

# Ontology, epistemology and the complexity of human neurobiology

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**Abstract.** Certain ontology and epistemology perspectives are most relevant to human systems' enquiry. These are derived from a synergy of insights from theories of autopoiesis, interpersonal neurobiology and complexity. Ontology has implications for our comprehension of the nature of human systems: 1/ Human systems are embodied and situated, exhibiting self-organising and emergent properties; 2/ Human experience is personal but not private, it is born in the interactions with the environment, and is validated by the human structure; 3/ Changes in human structure are necessarily subservient to conservation of autopoiesis, i.e. self-production and maintaining life. The epistemological implications deem ontology and epistemology as mutually informative in human enquiry; the thrust of this article. Our knowledge is limited by our capabilities of awareness. The quality of perception interlinks with cultivating awareness and intentionality for maintaining wellbeing, i.e. sustaining life-enhancing conditions. The concept of 'wellbeing informatics' is used to outline a tangible approach to evaluating wellbeing.

**Keywords:** Autopoiesis, complexity, neurobiology, ontology, epistemology



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**Dr Rauch** is a neurobiologist. He examines the neural correlates of low intensity physical activity (based on natural movement principles) and biofeedback as a means of combatting ANS dysregulation to improve health and wellbeing. The same natural movement principles are also effective in improving performances on the sports field and in the workplace. Two crucial aspects of ANS dysregulation that needs to be optimized are: neutralizing excessive somatic sympathetic nerve activations (SNA) and

enhancing vagal nerve activation of the heart and the viscera. Dr. Rauch's recent research established that heart rate and HRV are good markers of SNA and vagal activity, respectively if the measurements are done under well controlled conditions.

## 1. Introduction

The purpose of this article is to introduce perspectives on ontology and epistemology with relevance to enquiry, and sense making in human systems. The last few decades have seen advancements in science, and trans-disciplinary synergies have rendered a shift from a reductionist to a more holistic paradigm [21, 22]. New insights have implications for the comprehension of the nature of being human and the nature of societal systems. This, in turn, informs epistemology and knowledge creation coherent with the ontological perspective. According to the 2017 Stanford Encyclopaedia of Philosophy, ontology concerns itself with the nature of things and the study of the most general features of what there is, and how the things, that are relate to each other metaphysically. In this article it is used to describe the nature of human systems from the perspective of autopoiesis [14, 15], the theory of mindsight [24] and complexity [2, 4, 9, 12, 17, 16, 19]. Grasp of the nature of 'being human', with relevance to the physical, mental and societal domains in the theory of autopoiesis leads to epistemological perspectives that deviate from the rationalistic metaphor of knowledge as an objective representation of a world outside of the human observer [12, 32]. Systems ontology leads to considering methods of enquiry and intervention coherent with the nature of the system. Ontology and epistemology intertwine into an impacting and developing relationship, and are mutually informative in human enquiry.

## 2. Autopoiesis

There is a large body of literature by the Chilean biologists Humberto Maturana and Francisco

Varela, usually referred to as autopoietic theory [14, 15]. The theory describes the nature of living systems and has found far wider application than may be suggested from its biological roots, thus, generating implications for epistemology, communication and societal systems theory.

Autopoietic theory proposes a generative definition of a living system, i.e. autopoietic system in the physical domain. An autopoietic system is defined as a network of processes of production of components that produces the components that through their interaction and transformations continuously regenerate the network of processes that produced them, and constitute the entity as a concrete unity in the space by specifying the topological domain of its realisation as such a network [14]. Thus, the internal dynamics of the components (neural nets, metabolic nets, etc.) generate and sustain the global processes of the autopoietic entity. At the same time, however, the global processes (behaviour, consciousness, mind) constrain and govern the interactions and the state of the individual components. This dialectic relationship between local and global levels is described in autopoietic theory as 'reciprocal' [14]. For example, in organisms with a nervous system, the rules of interactions within the neural network are in reciprocal relationship with the overall activity of the living entity. To a very large extent, behaviour is a regulator of perception [30, 31], i.e. what the organism senses is a function of how it behaves and of its state of being, and how it is and how it behaves, is a function of what it senses. 'Situated behaviour', thus, takes the form of coupling with the environment; where environmental perturbations trigger changes in the entity but do not determine them, because changes in living systems are necessarily subservient to conservation of autopoiesis [14, 15]. The observer is in a position to distinguish the structure of a living system and the structure of the environment, and, observe them both changing in their mutual interaction. The important thing is that both the system and the environment undergo transformations through the process of coupling, referred to as 'structural coupling', and these transformations are determined by the structure of the transformed entity and not only by the perturbation. In autopoietic (living) entities with a nervous system, the coupling with the environment constrains and governs the neural dynamics. Thus, it is clear that the mode of coupling with the environment has two complementary dimensions: First, the living entity

154 depends on its environment and defines itself through  
 155 the interactions with that environment (these interac-  
 156 tions are of the nature of macro-physical encounters  
 157 such as sensory transduction or muscle movements);  
 158 Second, yet no less important, coupling is only possi-  
 159 ble because these encounters are embraced from the  
 160 perspective of the global processes (mind, conscious-  
 161 ness, behaviour) produced by the internal dynamics  
 162 of the autopoietic system. This action appears to the  
 163 observer as an ongoing cognitive activity, and the  
 164 living organism exhibits the properties of a cognitive  
 165 self [14].

166 The dialectics of living organisms are based on  
 167 the necessary emergence of a meaning proper to the  
 168 perspective of the cognitive self (for example one's  
 169 perception), and on a coupling with the environ-  
 170 ment which refers to the necessary dependence of the  
 171 self on its environment (for example socio-linguistic  
 172 interactions). Consequently, the contents of human  
 173 experience depend crucially on the mutual embed-  
 174 dedness of the neural dynamics (embedded in the  
 175 overall physical and chemical dynamics), the human  
 176 agent as a unity with global processes (behaviour,  
 177 mind, consciousness) and the environment. Thus,  
 178 human experience is personal but not private. Expe-  
 179 rience is clearly a personal event, but that does not  
 180 mean it is private, in the sense of some kind of  
 181 isolated subject that is parachuted down onto a pre  
 182 given objective world [30]. It appears more appro-  
 183 priate to view personal experience as 'ripples on  
 184 the common ocean'. An investigation of the struc-  
 185 ture of human experience inevitably induces a shift  
 186 towards a consideration that several levels of con-  
 187 sciousness become inextricably linked to those of  
 188 others and to the phenomenal world in an emphatic  
 189 mesh [31]. The irreducibility of human experience  
 190 cannot be underestimated when developing research  
 191 approaches or methodologies [11, 12]. Human expe-  
 192 rience represents an irreducible first-person ontology  
 193 [28]. It is not sufficient to explain experience by  
 194 assuming a third person or objective viewpoint. What  
 195 is required is to recognise that both first-person and  
 196 third person accounts, and their interplay, are neces-  
 197 sary in order to do justice to the quality of enquiry  
 198 [22, 29].

199 An autopoietic ontology suggests: the human expe-  
 200 rience is validated in a special way by the human  
 201 structure, and this shapes the entity that arises in the  
 202 description [14, 15]. This ontological perspective has  
 203 impact on epistemology, i.e. it challenges the frag-  
 204 mented world view of an observer separate from the  
 observed reality.

### 205 3. Linguistic interactions, language and 206 complexity in human organisations

207 An organism can enter into structural coupling  
 208 with other organisms, and if the interacting organisms  
 209 reciprocally select in each other their respective paths  
 210 of ontogenic structural changes, then they generate a  
 211 domain of communicative interactions. The individ-  
 212 ual ontogenies of the participating organisms occur as  
 213 part of the network of co-ontogenies that they bring  
 214 about in constituting societal unities. The observer  
 215 designates as communicative those behaviours which  
 216 occur in societal coupling, and, as communication  
 217 that behavioural co-ordination he observes as a result.  
 218 This consensual domain of communicative interac-  
 219 tions in which the behaviourally coupled organisms  
 220 orient each other with modes of behaviour, whose  
 221 internal determination has become specified dur-  
 222 ing their coupled ontogenies, is a linguistic domain.  
 223 The name 'linguistic domain' was chosen because  
 224 such learned communicative behaviours constitute  
 225 the basis for language, although they are not iden-  
 226 tical with it [14]. The conduct of each organism  
 227 is internally determined by its autopoietic structure.  
 228 However, the conduct of one organism is a source of  
 229 perturbations for the others while the coupling lasts.  
 230 The linguistic domain, therefore, is intrinsically non-  
 231 informative, although the observer may describe it  
 232 as if it were so. What determines the interaction, is  
 233 the dynamics of structural coupling of the interacting  
 234 organisms [14, 30].

235 Such a view contradicts the more traditionally  
 236 established metaphor of 'the transmission of informa-  
 237 tion', in which communication represents something  
 238 which is generated at a certain point and carried  
 239 through an information channel, or conduit, and  
 240 delivered to a receiver. This metaphor is not correct,  
 241 since biologically there is no transmitted information  
 242 [14]. Moreover, it presupposes that what happens to  
 243 the receiver (listener) is predetermined only by the  
 244 perturbing agent. In actual fact, however, commu-  
 245 nication depends not only on what is transmitted,  
 246 but what happens in the organism that receives it.  
 247 Communication, therefore, is a matter of mutual  
 248 orientation, primarily with respect to each other's  
 249 behaviour, and secondarily with respect to some  
 250 subject [7].

251 To an observer, linguistic co-ordinations of actions  
 252 appear as distinctions, linguistic distinctions. They  
 253 describe objects in the environment of those who  
 254 operate in a linguistic domain. Thus, when an  
 255 observer operates in a linguistic domain, he operates

in the domain of descriptions. Moreover, language as a phenomenon takes place in the recursion of linguistic interactions – linguistic co-ordinations of linguistic co-ordinations of actions. Therefore, the linguistic domain becomes part of the environment in which linguistic co-ordination of actions take place, and language appears to an observer as a domain of descriptions of descriptions. But what an observer does is this - he makes linguistic distinctions of linguistic distinctions, or what another observer would say are ontogenically generated descriptions of descriptions [14]. With language arises also the observer as a languaging entity; by operating in language with other observers, this entity generates the self and its circumstances as linguistic distinctions of its participation in a linguistic domain. In this way meaning arises as a relationship of linguistic distinctions [14].

Language cannot be regarded as a system of symbols that stand for things in the world, and thus reveal our ‘objective’ knowledge of it. Words are tokens for linguistic co-ordination of actions. Therefore, it is appropriate to discuss languaging as a venue for action rather than language as a symbolic notation. Human organisations exist, for their members, in co-creating reality where language agreements decide what is true and what is false. This is not an agreement in opinions but in form of life. The key point is that by languaging together, the behavioural co-ordination, which is language, brings forth a world. Language allows for limitless recursion in the coupling of behavioural capabilities of individuals with the changes in societal life they generate [14].

If language is used to promote the status-quo or one way or other reinforce a specific worldview, then it can lead to pathological organisational life, where the individual members are ‘enslaved’ to support and act in organisational processes that they have no access to change. Such organisations, deliberately or not, use language as a repressive tool to shape human experience, and because of this, the creative potential of exploring and developing human experience into alternative language and practices is lost [15].

A simple pragmatic alternative is to respect human experience. What is required is to foster an environment where awareness and attentiveness, are actively developed, and where, conversations encourage new linguistic distinctions based on new experiences, to emerge. Practices like dialogue become essential in organisational conversations. The basic requirement of dialogue is to be able to talk while suspending opinions, while neither suppressing them nor insisting

upon them, not trying to convince but simply to understand, without having to say who is right or wrong [3]. This type of communication, enhances awareness of what there is to be heard, without focusing it through the lenses of preconceptions and creates a new frame of mind in which there is a common (or organisational) consciousness: a new kind of intelligence.

The dialogue process is to be seen as a core element within any human enterprise, as it creates the context for all activities, rather than (as may be suggested by more traditional communication approaches) being merely part of the chain of activities. Dialogue is about involvement, about co-creation. Thus, a generative dialogue process in organisations will enhance their ability to develop a meaningful language, a valid venue for action and continuous learning.

The phenomenal domain of human organisations is realised through the network of linguistic interactions. Stacey, in interpreting the impact of complexity theory on management paradigms, argues that such networks through local agent interactions are capable of spontaneous self-organisation, to produce emergent, evolving patterns of behaviours of the network without any prior comprehensive, system-wide blueprint for evolution [27]. The dynamics are determined by the pattern and nature of the actor’s relationships and linguistic interactions, and the response to any perturbation is determined by these very dynamics. Stabilising the behaviour of the network means simply repeating the past. Dialogue allows for emergence of new meaning and destabilises the status-quo, the network conducts itself as a complex adaptive system, i.e. rapidly generating emergent behaviours in response to perturbations [21]. This is what Maturana and Varela define as learning [14]. The flexibility to learn and innovate is essential. Operating in the complex systems domain, human organisations perceive and respond to the smallest changes in the environment or, indeed, inside themselves.

#### 4. Reductionism vs holism

Autopoietic theory resonates with the emerging paradigm of holism [23, 24]. There is now a significant body of research that supports the insight that our nervous system, mind and interactions with the environment are all interconnected [5, 11, 13, 18].

The prevailing reductionist paradigm of the twentieth century has shaped comprehension of human systems and reality through several assumptions:

Matter is the fundamental building block of the Universe; Perceptions are accurate representations of an objective reality that exists outside of the human observer; Knowledge is absolute and allows to predict and thus control nature [4]. This worldview, in turn, leads to further conceptions, some of which are: The Universe and the things comprising it (including humans), function as machines that could be understood through the study of the parts that constitute them; Humans exist as material bodies and thus are separate from each other and from nature; Genes determine biology; Language describes an 'objective' world.

These assumptions and conceptions have shaped prevailing attitudes, intentionality, beliefs, behaviours and artefacts, thus, the predominance of rational thinking, reliance on 'facts', and leaving out potential invisible influences such as the impact of the mind on the body and indeed on the world, the possibility of connection between minds, and the human tendency for cooperation [1]. This, in turn, determines the boundaries of the epistemological endeavour and the realm of possible action. It is therefore, important to explore the changes in ontological view informed by contemporary science, i.e. moving towards a holistic paradigm of the nature of reality. Insights from quantum physics, complexity theory, systems biology are informing a view of the nature of reality, which encourages profoundly different conceptions of the human potential.

Physics now suggests that energy and matter represent one 'reality' and need to be studied as part of a unified whole [4]. Energy fields exist around and within matter. They extend over space and interact with themselves and with matter. Thus, everything is connected to everything else. The quantum reality of entanglement opens the possibility of an instant non-local connection transcending time and space. If the fields impact physical reality, then further questions arise: How do these fields emerge and change? What is their observable impact on reality? How could we influence them?

Empirical research in contemporary evolutionary biology suggests that human systems are not separate from their environment (humans are not mere products of their genes). It is the environment, matter and energy fields that determine how genes unfold and manifest into matter [8]. Human minds, i.e. thoughts, emotions and intentions, have impact on biological embodiment and on the physical environment [8]. Minds are not simply products of brains, they are interconnected in principle everything there is.

The holistic perspective of reality informs a more complex view of the dimensions of human experience. As argued earlier, autopoiesis explores the mutual emeddedness of the nervous system, mind and interactions with the environment, thus, rendering traditional notions of representation and computation as inadequate [30]. What becomes important, in the study of human experience, is the comprehension of the complex interplay of brain/body, mental activity and world [7], i.e. how we as humans, examine what we live through, how we become aware of our own mental life. Accordingly, an aspect of exploring human experience involves developing and cultivating this basic ability through specific training. A hands-on, non-dogmatic approach can lead to progress. In Varela's work, this action of 'becoming aware' is punctuated by three 'gestures': (1) Suspension – a conscious transient suspension of beliefs about the thing being examined; (2) Redirection – turning ones own attention from the object to its source, backwards towards the arising of the thoughts themselves; and, (3) Letting go - changing one's attitude from looking for something to letting it come.

## 5. Awareness and mindsight

'Mindsight' is a term coined by Daniel Siegel [23, 24] to describe the human capacity to perceive the mind of the self and others.

The theory of mindsight defines the mind is an embodied and relational process emerging from the mutual interconnectedness of the physical, mental, and relational (both human and non-human) domains of reality. The mind, as an emergent property, of the body and relationships, is created within the internal neurophysiological processes and relational experiences. In other words the mind is a process that emerges from the distributed nervous system, extending throughout the entire body, and also from the communication patterns that occur within relationships [24]. To put it simply, relationships and neural linkages together shape the mind [23]. The brain (the embodied nervous system), mind and relationships are aspects of one reality and need to be considered together, where the body provides the biological structure for hosting human experience, and the mind is embodied, and relational process that regulates the information and energy flow in the embodied brain and in the relationships with others and the environment [23]. The term 'embodied brain' refers to the whole nervous system, not just the brain in the skull.

458 The regulation of energy and information flow  
 459 is achieved through the management of intentional-  
 460 ity and attention [24]. Intentionality determines the  
 461 direction of attention. Attention acts like ‘a scalpel’,  
 462 as the direction and scope of attention can trigger  
 463 changes in the brain (neural plasticity) and in the com-  
 464 munication space of relationships and then further  
 465 influence our mental activity, brain and relationships  
 466 in a continuous cycle [27]. The intentionality of ‘see-  
 467 ing reality’ more clearly and continuously enhancing  
 468 awareness and reflection capability requires the inte-  
 469 gration and stabilising of attention in monitoring  
 470 body sensations, mental activity and relationships.

471 In Western translation a heightened state of aware-  
 472 ness is often referred to as ‘mindfulness’. This  
 473 terminology is widely accepted in the West, where  
 474 the state of ‘mindfulness’ is defined as an opposite to  
 475 ‘mindlessness’, i.e. functioning on autopilot or sim-  
 476 ply downloading mental models, assumptions and  
 477 prejudices rather than witnessing present experience  
 478 as it unfolds. Jon Kabat-Zinn provides an operational  
 479 working definition of mindfulness as: ‘The awareness  
 480 that emerges through paying attention on purpose,  
 481 in the present moment, and non-judgmentally to the  
 482 unfolding of experience moment by moment’ [10].  
 483 It is important to clarify that our comprehension of  
 484 mindfulness, as paying attention to experience as it  
 485 unfolds, is not only connected to present moment sen-  
 486 sations, but to accepting and witnessing our present  
 487 moment experience, that may involve some or all  
 488 aspects of experience, i.e. sensations, mental activity  
 489 (thoughts, feelings, memory, intentions, beliefs, atti-  
 490 tudes, etc.) and relational experience (connectedness  
 491 to others, to our planet, to nature, etc.) [24].

492 Daniel Siegel chooses to use the metaphor of  
 493 the cameraman to explain two important aspects of  
 494 awareness practices [24]. To capture a clear and accu-  
 495 rate image, the cameraman needs to take care of:  
 496 (1) opening the lens of the camera to allow for full  
 497 view; and (2) stabilising the camera (using a tripod) to  
 498 avoid blur in the image. Opening the lens of aware-  
 499 ness requires attention to all aspects of experience:  
 500 sensory perceptions, body awareness, awareness of  
 501 mental activity such as thoughts, feelings, attitudes,  
 502 beliefs, intentions, etc.; and, relational awareness of  
 503 connectedness with others and with nature. However,  
 504 the picture of reality will still be blurry if the observer  
 505 fails to stabilise the camera of awareness. Stabilising  
 506 the camera of awareness requires openness, obser-  
 507 vation and objectivity. Siegel refers to these three  
 508 fundamental components as the three legs of the tri-  
 509 pod that stabilise the awareness lens (in his work

510 Siegel uses the word *mindsight* instead of aware-  
 511 ness) [24]. When the lens of awareness is stabilised,  
 512 the details come into focus with more depth and  
 513 precision. Openness implies acceptance of what is,  
 514 without any preconceived ideas or attitudes of how  
 515 things ‘should be’, i.e. let go of expectations and  
 516 receive things as they are. Openness allows to recog-  
 517 nise restrictive judgements and release them from the  
 518 mind. Observation allows for a larger frame of refer-  
 519 ence of self-observation, i.e. to detach from habitual  
 520 responses and find a way to modify them. Objectivity  
 521 recognises that awareness is separate from what the  
 522 observer is aware of.

523 Siegel brings into focus five dimensions of aware-  
 524 ness: 1/ Awareness of sensory input (touch, smell,  
 525 sight, sound, taste); 2/ Internal body sensations of  
 526 comfort or discomfort; 3/ Mental activity (images,  
 527 beliefs, thoughts, feelings, attitudes); 4/ Relationship  
 528 with people, nature, artefacts; 5/ Awareness of aware-  
 529 ness. The five dimensions constitute a structure for  
 530 managing awareness and attention [24].

531 Research from neurobiology [6, 13, 18, 25, 30, 31]  
 532 provides evidence that awareness development prac-  
 533 tices are correlated with the development of the  
 534 pre-frontal cortex of the brain, vertical (gut, heart and  
 535 cortex) and horizontal (left, right brain hemisphere)  
 536 integration of the brain and the development of  
 537 qualities of: Emotional balance and modulation of  
 538 fear; Response flexibility – pause before you act;  
 539 Insight – linking past with present experience and  
 540 future possibility; Empathy and compassion for  
 541 ourselves and others; Morality – what is appropriate  
 542 from the perspective of the common good; Intuition  
 543 - non rational way of wisdom and knowing, and thus  
 544 with wellbeing.

545 Siegel [23, 24] relates the concept of wellbeing  
 546 with complexity. In his acronym *FACES* (Flexible,  
 547 Adaptive, Coherent, Energised and Stable), he refers  
 548 to the wellbeing of a system (in the physical, mental,  
 549 and/or societal domain) as the capability to function  
 550 as a complex adaptive system, i.e. exhibiting coherent  
 551 emergent behaviours in relation to changes in its envi-  
 552 ronment, as opposed to rigid or random responses.

## 553 **6. Towards wellbeing informatics:** 554 **complexity, intentionality, awareness and** 555 **measurement**

556 In science, the purpose of research is to develop  
 557 insight and to predict. Science has the element  
 558 of experimental falsifiability, which is lacking  
 559

559 from traditional disciplines, making it flexible and  
 560 open ended. Scientific enquiry requires measure-  
 561 ment as its system of validation/falsifiability. What  
 562 about measurement and prediction in the human  
 563 domain?

564 Humans and human organisations exhibit complex  
 565 systems behaviour, producing emergent properties  
 566 and processes (mind, culture, etc.). It is possible  
 567 for a complex system to move towards an ordered  
 568 system or a system exhibiting random behaviour,  
 569 when constraints change. For a system, the ability  
 570 to function in a complex way is needed for adap-  
 571 tation and innovation and provides the underlying  
 572 capability for survival, sustainability and health, in  
 573 both individuals and organisations. What the theory  
 574 of complex systems tells us is, that the very nature of  
 575 the multiple interacting and continuously changing  
 576 relationships and constraints of the system, prevent  
 577 precise prediction over longer periods of time, render-  
 578 ing the scientific approach of verification/falsification  
 579 problematic. This has important implications for the  
 580 measurement and comprehension of human systems.  
 581 Measurement in human systems requires: describ-  
 582 ing the system in real time, both its state of being  
 583 in the now and its tendency and direction of possi-  
 584 ble change [12]. As human systems are embodied  
 585 and situated, measurements need to cross boundaries  
 586 between the physical, mental and societal domains.  
 587 What is to be measured, is the state of being of the  
 588 system and the individuals comprising it, in real time,  
 589 simultaneously in these different domains. Both first  
 590 and third person accounts of the state of the system  
 591 are important and in large human organisations a dis-  
 592 tributed ethnography approach assists insight [26].  
 593 What is important to comprehend and assess is the  
 594 state of being in terms of complexity capability, i.e.  
 595 capability for a coherent dynamic response to change,  
 596 and the existence of an ecology capable of sustaining  
 597 wellbeing.

598 Measuring and monitoring for wellbeing, referred  
 599 to in this article, as ‘wellbeing informatics’, requires:  
 600 An approach which prioritises description over evalua-  
 601 tion; An enquiry that crosses the boundaries between  
 602 physical, mental and societal domains; Grounding in  
 603 phenomenology and the ‘act of becoming aware’.  
 604 Psychophysiological measurement such as Heart  
 605 Rate Variability provides a valuable link between  
 606 the human actor and objective physiology [11, 18].  
 607 Catalysing new knowledge requires new ways of  
 608 engagement and experimentation. As Varela points  
 609 out ‘behaviour is to a very large extent a modulator  
 610 of perception’ [29].

The term ‘wellbeing informatics’ is important as  
 it implies a tangible, evidence based approach to the  
 study and evaluation of human and systemic wellbe-  
 ing, using the tools provided by informatics to create  
 a framework within which one may consider the  
 interaction between humans and information along-  
 side the construction of interfaces, organisations,  
 technologies and systems.

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