of their performance.

To this end, the paper starts with shortly characterising what it means that humans are living organisms being-in-the-world and what the pre-representational perception of the world is about. This lays the ground to analyse the dynamic relationship of tacit and codified knowledge. As a consequence of this distinction and relationship, the question arises how new ideas can be generated and introduced in codified knowledge leading to the logical form of abductive reasoning. With these basic cognitions in mind, computers are characterized as semiotic machines and the problematic relationship between humans and allegedly ‘‘smart” machines is analysed and assessed. Finally, conclusions about the potentials of human action competence and the limits of computer performance are drawn.

2 Being-in-the-world

In the newly flaming up AI discourse, spectacular technical demonstrations cause a big stir and confusion again, although they are build on well-known old conceptions of cognition. There is a continued prevailing tendency to compare or even equalize autonomous intentional acting of humans with the other-directed functional behaviour of machines. It particularly tends to confuse functional isomorphism with identity, equality of form with equality of substance. With respect to these tendencies, it appears necessary to recall some very basic facts about what it means to be a living human interacting with the world.

To begin with, humans are, like animals, first of all, natural beings, existing in a natural world around them which keeps them alive through metabolism. As living organisms, coming into being through the self-organising dynamics of ‘‘autopoiesis” forming their ‘inner’ nature, they interact with the ‘outer’ nature surrounding them in need of being nurtured by digestible natural products at reach. While the sensory-motor capacities of their organism form the interface between inner and outer nature, the quality of this dependence can be sensed and felt as well-being or illness (Maturana and Varela 1992). Moreover, humans are, as ‘social animals’, born into a community of others and need to be looked after during a long phase of adolescence and socialisation. As individual members of the community, they collectively make provisions for their living.

The human organism’s inner nature is, however, not only passively dependent on a favourable outer nature, but has, by evolution, also some reflective and productive powers at its disposal to actively get what it needs. Humans are, other than animals, equipped with the capacity of knowing about and of reflecting upon their being-in-the-world and to develop consciousness (an irrefutable fact the emergence of which we cannot fully explain scientifically so far, though). In contrast to the Cartesean conception of a rational mind being independent of bodily experience and feeling, human perception and cognition rely on manifold interactions between the brain and the body of which it is an organic part (Damasio 1994). As a natural evolutionary heritage, this active and deliberate ‘‘being-in-the-world”, together with the perceptual and motor capabilities it produces and maintains, provides humans with the necessary skills to survive (originally living as collectively acting ‘‘hunters and gatherers”).

Against this background, Dreyfus and Taylor (2015) remind us again of the primacy of embodiment emphasising the living body as the primary site of experiencing the world and of the fundamental role immediate perception plays in engaging with it. Referring to Heidegger’s ontology in ‘‘Being and Time” (1962), and Merleau-Ponty’s ‘‘Phenomenology of Perception” (1962), he insists that the world and the human body with its rich sensory-motor functions of perceiving the world are intricately intertwined. This interaction between inner and outer nature triggering their mutual momentum (also known as ‘‘structural coupling”; Maturana and Varela 1992), enables the body to feel what it needs and to find what the world offers to still the needs; it amounts to continuous skilful coping with the emerging situations of actively being-in-the-world. The active body and that which it perceives cannot be disentangled, while its saturation and wellbeing indicate success in this relationship.

Reflecting on indications of crisis in natural sciences, the late Edmund Husserl had already emphasised the significance of what he called the primarily experienced ‘‘life-world as the forgotten meaning-fundament of natural science: […] we must note something of the highest importance that occurred even as early as Galileo: the surreptitious substitution of the mathematically substructed world of identities for the only real world, the one that is actually given through perception, that is ever experienced and experienceable—our every day life-world” (Hussserl 1970: 48f). He thus laid open the root of taking a symbolic ‘‘garb of ideas” for objective reality confusing the method or model with actuality.

The conception of a non-mediated, pre-representational, and pre-reflective activity driven by ‘‘motor intentionality” (Dreyfus and Taylor 2015) leads to the view of an embodied and socially embedded actor grappling with the physical and socio-cultural world around him. In this perspective, the pre-representational coping with the world is not being produced by the actor alone, but in co-construction with the world by interacting with what it offers, with the ‘‘things present-at-hand” (Heidegger 1962). The phenomenal ‘‘thing” is, in this view, not the unchanging object of the natural sciences, but a correlate of our body and its sensory-motor functions. According to this ‘‘contact theory” of human existence, the thing’s experience and meaning result from the interaction, they are not internal to the actor, but lie in the interspace of dealing with it. Driven by curiosity and intentionality, the actor thus attains an intuitive percipience of the whole situation in which he is acting and, in particular, of the meaning things have in situated use without being conspicuous.

The phenomenological ‘‘contact” theoretical world view emphasising these facts has been brought forward against the representational view of conceptual cognition, against Descartes’ *cogito* prevailing in the Western world to which it indeed stands in stark contrast (Damasio 1994; Dreyfus 2002; Ryle 1949). Both world views have long been regarded as opposing or even excluding each other. They may, however, also be looked at as mutually completive views taking into account the additional fact that humans are able to awake to their being-in-the-world. Consciousness is a higher level of percipience transcending feeling, experience, will, and skills; it comprises, beyond immediate perception (as outlined), at least two more basic capacities: first, to perceive something and to be aware of perceiving it at the same time, and second, to perceive it *as* something, i.e., to subsume it under a concept. Consciousness thus enables humans to perceive and act (intuitively and immediately) on the one hand and to reflect on what they perceive and do (conceptually and analytically) on the other.

Individuals become intentional actors by virtue of observing how others are mirroring their acting. Based on this basic reflective capacity, humans are able to experience as well as to observe themselves as acting intentionally and, in particular, cooperatively, i.e., to conceive themselves as social actors, in other words: to say ‘‘I”. By becoming conscious of their position in these natural and social relationships, humans are enabled—and forced at the same time—to jointly take care of their lives, to take their specifically human needs as guideline for their deliberate and active intervention in or rearrangement of their living conditions, in other words: they become able to work (this capacity being fully developed during the neolithic revolution). Their bodily existence within these natural relationships forming an objective material precondition for human living enables humans to discover the creative or productive powers slumbering within them to take possession of the outer nature, to extend its potential for improving their living conditions with care. This inescapable fact also confronts humans with the necessity, however, to reflect on the risks such interventions may generate for maintaining the living conditions.

In the course of their conscious engagement with the physical and socio-cultural world, humans have developed two basic productive capacities: dealing with tools (as technical acting) and dealing with signs (as signifying acting). Both capacities are based on the formation of concepts (representations) as abstract generalised experiences and their objectification that can be shared; they thus initiate a cultural evolution based on and superimposing the original natural relationships. Tools are purposefully shaped artifacts complementing and augmenting either sensory or motor organs of the body for more effective observation of or intervention in the outer nature, while signs and significations are socially generated entities enabling humans to reflect on what they are doing, to mentally perform trials, to communicate with each other, and to coordinate joint actions.

Tools such as hand-axes, ploughs, or knifes are positioned as intermediaries between the inner and outer nature tying the needs and capacities on the part of the acting subject with adequately constructed properties on the part of the tool. For appropriately mediating between the two, tools need to be designed and mastered according to the purpose pursued within the constraints set by formability of nature and usability of things. For effective practical use, tools need to be sufficiently appropriated, internalised and wielded; only then the acting subject can merge with the intended object in specifically skilful actions.

Physical signs such as gestures, speech sounds, or written characters, on the other hand, serve as representations referring for somebody in a certain respect to something else as denoted object, i.e., having a meaning for somebody in a specific action context. Besides this representative function, signs further can be used as cognitive means in the sense that all cognition is mediated by signs (in contrast to immediate percipience as outlined above). In particular, they can be used to represent absent or even purely thought-of objects, to describe plans for instance. Signs do not exist per se, but are always part of a process of signification, or ‘‘sign process" (Peirce 1903) as a social fact. Signification or sign processes (‘‘semiosis") depend on collective intentionality of the actors enabling communication and cooperation in a social collective (as has been approved only recently; cf. Searle 2010; Tomasello 2008, 2014). Signs are our ‘‘windows" to the world through which we grasp or conceive the signification of certain aspects of world; using signs implies that there is no world without the meaning of ‘‘world".

3 The dynamics of "knowing how" and "knowing that"

The contact theoretical, pre-representational as well as the representational views on perception (or the two levels they refer to, respectively) also correlate with two corresponding, fundamentally different types of knowledge: implicit, practical or tacit knowledge (Polanyi 1966) on the one hand, and explicit, theoretical or propositional knowledge on the other. This appears to be a very basic distinction which is referred to in a whole bundle of literature in a similar way (Dreyfus and Dreyfus 1986; Giddens 1984; Göranzon and Josefson 1988; Nonaka 1994; Polanyi 1966; Ryle 1949; Varela et al. 1991). While human activities and related perceptions produce, according to the pre-representational world view, a wealth of embodied experiences, skills, and tacit knowledge, observing and conceptually reflecting on social practices of acting collectively, associated with the representational world view, lead to explicit or propositional knowledge as objectifications.

Tacit knowledge (implicit ‘‘knowing how"; Polanyi 1966; Ryle 1949) is the practical human action competence emerging from interacting with the world and comprising reflective, operational, and co-operational capabilities, skills, and experiences the human living body develops during lifetime. They enable effective acting in specific situations, particularly judging complex relationships and coping with uncertainty, to achieve needs and interests. They amount to successful ‘‘situated action" (Suchman 1987). Knowing how is the result of our intentional relationship to the world. It embraces the capacity to perceive and capture a situation as a whole, not as a constellation of separated parts and properties, as well as procedural routines for appropriately continued action. This action competence is mostly unconscious (‘‘tacit"); it grows with experience and by appropriating and internalising explicit knowledge as well as technical artifacts for effective practical use.

Propositional knowledge (explicit ‘‘knowing that"; Ryle 1949), in contrast, consists in making experiences conscious through reflection and conceptualisation. By means of appropriate concepts, certain aspects of social practices in the world are being ordered and partially explicated in propositions about the practices. Hence, explicit knowledge is always partial, perspective, and limited: It is limited with respect to capabilities as experts know more than they can tell (Dreyfus and Dreyfus 1986; Polanyi 1966). It also is limited logically as concepts and propositions comprise only what they stand for (excluding everything else). Explicit knowledge takes the form of theories, i.e., systems of consistently related concepts and propositions. Theories explain how something works (comprehending); they are self-referentially closed and need to be appropriated for effective practical use (real problem solving). The limitations are the price to be paid for conceiving aspects of our being-in-the-world, for obtaining abstract and generalised knowledge about it.

Both types of knowledge do not exist independently in isolation, but rather are intertwined in such a way that they mutually produce each other under certain conditions. Experience and tacit ‘‘knowing how" (Ryle 1949) as a result of our bodily existence is the primary basis of all acting and perceiving; as such it establishes a social practice and it is disposable at any time (although it may eventually turn out not to be sufficient). The intuitive and antecedent actions and perceptions generating experience normally express themselves as a continuing successful practice: ‘‘A successful practice precedes its own theory" (Ryle 1949: 30). Explicit ‘‘knowing that", in contrast, is secondary and limited; it is, however, objectified (externalised) and represented by signs and can, therefore, be cumulated and communicated to others. It emerges by reflecting on and explicating an existing social practice, and it needs to be appropriated and internalised on its part to meaningfully affect a social practice, though. As it roots in abductive reasoning, it is prone to fail, and Descartes was right to maintain his fundamental doubts about the certainty of cognition in the form of propositional knowledge. His deep error and that of his followers up to the AI propagandists is, however, to regard this type of knowledge as the only one, thus overemphasizing its relevance for effective acting in the world, while ignoring the tacit dimension of knowing and the phenomenology of pre-representational perception (Dreyfus 2002).

Taking a practice theoretical perspective (Reckwitz 2002) on this dynamic relationship by which new knowledge is created (Nonaka 1994), the actors of a social practice are, in the flow of continued collective activity, primarily performing internalised, embodied routines as a product of habituation. Performing a social practice may also comprise dealing with things such as technical artifacts through which the effects of acting are augmented, while new action routines are formed and embodied in use. These internalised routines can analytically be differentiated into acts of signification, domination, and legitimation; altogether they enable and constrain further acting as taken for granted according to the practice theoretical view of, e.g., structuration theory (Giddens 1984; with particular regard to computer artifacts:; Rohde et al. 2016; cf. the inner loop in Fig. 1).

Both, performing routines or appropriating resources constitute a set of action conditions (recognized or not) for further acting in ongoing social practices, the effects of which deliver results (intended or not) that (re-)structure routines. In the course of this continuous collective action flow, moments of irritation or surprise may occur, where things become conspicuous for whatever reason (possibly because established routines fail) and attract specific attention. Such problems lead to a situation in which things normally taken for granted lose their ‘‘objectivity”, since objectivity is not naturally given, but ascribed through shared signification. The experienced disorientation in such action crises not only relates to the object, but also concerns the social actors themselves. It initiates reflection and search processes to regain the capacity to act appropriately (as, e.g., treated with notions of ‘‘break-down” and ‘‘reflection-in-action” by Schon 1983).

Remedy would normally be achieved by reflecting on and conceptualizing routinized action patterns in explicit terms according to the logic of abduction (Peirce 1935), i.e., by forming appropriate conceptual hypotheses which provide a ‘best fit’ with previous experience and knowledge, seeking to explain and to transcend the problematic situation. Actors are able, in this way, to reframe their knowledge and to test their new understanding, to internalize it if proven to be effective, and thus to regain the capacity for effective routine action. This capacity then also includes the ability to anticipate the possible functions and properties of artifacts, learned from previous actions.

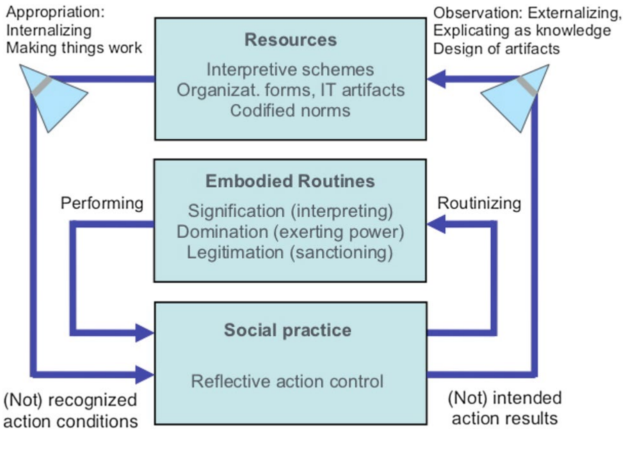

Fig. 1 Structuring a social practice (own representation)

Material resources, together with the appropriated routines to handle them, like other internalised action routines (signification, domination, and legitimation), constitute social structures that enable and, at the same time, constrain collective acting (‘‘duality of social structure”; Giddens 1984). By making sense of the internalised resources ‘‘present-at-hand” through interpretation (signification), by sanctioning actions according to codified norms (legitimation), by influencing other actors through administrative resources or by shaping activities through the use of technical artifacts (like, e.g., software functions; domination), they both continuously (re-)create routines, and eventually develop further resources, that constrain the scope for future action, interaction and negotiation. The more material resources are adjusted to the action context and the more appropriately they are interpreted and appropriated (or ‘‘encarnated”) for practical use, the more effective and efficient the social practices will be (Rohde et al. 2016).

In sum, humans act with the artifacts at hand by virtue of the meaning they attribute to the artifact’s functions and the results they produce. By making sense of and effectively making the artifacts’ functions work in use, specific regularities and use patterns emerge, which become internalised as new routines. Through recurrent interaction with the artifacts at hand, certain of the artifact’s functions or properties thus become implicated in an ongoing process of structuration in which rules and routines of use emerge. The resulting recurrent social practice produces and reproduces a particular social structure of artifact use.

With respect to the use of internalised artifacts as analysed by Merleau-Ponty (1962)—or taking up similar results from the alternative perspective of activity theory (Engeström et al. 1999; Leontiev 1978)—, two different classes of artifacts need to be distinguished regarding capacities and skills involved in using appropriated artifacts. Internalised artifacts that mediate motor skills make them a part of the body schema such that they become a medium through which motor skills are expressed. This mediation of motor skills may either be expressed through artifacts serving as tools for physically interacting with the environment requiring wielding skills in handling the tools. Or artifacts serve as appendages to the body by which it moves through the environment requiring navigational skills. For most artifacts used in this way, the perceptual functions are subordinate to their motor functions. By being appropriated and incorporated into the body schema, the artifacts become part of the bodily space (‘‘space of situation’’; Merleau-Ponty 1962), thus becoming an integral part of the motor or perceptual skill repertoire. In any case, embodied artifacts serve as media through which motor or perceptual functions are expressed, and they typically enhance or extend the performance or potential reach of perceptual and motor skills.

Besides those embodied artifacts mediating and extending motor and perceptual skills, there is another totally different class called ‘‘cognitive artifacts’’ (Norman 1993: 47ff) which are designed to manipulate, store, or retrieve physical signs representing socially relevant information to be generated by their users (e.g., computers, calculators, forms, or books). They support and eventually extend cognitive abilities, such as thought or reflection, memory, problem solving, or language use. Cognitive abilities or skills are grounded in, but not directly reducible to, sensory-motor skills, as the embodied use of such media conveying representations in the form of signs require additional capabilities to appropriately interpret and make sense of the signs in a specific situation that go beyond perception and manipulation.

4 Abductive reasoning

According to the outer loop in Fig. 1, explicating experience as propositional knowledge or designing a technical artifact’s functions based on such knowledge as well as, conversely, appropriating such knowledge or those functions for effective practical use are both creative actions requiring tacit skills for their part. These creative skills are logically based on abductive reasoning, a third type of inference (besides induction and deduction) launched by Charles S. Peirce addressing logical problems of discovery. Since the genesis of a hypothesis was an open question in scientific inquiry so far, he introduced abduction as the only logical operation dealing with a new idea transcending existing cognition. One basic way of formulating abduction is the following (Peirce, CP 5.189):

> ‘The surprising fact, C, is observed;
> But if H [an explanatory hypothesis] were true, C would be a matter of course, Hence, there is reason to suspect that H is true.

Abduction can thus be understood as a mode of inference in search of explanations for puzzling or anomalous phenomena or events. It allows to more comprehensively understand the process of scientific inquiry as a three step procedure of abduction (in search of an appropriate hypothesis), deduction (for deriving facts to test), and induction (to interpret the test results).

The abductive mode of inference can, however, be criticised with at least two respects: first, because it might be too permissive to be of much use as it seems to permit inferences to all sorts of wild hypotheses. Second, because it still not really addresses the genesis of the hypothesis, a creative act that clearly transcends logical reasoning. Both critical aspects point to the need for the researchers’ implicit ‘‘knowledge of familiarity’’ (Göranzon and Josefson 1988: 17), their tacit skills in ‘‘seeing’’ similarities or analogies when looking at the new or puzzling situation. The skill of creating a suitable hypothesis based on analogy or ‘likeness’ without following explicit rules is an essential part of human intelligence. In fact, many historical cases of scientific discovery illustrate this creative moment of ‘‘eureka’’ experience. It often relies on a form of sign-based reasoning called ‘‘diagrammatic reasoning’’ by Peirce.

There are a multitude of cases to demonstrate diagrammatic reasoning. The method by which Thales of Milet has determined the height of a giant pyramid provides an illustrating example. Taking the experiential cognition that objects of different height throw shadows whose lengths stand in equal relationship as their heights (cf. Fig. 2) as abductive reason, he could measure the pyramid’s shadow p and compare it to the more easily measurable shadow s of an upright stick of length S. The unknown height P of the pyramid can thus be calculated from easily measurable values.

Another specifically illustrative example for diagrammatic thinking early in history is the proof of the famous ‘‘Pythagoras theorem’’ which actually goes back in time as far as at least 4000 years (long before Pythagoras lived): In the old fluvial cultures of Mesopotamia and Egypt with its high agricultural surplus product, there were a strong need as well as elaborated practices for disposing and surveying field areas. The basic tool for this was a closed loop rope with 12 (=3+4+5) equidistant marks on it to create a right angle at any place according to the Pythagoras theorem (e.g., 9+16=25):

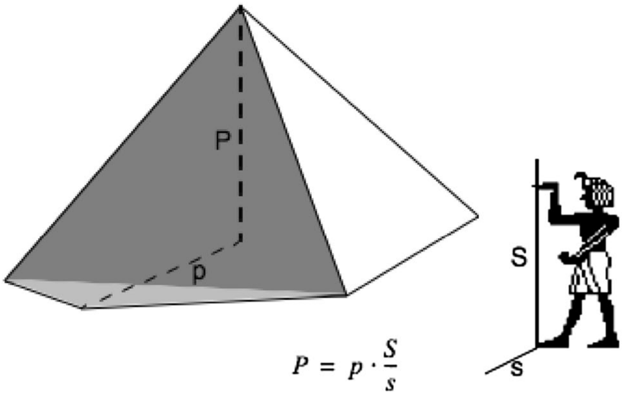

Fig. 2 Determination of a pyramid’s height (own representation)

A triangle is right-angled <=> $a^2+b^2=c^2$.

A theorem proof (one among many possible others) builds on the widespread social practices and experiences in dealing with geometric areas at the time. Diagrammatic thinking playing with geometric areas immediately leads, starting from the lower left rectangular triangle, to the geometric configuration shown in Fig. 3 where the big square with the area $(a+b)^2$ is composed of the square c^2 plus four right-angled triangles with the area $(a\ b)/2$ each. This results in the equations shown in Fig. 3.

5 Computers as semiotic machines

As indicated by the the wide-spread denomination ‘‘information technology”, computers have for a long time been regarded as ‘‘information processing” machines—cf., e.g., the Académie Francaise definition for ‘‘Informatique” (computer science) as ‘‘rational, in particular automatic, processing of information”. This view is, however, extremely misleading, as information is a concept belonging to the social world of signification, of assigning meaning to processes or events: Information, i.e., ‘‘any difference that makes a difference” (Bateson 1980: 250), solely originates from the activity of social actors interpreting such processes or events in the context of a social practice. As such, information simply does not exist inside a computer system clearly operating in the physical world of causes and effects.

That which is actually operated in computers are physical signs or signals being processed simply following the functional instructions of an algorithm. Physical signals are thus being processed by computable functions (as specified by the conception of the Turing machine)—and nothing else. Hence, there is no mystery at all, the computing machine explicitly does not process information, and it does not, in any comprehendible sense, ‘‘know” what is the meaning of the signals processed, nor does it ‘‘know” what it is doing, while it performs those functions. Equally, Winograd and Flores (1986: 86f), referring to signal processing, also emphasise: ‘‘One could describe the operations of a digital computer merely as a sequence of electrical impulses traveling through a complex net of electronic elements, without considering these impulses as symbols for anything.”

$$(a+b)^2 = c^2 + 4\ (a\ b)/2$$

$$a^2 + 2\ a\ b + b^2 = c^2 + 2\ a\ b$$

$$a^2 + b^2 = c^2 \qquad \text{q e d.}$$

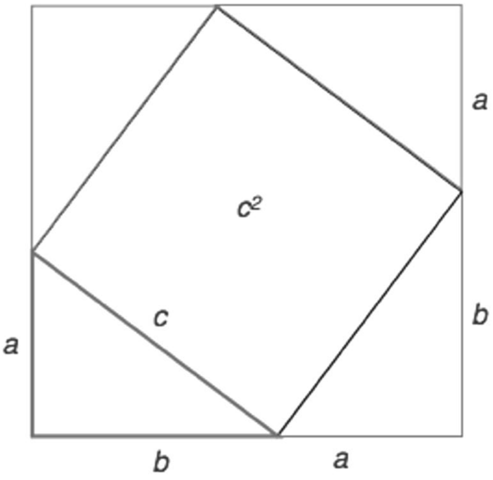

Fig. 3 Proof of the Pythagoras theorem (own representation)

Signification is not a property of symbols, but rather is assigned through interpretation in the context of a social practice, construed in use. There seemingly is an unsurmountable gap between the social world of significations, of assigning meaning in sign processes, and the physical world of signal processing in computer systems. Both worlds can be brought together, however, by merging the technical computer functions with the social practices using them according to the practice theoretical perspective outlined. Such a sociotechnical system may be analysed in detail by taking up the triadic sign concept as elaborated by Peirce (1903). He looks at signs and processes of ascribing signification as a triadic relationship connecting three entities: a physical sign (signal or ‘‘representamen” R), the ‘‘object” O it denotes or refers to, and the ‘‘interpretant” I or meaning it assigns to this relationship (Fig. 4).

In particular, this triadic sign concept allows to comprehend the algorithmically determined signal processing in computer systems as ‘‘degenerated” sign processes reduced to a dyadic relation without a ‘‘window to the world”, i.e., lacking the reference to an object of experience (its denotation). It only is a ‘‘quasi-semiosis” operating solely with physical signals as ‘‘quasi-signs” (Nöth 2002). This reduced quasi-semiosis can, however, be embedded in or merged with a complete semiosis or sign process of a social practice by means of a common ‘‘representamen”, i.e., a definitely coded physical signal made accessible to human senses (e.g., on a screen) which as such can be subject to interpretation in the context of a social practice outside the computer (provided that the algorithmic functions in use are known).

This kind of semiotic analysis equally applies to the use of computers as ‘‘embedded systems”, as controllers of physical (or biological) processes in so called ‘‘cyber-physical systems”. In these cases, the systems or processes to be controlled need first to be sufficiently described and modelled in the form of sign-based heuristic or mathematical models that allow for designing appropriate control algorithms. By means of these control algorithms, the computer then directly operates relevant sensory signals

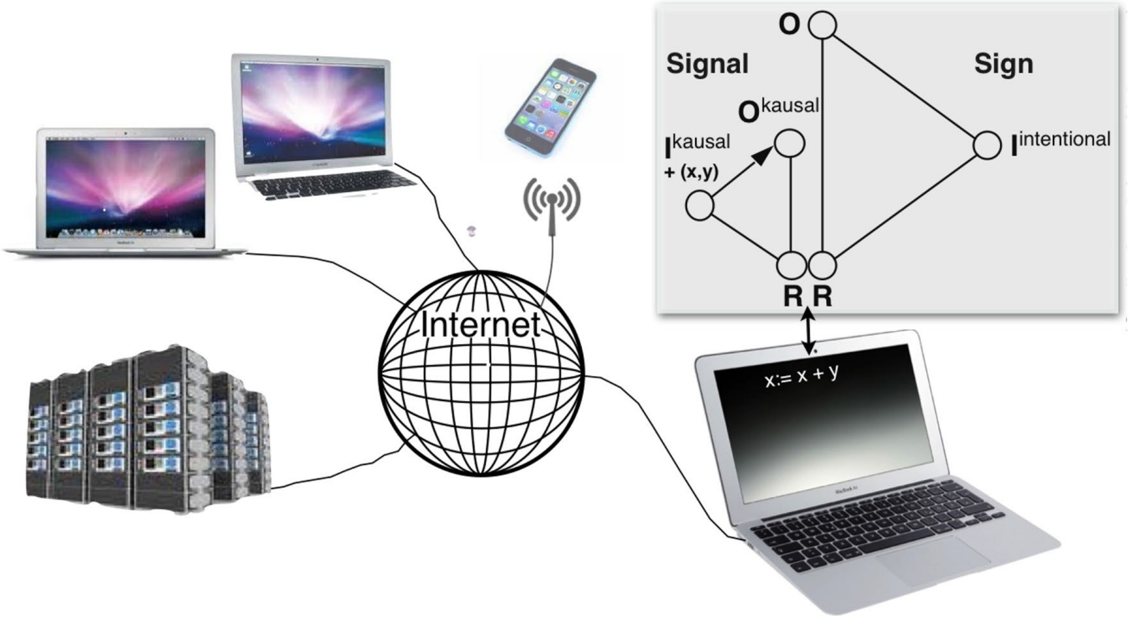

Fig. 4 Algorithmic sign mediating signal and signification (own representation)

for generating actor signals, solely in the form of a ‘‘quasi-semiosis”, to grant an intended automatic system or process behaviour.

The semiotic nature of computers may be illustrated by analysing sign processes in the social practice of computer-supported knowledge work referring to what has been specified as ‘‘algorithmic signs” (Nake and Grabowski 2001): The use of computers in this setting is based on two coupled sign processes interlinked by the same representamen R (irrespective of reversibly definite codification). While interacting with the computer, humans use triadic signs as input being meaningful to them in their social practice. Inside the computer system, however, these signs, being readable and meaningfully interpretable in the outside action context, are reduced to pure electronic signals as ‘‘quasi-signs”. The signals do not ‘‘know” any more for what they stand and what they mean. Rather, they are being processed through a program according to the completely determined instructions of the underlying algorithm. In Peircean notation, the algorithmic instructions in this sign process reduced to syntactical operations on signals take the role of an interpretant, however a ‘‘causal interpretant” I^{causal} that formally falls in one with the designated object O^{causal}. As soon as the processed signals—in the example shown the add-operation $+(x,y)$—are accessible to the senses again, e.g., on a screen, they can, provided that the underlying algorithmic functions are known, be interpreted in the context of the social practice using the computer system's functions (Brödner 2009; cf. Fig. 4). Inside the computer system, the signal processing is fully determined by semiconductor physics and formal logic, while outside the corresponding signals are taken as full signs and subject to intentional interpretation.

6 Human intelligence and "smart" machines

Taking up the view of humans as living organisms being-in-the-world again, a number of basic facts about the ontological status of humans, (semiotic) machines and their relationship can now be stated:

- While humans grow and literally ‘‘make” themselves through the self-organising dynamics of ‘‘autopoiesis” (Maturana and Varela 1992), by metabolism and conscious interaction with the world, computers as semiotic machines are, like other artifacts, made for human purposes using explicit theoretical knowledge about the world.
- While humans act autonomously and intentionally in a self-determined (contingent) way, semiotic machines operate automatically with a causally determined behaviour.
- While humans are able, thanks to their skill of dealing with signs, to learn through reflection and insight, semiotic machines can at best adapt to environmental conditions controlled by algorithms.
- While humans possess implicit tacit knowledge, growing experience, situated judgment, and action competence which are expressed and, at the same time, variably reproduced through action (forming the core of

working capacity), the behaviour of semiotic machines is controlled by algorithms based on a practice's formalised sign processes; the algorithmic functions need to be appropriated for becoming effectively used in a thereby changed practice, in particular for managing prevailing processes not modelled and formalised so far.
- While the physical or algorithmic functions of machines completely underly the purpose they are designed for, the purpose itself is set by collective intentionality of social actors and, hence, subject to their interests and world views: Technical artifacts are socially embedded.

From the very beginning, computers have been described by extremely misleading metaphors like ‘‘electronic brain", ‘‘autonomous" or ‘‘self-organising behaviour", ‘‘intelligent", ‘‘smart", or even ‘‘self-healing machines", ‘‘machine learning", or ‘‘neural nets" (now being omnipresent). In particular, ‘‘artificial intelligence" is a strongly mistaken attribution: The word ‘‘intelligence" roots in the Latin verb *intellegere* whose meaning is to gain insight in or cognition of something. This exactly is what computers are *not* able to do; instead, the attribute actually applies to the programmers designing the algorithms such that they fit the computer with intended adaptive behaviour. AI attributed to the system actually is the designers' objectified intelligence, their ‘‘coagulated" knowledge and experience, not the system's own achievement. These metaphors appear as linguistic tricks leading people to believe that computers as semiotic machines behave as if they were like humans. In the present discourse on ‘‘singularity", both, euphoric propagandists as well as apocalyptic alerters of unbounded AI, are equally taken in by the self-deception.

This mystification of computers denies the fundamental differences stated by reducing, in a functionalist perspective, competent autonomous acting of humans to algorithmically controlled behaviour of machines. At the same time, it produces illusions about the actual performance capacity of computers. Even worse: The confusion fades out the real problems of the complex relationship between humans and semiotic machines, how human–computer interaction can be made more effective and productive, how computers can be designed as ‘‘things that make us smart" (Norman 1993). How can human action competence and working capacity be enhanced by appropriately designing computer functions such that they meet human action requirements, on the one hand, and how can they be put to effective use in the context of a social practice on the other? The real problem is not to imitate human capabilities, but rather to support and amplify those capabilities by combining them with the performance of computers. This endeavour of human-centred design requires to take needs and conditions of human acting into account and to design computer functions appropriately.

Exactly with respect to this primary and urgent development task in human–computer interaction, present AI efforts generate severe problems rather than enabling solutions. As the behaviour of adaptive systems like multi-agent systems or artificial ‘‘neural networks" is history-dependent and based on implicit adaptation processes, it is intransparent and the results are difficult if not impossible to assess. How should humans be able to appropriate such systems with intransparent behaviour, how should they deliberately interact with them, if they behave differently and unexpectedly in comparable situations? Such behaviour contradicts one of the basic rules of human–machine interaction, the requirement of expectation conformity. Without being able to actually assess the validity of the outcomes, humans are ultimately condemned to blindly trust in the system's error-prone performance susceptible to interference—an ethically unacceptable situation (Brödner 2017).

With respect to computer-assisted knowledge work, for instance, as it recently has been envisaged by ‘‘cognitive computing" services (by means of IBM's Watson, cf. Kelly 2015; just another misnomer, by the way), these considerations are particularly relevant. Computers in fact appear to be pertinent to collect, store, manage, or retrieve huge amounts of explicit knowledge in various domains. For practical use in specific situations, the knowledge needs to be selected and presented conveniently, a task which typically requires experience and skills in situated judgment power. In situation-specific knowledge application, users assisted by the system are either compelled to blindly bank on its automatic, however intransparent adaptation capacity—as it cannot, for lack of reflecting its own procedures, ‘‘explain" or ‘‘justify" the validity of its results—, or they need sophisticated interactive software methods and techniques on demand for making the system's calculations transparent on different levels of detail such that they can conclude wether the results are justified (not provided so far).

More generally, the ‘‘imitation game" of the ‘‘Turing test" is another illustrative example to demonstrate how the functionalist view reduces the rich experience-based being of humans to the behaviour of machines. It is designed to investigate, whether ‘‘intelligence" can be justifiably ascribed to a computer as a property of its behaviour. It is based on the exchange of written natural language signs between a person C acting as an interrogator of two players A and B behind a wall where A acts as a man and B as a woman. Player A may be replaced by a computer for trial. By asking questions of player A and player B, player C tries to determine which of the two is the man and which is the woman. Player A's role is to trick the interrogator into making the wrong decision, while player B attempts to assist the interrogator in making the right one. If the computer succeeds in his role in a sufficient number of cases, it has passed the test (Turing 1950).

Rather than testing artificial ‘‘intelligence”, the test actually expresses which relationship human thinking takes to itself: AI conceptions construe the behaviour of objects as if they were intelligent. The Turing test is a form of observing and interpreting sign processes, rather than taking part in a real talk situation: Through the exchange of written signs excluding bodily experience as an essential basis of human perception and intelligence, not really living persons communicate, but rather conventional role models or stereotypes (being a prerequisite for semiotic machines to formally interpret signs). In this arrangement, human experience-based interaction comes down to regular conventional communication patterns, and human intelligence as an individual capability is reduced to a mere property of objects—in other words: Humans in this way construe themselves as machines.

This can be further made clear by looking at theatre performances as a contrasting arrangement where the whole course of events unites actors and audience with their full bodily existence and complete live experience in a common setting. Not just the spoken words taken as signs, but rather the whole situated dramatic procedures and occurrences are implicating the audience and intensifying the actors’ performance as well. Based on their different experiences and empathy, some members of the audience may be empathically touched by dramatic situations, others may rather reflect on hidden messages of the drama. All this happens although—or even because—everybody is aware that it is an ‘‘imitation game”, a play, not a real drama. It thus perfectly demonstrates what human intelligence is all about.

7 Conclusion: avoiding the AI Trap

A few important conclusions can finally be drawn from these considerations. First of all, the basic mistake made by the protagonists of the representational world view, from Descartes’ cogito to present cognitivist and AI communities, consists in regarding conceptual cognition as exclusive access to the world for humans. With this stance, they ignore or even deny the biological roots of human cognition, the existential fact of bodily being-in-the-world with its immediate intuitive perception in situated action.

Prior to conceptual cognition, successful continued action in and interaction with the surrounding physical and socio-cultural world, based on collective intentionality, holistic perception and immediate experience, are at the core of sense-making and human intelligence. It expresses itself as tacit ‘‘knowing how” and skillful acting which allocates pre-representational meaning to things, to dealing with them, and to interactions with others, thus constituting a social practice: Meaning is use (Putnam 1988; Wittgenstein 2009). Explicit propositional knowledge envisaged by cognitivism, in contrast, is derivative only, attained by observing the practice and conceptualizing its experiences, it is, therefore, secondary and limited. Due to decontextualisation and abstraction, it has more general validity, but it needs to be appropriated and internalised for practically effective use in situated action, however.

Computer systems, even those being enabled to adapt to environmental conditions by sensor data, attain their functionality solely through conveniently designed algorithms from outside, based on propositional knowledge about their field of application. They, therefore, are lacking own intentionality and self-determined activity as indispensable material basis for perception, sense-making, and experience. With respect to sign processes, they solely operate signals which are, as quasi-signs, lacking the references to experienced objects of the world and, hence, cannot ‘‘know” for what the signals stand or what they are about. And with respect to abductive reasoning, they are lacking the human capability to create an appropriate hypothesis for transcending the bonds of an existing formal symbol system.

More recent efforts on the part of AI and robotics for ‘‘embodying” their systems to broaden the range of automatic behaviour do not really change the picture. They all amount to the implementation of purely physical, mainly mechanical or electrical devices enabling sensor-controlled automatic movement in a physical space. This reductionist view of ‘‘embodiment” does not with any respect transcend the border to a living body deliberately and autonomously acting in the physical and socio-cultural world around it from which meaning arises.

For these reasons, it is extremely misleading to assign the attribute ‘‘artificial intelligence” to computer systems. It distracts the awareness from the fact that all intelligence is on the side of the programmer who provides the computer system with functions that, as its objectifications, solely mimic or simulate intelligent behaviour in a generally limited way. Rather than investing high, but questionable efforts and resources to explore up to which limits such an endeavour can be driven, it appears much more reasonable to thoroughly investigate how the unique human productive forces with its resulting practical and cognitive skills can be enhanced or amplified by combining them with the data processing performance of computer systems.

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