1. The Interface

1.1. Reconsidering the Interface

In her introduction to *The Art of Human-Computer Interface Design*, a collected volume of essays, Brenda Laurel asks a basic yet central question: "What's an interface?" (Laurel 1990b, p. xi). In computing science, the term "interface" usually stands for devices and technical solutions that define the manner in which humans interact with computers.

There are, however, different meanings of the word. A web entry sums up the uses of the term depending on context:

> "INTERFACE
>
> The point of interconnection between two entities. 'Public relation firms often serve as the interface between a company and the press.'
>
> - (computing) The point of interconnection between two systems or subsystems. 'The data is sent over the air interface to the remote system.'
>
> - (computing) The connection between a user and a machine. 'The options are selected via the user interface.'
>
> - (chemistry, physics) A thin layer or boundary between two different substances or two phases of a single substance. For example, if water and oil are mixed together, they tend to separate, and at equilibrium they are in two different strata with an oil-water interface in between. The surface of a lake is a water-air interface.
>
> - (computing) In object-oriented programming, a piece of code defining a set of operations that other code must implement."[15]

Taking a step back, the transfer of the word "interface", from its original meaning to computing, is interesting. The fourth definition, which relates to chemistry, describes this origin. Here, interface means "phase boundary" – a boundary between different aggregate states of a substance or a medium. These are distinct from each other precisely because they do not intermix. The substances or different systems can only exchange through an interface. The interface describes in what way they face[16] each other in order to communicate: "Moreover, the word means 'intermediate layer': for both boxes involved, it is irrelevant how each respectively treats

15 See: *http://en.wiktionary.org/wiki/interface*, checked on 21/08/2013

16 Note the meaning in Latin: inter = between, and facies = appearance, form, figure, visage.

C. Draude, *Computing Bodies,*
DOI 10.1007/978-3-658-18660-9_2

messages internally, and therefore how it manages to produce answers. The delineation of boundaries is integral to itself, and the black boxes need only to know the side facing them in order to ensure communication."[17]

Therefore, the original meaning stresses the surface character, while the differences between the substances are emphasized by their characterization as black boxes. These black boxes can be distinct in their set-up or differ in their internal information and communication procedures. What counts is the interface's ability to translate or transport relevant information. Historian Hans Dieter Hellige points out that the term interface was later transferred to physics and then to electrical engineering (Hellige 2008, p. 11). Subsequently, interface came to name the conceptual space in which the computer and the human interact. To begin with, the usage of the term describes a clear separation between two entities who are then in need of intermediation. The human and the computer might as well be black boxes with their internal communication structures differing decidedly. But, as long as their output is being moderated and mediated accordingly, differences in their internal structure do not matter.

Already in the 1960s, prominent figures of technological development such as Douglas Engelbart and Josef Licklider argued against this image of black boxes. Both Engelbart and Licklider stressed the coupling of human and machine over their separation. Rather than a scenario in which two black boxes meet – with the human on one side and the computer on the other – they emphasize the formation of a new, sociotechnical space that changes (or at least has effects on) both entities. Human and computer are linked in a cybernetic feedback loop. According to this concept, human-computer interaction is a much more symbiotic, synergistic, and interlinked process than is indicated by the term interface. Licklider, for example, coined the term “man-computer intermedium” in order to grasp this process (Hellige 2008, p. 14). Others, like Frederick P. Brooks in 1965, put an emphasis on the "architecture of input-output system" and suggested that this process be understood in terms of an interaction space (quoted in Hellige 2008, p. 12). In the 1970s and 1980s, however, the term “user interface” prevailed[18]. What is of interest is the question of why this happened. Why do certain conceptualizations of human-computer interaction have more impact than others?

17 "Daneben bedeutet das Wort ‘Zwischenschicht‘: Für die beiden beteiligten Boxes ist es ohne Belang, wie die jeweils andere intern mit den Botschaften umgeht, und wie die Antworten darauf zustande kommen. Die Beschreibung der Grenze ist Teil ihrer selbst, und die Black Boxes brauchen nur die ihnen zugewandte Seite zu kennen, um die Kommunikation zu gewährleisten." See: *http://de.wikipedia.org/wiki/Interface*, checked on 21/08/2013

18 For an excellent, detailed discussion, see Hellige (2008).

Lasse Scherffig finds the answer in Western cultural history. He links the idea of two separate entities that collide at the interface to a modernist conception of the world. In particular, he stresses the Cartesian idea of the human subject:

> “In its most classical view human and computer meet at the interface. The computer in this view is more or less the Turing machine. The human in this view is the Cartesian subject. Between both there is a gap [Norman, 1986, p. 31]. On one side there is mind, on the other there is the physical world. In between there is a translator. For Descartes, mind-body interaction took place at the pineal gland [Beckermann, 1999, p. 50]. Today human computer interaction takes place at the interface. [...] The German term for interface is 'Schnittstelle', which literally translates to 'location of the cut'.” (Scherffig 2005, pp. 33–34)

Henceforth, the distinct Cartesian separation of mind and body finds its counterpart in the concepts and realizations of the "Schnittstelle"[19]. Scherffig states that the gap even finds expression in the hyphen that divides, and at the same time links, human-computer interaction. The role of the interface is to connect these previously “cut apart” pieces – if it succeeds, then a functioning (communication) system is formed. What is of major interest for this analysis is how the bridging of this gap – the interface – gains importance and, with the embodied agent/Virtual Human, finally receives a life of its own (at least in concept).

In her analysis, according to which the computer is described as *Das Medium aus der Maschine*, or a medium that derives from the machine, Heidi Schelhowe describes how the conception of the computer – and accordingly of the interface – has changed throughout the years. In the early days of computing, which she exemplifies with Konrad Zuse's Z3, the interface was not at all conceived as a medium. Instead, the computer was to be handled like a machine. Its working principle of signal processing was rather accessible while the machine was manipulated through punch cards (Schelhowe 1997, p. 153). In this first generation of knobs, dials, and front panels, there was hardly any intermediation between human and machine. *What you touched was what you got*. The handling of the machine mirrored the modes by which one operated it.

An important shift took place, in 1961, with the Compatible Time-Sharing System (CTSS) at MIT. The basic innovation of time-sharing operating systems was that they let several users share one mainframe computer. The users – which is to say, in this case, the programmers – operated through teletypewriter machines. Because of this, the CTSS encouraged communication among users. It introduced

19 “The German term ‘Schnittstelle’, meaning interface, posits explicitly, according to DIN 44300, that it refers ‘to a transition of the booundaries between two entities of the same kind’.” (“Der deutsche Begriff 'Schnittstelle' postuliert ausdrücklich gemäß DIN 44300, dass es sich hierbei um einen 'Übergang an der Grenze zwischen zwei gleichartigen Einheiten handelt."“) (Hellige 2008 p. 13)

the communication aspect and thereby marked the beginning of human-computer *communication*. Fernando J. Corbató, Marjorie Merwin Daggett, and Robert C. Daley describe the need for time-sharing. Furthermore, they state that it introduced a whole set of new challenges to the field:

> "Thus, what is desired is to drastically increase the rate of interaction between the programmer and the computer without large economic loss and also to make each interaction more meaningful by extensive and complex system programming to assist in the man-computer communication. To solve these interaction problems we would like to have a computer made simultaneously available to many users in a manner somewhat like a telephone exchange. Each user would be able to use a console at his own pace and without concern for the activity of others using the system. This console could as a minimum be merely a typewriter but more ideally would contain an incrementally modifiable self-sustaining display." (Corbató et al. 1962)

Not only does time-sharing advance the role of communication, it also contributes to a distancing of the user from the machine's working mode. Schelhowe, however, stresses that at this point it is merely the sensual experience of handling a machine which recedes; the computer is still understood as a machine that computes (Schelhowe 1997, p. 154f). In order for many users to have access to one machine, the display monitor gains importance. An increased capacity of abstraction and imagination is demanded from the human, who must now converse with the machine through type-pad and screen, as interface, rather than through pushing buttons on a machine. The semiotic character[20] of the computer begins to manifest itself at the interface. Signs and symbols start mediating the interaction process between human and machine.

Time-sharing does not emphasize a strict separation between human and machine. On the contrary, the programmer is considered to be part of the system. Licklider's claims that human and computer are entangled in a cybernetic feedback loop is more obvious at this early stage. Furthermore, in the conversation paradigm of the command-line interface, programmer and computer are connected through typewritten input. For this, the human has to learn a specific language in order to handle the machine. Just as in a dialog, these commands are not represented on the screen but have to be memorized by the human. Unlike a human-to-human dialog, the used language is highly formalized and has to be precise in order to work. Particularly telling here is the term "command", an expression invoking the military. Interestingly, with the command-line interface, it is the commander who has to learn the language of the subordinate. To rule the computer, its logic and symbolic manipulation have to be followed exactly (Hofmann 1997, p. 73). The socio-

20 See Chapter 2.2.

cultural setting of the technology is framed by the language and metaphors that are used, and such language and metaphors manifest themselves in technological implementations.

As mentioned above, Licklider, in particular, stresses the symbiotic character of this type of interaction. While interacting, user and computer follow different tasks: the human defines goals, makes plans, and evaluates; the machine takes over routine work and thus frees the user from presumably tiring tasks. The question of how the interface is conceptualized then becomes a question of how these assignments of tasks are distributed, organized, and represented (Schelhowe 1997, p. 156). Interestingly, this attribution of roles enhances the gap between human and machine through the way in which certain human traits are sourced out to the machine. This attribution grants the creative, decision-making, emotional part to the human and the precise, calculating, routine – and assumingly more boring – part to the computer. At this early point, a dichotomy becomes established. On one hand, there are things that are not – or that are not as readily – computable, such as creativity and emotions. On the other hand, there remain the more rule-oriented and computable routine tasks. Read against the background of the Cartesian split, rule-orientation is attributed to the computer, whereas creativity and emotions are viewed as inherently human. Logic and reason appear more easily transferable to the computer due to their roots in mathematics[21]. Simultaneously, they seem more abstractable from the human body. Emotion, the senses, and creativity, in contrast, are more tied to matter/materiality and considered inherently uncomputable – at least in these early stages[22]. The embodied agent/Virtual Human interface, which seems to challenge these dichotomies, will develop a later phase.

In order to understand the course of human-computer interaction, it should be noted that this early stage of time-sharing already constitutes the trajectory that this course will later follow: "From the user's standpoint, how they interact with the computer is an issue surpassingly more important than what the computer is built from" (Walker 1990, p. 439).

The idea of a "self-sustaining display", which Corbató et al. envisioned, proves to become more and more extrapolated throughout the course of human-computer interaction. The popular, widespread graphical user interface (GUI) and new developments like touchpad technologies come very close to this idea.

21 For a further discussion of this, see „Die Herschaft der Regel. Zur Grundlagengeschichte des Computers," by sociologist Bettina Heintz (1993). The author recontexualizes the field of mathematics by pointing out its social and historical situatedness. Thus, the computing machine apperas as product of modernity – that is, a machine defined by distinctively modern traits like rationality, mechaninzation, and economization.

22 Chapter 3.1.

Throughout the history of human-computer interaction, the technology changes along with the anticipated user groups and the designers. Or, more accurately, the dichotomy between users and designers itself is a product of this history. Roughly speaking, until the 1970s the programmers were the ones who handled computers. With a wider distribution of computers, however, the term "user" comes to refer to someone who is not a computer expert – that is, to a person who uses, but does not design, the technology (Hofmann 1997, p. 71). Jeanette Hofmann analyzes the establishment of this new distinction between experts and non-experts. Giving examples of word processing software and hardware solutions, she reconstructs how technology results from the "Nutzerbilder", or images of users, that are anticipated by the software designers. She finds that: "Behind every programming draft there is a more or less explicitly designed 'script', which includes the characteristics of the user, as well as their actions"[23].

These "user scripts" are gendered in a complex way. Hofmann describes common images in terms of "the eternal beginner (female)"[24], " the technical expert (female)"[25], and "the casual writer (male)"[26]. In the 1980s, word processing software typically addressed typists and secretaries – work positions that are mostly occupied by women. Depending on the anticipated user that was imagined, the soft- and hardware offered rather predetermined and static technical solutions. For example, some programs start with the idea that the "the user is a beginner" and will remain so, either because this user cannot become or does not want to become capable of handling technology that is more complex. But there are also interfaces where the technology is more open and adjustable, and these follow the idea that "the user will eventually become an expert".

Interestingly, the graphical user interface realized by the Xerox Star computer, in 1981[27], took a man, who is a manager, as user model. It introduced a desktop metaphor that catered to a person who usually did not do the typing and was too busy to remember all the complex and precise commands of other interfaces: "Graphical objects that reproduce the world of the office, are understood as concessions of the software designer to the, presumed to be weak, memories of

23 "Hinter jedem Programmentwurf steht ein mehr oder minder explizit formuliertes 'Script', das Eigenschaften der Nutzer sowie ihrer Tätigkeiten umfaßt." (Hofmann 1997, p. 74)
24 "Die ewige Anfängerin" (ibid., p. 75)
25 "Die technische Expertin" (ibid., p. 78)
26 "Der Gelegenheitsschreiber" (ibid., p. 85)
27 "Augment", by Doug Engelbart, can be seen as a predecessor. (ibid., p. 93)

their audience. Also, the estrangement (based on that of men) in relation to the world of digital text processing ought to be reduced with this."[28].

This “knowledge worker” is pictured as someone who conceptualizes and builds texts. In contrast to the secretary, who is understood as a mere typist, it is with the knowledge worker that writing becomes a creative process. The gendered division of labor in the workplace thus finds its counterpart in interface technologies (Hofmann 1997, p. 91f).

It is with the graphical user interface, then, that the interaction scenario changes from one defined in terms of expert users, such as the experienced typist or the programmer, to one defined in terms of the knowledge worker – and, subsequently, of the “everyday user”, who should not be bothered with the working mode of the machine. It should be noted that this comprises a shift from handling the computer through precise, abstract language to handling it through more graphical, representational – and, later, even embodied or tangible – interaction scenarios.

1.2. Human-Computer Interface: Bridging the Gap – Establishing the Gap

The artist J. L. Andruszkiewicz states: “All human interaction with computers takes place at an interface. An unusual characteristic of the computer interface is, as it allows some interactions between the user and the system, it also prevents others; this is the case no matter on what system level the user is accessing the computer” (Andruszkiewicz 2009a). The role of the interface is one of intermediation. And it materializes certain possibilities of agency while neglecting others.

According to its developers, the embodied interface agent/Virtual Human is considered a post-GUI solution that will make computing technology not only accessible – easy for all to use – but also more adaptable to post-desktop environments (Cassell 2000a). Given embodied agent research's focus on the human, the technological mirroring of human cognitive abilities, behavior and appearance becomes important. For human-computer interaction, standard works, such as *User Centered System Design* (Norman, Draper 1986), make it their goal to map the multifaceted field by concentrating on the human. This perspective on the human is drawn from cognitive science.

28 "Graphische Objekte, die die Bürowelt nachbilden, sind als Entgegenkommen der Softwaredesigner an das als schwach unterstellte Gedächtnis ihrer Adressaten zu verstehen. Auch das (Männern nachempfundene) Fremdheitsgefühl gegenüber der digitalen Textverarbeitungswelt sollte auf diese Weise vermindert werden." (ibid., p. 86)

Below, I provide a short review of this highly influential approach. The concept of human agency and cognitive ability that is here established is one that reoccurs within the design of sociable or embodied agents. The work of Norman and colleagues (ibid.) demonstrates how human agency becomes reformulated against the background of computer science. Two fields of knowledge, cognitive science and computing, co-construct a new field: cognitive engineering (Norman 1987, p. 326).

Donald A. Norman, a prominent figure in the field of human-computer interaction, is renowned for a special interest in usability issues. He was originally trained in electrical engineering and later became a professor of cognitive psychology as well as of computer science. Stressing the importance of usability engineering, he proposes user-centered design for all areas of construction. His interests cover a wide range of topics, including technology and society, emotions and design, interaction, and education[29]. Although his body of work is vast, it is Norman's concept of agency that is of particular interest for the analysis of the embodied agent interface. In *The Design of Everyday Things* (Norman 1988), he describes human agency as an "action cycle". His aim, partly inspired by the observation of everyday events, is to extrapolate a structure of human action[30]. According to Norman, a person, in order to perform a task, undertakes “seven stages of action”. These span from the constant re-evaluation of the status quo (or of “the world”) to the human's articulation of its interests (or its “goals and intentions”). The action plan is thus divided into “stages of execution” and “stages of evaluation”, with “goals” playing an important role. They actually form the first stage.

29 See Donald Norman's website: *http://www.jnd.org/*, checked on 10/06/2013.
30 Norman 1988, p.45f

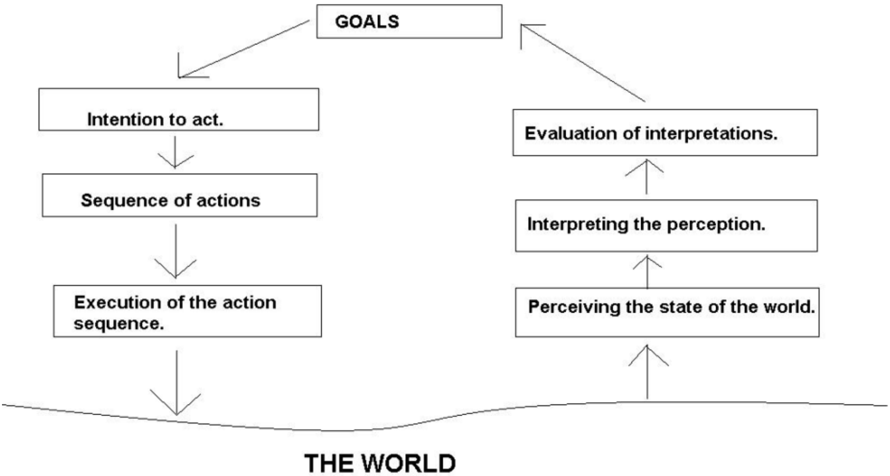

Fig. 4 Seven Stages of Action
(Source: Norman, 1988, p.45)

The terms "execution" and "evaluation" are important, for this is where interruptions or irritations in the flow may occur: execution refers to the realization, in action, of a person's intentions; evaluation refers to how well a person perceives and adjusts to "the world". Norman transfers this concept to the use of technical systems. He formulates a theory that specifies the gaps, or "gulfs", that exist between user and system. These must be bridged in order to reach a functioning state of interaction. It is in the article, *Direct Manipulation Interfaces*, which Norman co-authored with cognitive scientists Edwin L. Hutchins and James D. Hollan, that this concept is extrapolated (Norman 1986)[31]. The notion of "gulfs" is used to address the discrepancy between system and user, as well as the need for interface design to take this discrepancy into account. The "Gulf of Execution" and the "Gulf of Evaluation" are presented in the figure below.

31 Since the article was published two years earlier, it is likely that the concept of human agency co-developed with the more technical usage, which is probably why it was so successfully received within the computer science community.

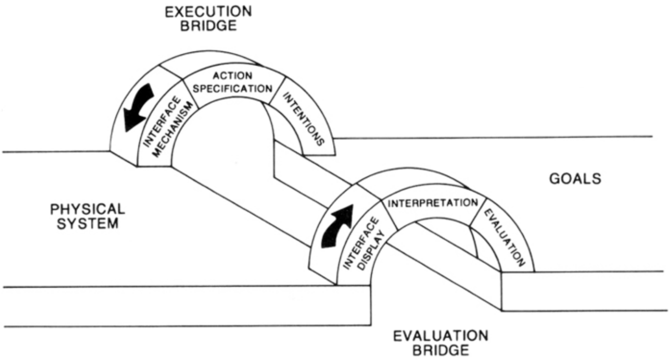

FIGURE 3.2. Bridging the Gulfs of Execution and Evaluation. The Gulf of *Execution* is bridged from the psychology side by the user's formation of intentions relevant to the system and the determination of an action sequence. It is bridged from the system side when the designer of the system builds the input characteristics of the interface. The Gulf of *Evaluation* is bridged from the psychology side by the user's perception of the system state and the interpretation placed on that perception, which is then evaluated by comparing it with the original goals and intentions. It is bridged from the system side when the designer builds the output characteristics of the interface.

Fig. 5 Gulfs of Interaction
(Source: Norman, 1986, p. 40)

The basic concept is that the user has certain goals that she or he wants to achieve by using the system, while the system needs to process this information and provide relevant output. The "Gulf of Execution" emerges in between the user's goals or intentions and the interaction possibilities that the system provides. The "Gulf of Evaluation" describes the challenge of assessing the state of the system. The better the interface manages to transmit this state to the user, the easier the interaction becomes. This transmission, however, must match the expectations of the user. Furthermore, the interface must represent an action or set of actions that will lead users to their desired goal and meet their intentions.

The design of the interface should acknowledge that the Gulf of Execution, as well as the Gulf of Evaluation, need to be overcome. This overcoming is pursued by a matching process: "The Gulf of Execution is bridged by making the commands and mechanisms of the system match the thoughts and goals of the user as much as possible" (Hutchins et al. 1986, p. 95). In this model, bridging the Gulf of Execution means that the user must form intentions, specify action sequences, execute actions, and select the right interface mechanisms. The Gulf of Evaluation then describes the challenge of assessing the state of the system according to how well the interface supports the discovery and interpretation of the system state. When the gulfs are successfully overcome, this leads "to the qualitative feeling that we are directly engaged with control of the objects – not with the programs, not with the computer, but with the semantic objects of our goals and intentions" (ibid.). In this view, the most successful interface is one that does not get noticed. Ideally, the system mirrors the user's intentions – the closer the interaction comes to realizing this goal, the more functional it is said to be.

As the Figure 5 shows, Norman's model makes a cut between user and system, but it also establishes connections between them. The original meaning of the term interface – taken from chemistry and describing a contact and a boundary surface – recedes, while the gap between user and system is highlighted. Nevertheless, the situation is ambivalent: on one side, there is the establishment of the gap between human and machine; on the other, it is possible to overcome this gap by adequate design. Looked at more closely, the concept also demonstrates that the user and the system are interwoven in an environment that is defined by a shared sequence of interaction possibilities. Here, some kind of convergence or leveling, regarding how action or agency is defined, needs to take place. Or, put differently, a concept is needed that describes human action in very close relation to the interaction possibilities that are realizable with a computer. Norman coins the term "cognitive engineering" for the emergence of what, according to him, should result from a transdisciplinary dialog between cognitive psychology and applied computer science. He writes:

> "Why cognitive engineering? Why a new term? After all there exist several terms used to describe the applied side of psychology: ergonomics, human factors, and engineering psychology. I believe a new term is needed because a new approach is needed. More than just psychology is required. More than psychology coupled with engineering." (Norman 1987, p. 326)

Norman stresses the challenge of a productive exchange between two diverse fields of knowledge. His concept has had a great impact on the field of human-computer interaction. Furthermore, this way of conceptualizing and modeling agency is prominent in artificial intelligence research and consequently recurs within architectures of embodied interface agents[32]. From a critical perspective, the success of cognitive engineering points to the fact that this approach to human cognition shares a basic logic with the cycle of information-processing, which is marked by input, process, output, and storage activities, as depicted in the following figure.

32 See Chapter 3.1.2.

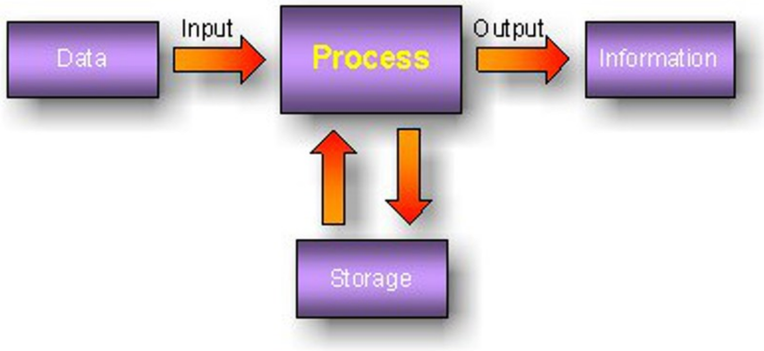

Fig. 6 Information Processing Cycle
(Source: *http://ilearnict.blogspot.de/2010/07/information-procesing-cycle.html*, checked on 6/7/2014)

Cognitive engineering defines human capacity as the ability to act by using a model of plans, intentions, and goal-orientation. The concept draws, *inter alia*, on the GOMS model, which stands for Goals, Operators, Methods, and Selection (Norman 1987, p. 328; Card et al. 1983). The GOMS model provides a theoretical framework for representing the computer user's state of mind and possible forms of action. Various specifications exist that are used for developing and evaluating (John 2003). Simply put, the user's goals have to be identified, and sub-goals, as smaller units, need to be established. Together with operators, which are the actions the system interface performs, these form the methods. If there is effectively more than one method that the human can choose in order to reach the goal, then the selection rules apply. GOMS has proven to be especially successful when the user is already familiar with the system and when he or she has a specific task to fulfill. Norman's concept is based upon the belief that human agency is a primarily cognitive process that starts with "some goal in mind". Following this, "this goal defines the final state to be satisfied. Before it can lead to actions it must be transformed into more specific intentions, into specific action sequences that bridge the gap between what one would like to do (one's intentions) and the specific capabilities of the system (the allowable physical actions)" (Norman 1987, p. 328). This theory of human agency is entangled with the logic of the cybernetic feedback loop, as another illustration of the seven stages of action shows:

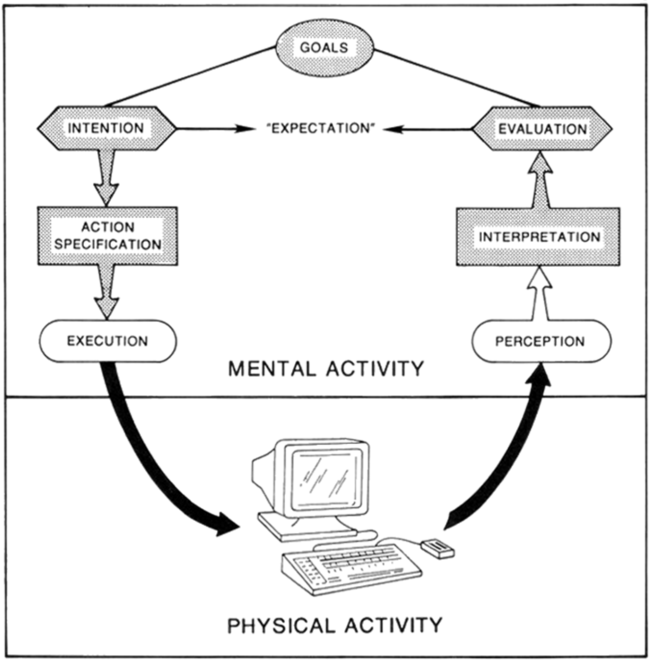

FIGURE 3.3. Seven stages of user activities involved in the performance of a task. The primary, central stage is the establishment of the goal. Then, to carry out an action requires three stages: forming the intention, specifying the action sequence, and executing the action. To assess the effect of the action also requires three stages, each in some sense complementary to the three stages of carrying out the action: perceiving the system state, interpreting the state, and evaluating the interpreted state with respect to the original goals and intentions.

Fig. 7 Seven Stages of Action II
(Source: Hutchins et al., 1986, p. 96)

Additionally, Norman writes elsewhere:

> "This speaks of goals, intentions, and the internal specification of actions. The actual production of an action is only half the story, however. The other half involves the feedback loop: the perception, interpretation, and evaluation of the results of the action. This led me to postulate seven stages of action:
>
> - forming the goal;
> - forming the intention;
> - specifying an action;

- executing the action;
- perceiving the system state;
- interpreting the system state;
- evaluating the outcome." (Norman 1987, p. 329)

Cognitive engineering provides a way of conceiving the entire concept of interaction. To begin with, the human user and technological artifact are separate entities, but Norman's theory of agency has the consequence of making them form a network. Conceptually, human agency and machine agency are brought to the same level. Or, put differently, human agency is reformulated in dialog with the input-processing-output model of the machine. Furthermore, Figure 7 shows a split between mental and physical activity, which invokes the Cartesian divide between mind and body.

This model of human-computer interaction has received both praise and critique – depending on the reviewer's perspective on human agency – for its information-processing approach. In the compendium, *Interfacing Thought*, John B. Black, Dana S. Kay, and Elliot M. Soloway state that "almost all of human behavior can be characterized in terms of goals and plans. In particular, most of what people do is devise plans of action and perform them in order to bring about some desired state of the world – that is, to accomplish a goal. Consequently, much of human knowledge about how to operate in the world is stored in memory in form of plan and goal knowledge representations" (Black et al. 1987, p. 36). This formalized (and rather simplified) way of conceiving human action is regarded by others as unrealistic. In the very same compendium, John Whiteside and Dennis Wixon "suggest, as a possibility, an alternative assumption: Users do not start with goals at all; rather they are always already acting in a situation, thrown to it as it were, unreflectively and unanalytically. What would theories, models, and systems based on such assumptions look like?" (Whiteside, Wixon 1987, p. 360)

The "goals and plans model" of human agency demonstrates the transfer of knowledge from one area to another. It can be described as a process of transformation resulting in new methods and practices, which finally inform the building of artifacts. Most prominently, it is Lucy Suchman who questions the goal and planning model. She criticizes the traditional view of human-computer interaction, in which the computer and the human are two separate entities that need to come together. According to Suchman, this separation – far from being a given fact – is an effect produced within the field of technology design. Suchman follows actor-network theory – which manifests itself in the statement that "we have never been modern" (Latour 2002) – in the sense that she regards all dichotomies that structure and stabilize Western culture as effects of material-semiotic practices. Dichotomies do not pre-exist as such. Suchman finds that this "clearly implies a very different understanding of the 'human-machine interface'. 'The interface' on the one hand becomes the name for a category of contingently enacted 'cuts' occurring always within sociomaterial practices, that effect 'persons' and 'machines' as distinct entities, and that in turn enable particular forms of subject/object intra-actions. At the same time, the singularity of 'the interface' explodes into a multiplicity of more and less closely aligned, dynamically configured moments of encounter between other sociomaterial configurations, objectified as persons and machines" (Suchman 2005).

This is to say that the theory of human agency depicted within the planning model follows a tradition of Western logic that favors abstract, analytical, and – most importantly – disembodied thinking (Suchman 1987, p. viii). In *Plans and Situated Actions. The Problem of Human-Machine Communication*, Suchman analyzes artificial intelligence models of agency and contrasts them with a notion of "situated action". She argues "that all activity, even the most analytic, is fundamentally concrete and embodied", and that actions are therefore always "situated actions [...], actions taken in the context of particular, concrete circumstances" (ibid.). In the preface to her book, Suchman refers to an ethnographic description of different modes of sea navigation, one whereby the Trukese navigator is contrasted with the European navigator. The European navigator follows – at least in concept – a strict planning model. The Truk's mode of navigation, on the other hand, is described as a goal-oriented action – one that is situated and that adapts to the environment using all the relevant information found along the way. Suchman's intention is not to romanticize the Trukese way of navigation, but rather to challenge the universal validity of the European approach. And it is, in fact, "the view of action exemplified by the European navigator [that] is now being reified in the design of intelligent machines" (Suchman 1987, p. ix).

In the cognitive engineering approach, for example, the human is not specified as – nor does it even appear as – a diversified concept. Norman's model addresses the fact that the interface presents to the user certain possibilities for interaction while neglecting others. This model is rooted in Western culture and presents a perspective that is based upon a modern, positivist world view. Like the GOMS model, it is considered more fitting for the representation of smaller, limited worlds and straightforward scenarios. Acting in a world that is defined by changing, unclear states, where actions often have an unpredictable outcome, is not covered by this concept. It does not picture users with non-intentional behavior or cases where people make unorthodox use of the technical system. The ability to act flexibly and the fact that action is situated in a specific local and cultural setting do not enter the focus of this particular approach. Furthermore, the logic of cognitive engineering does not consider emotions and embodiment as crucial for the cognitive process. Feminist critics of science have been particularly active in reporting, from early on, the absence of these topics from the field of artificial intelligence research (Adam 1998; Balsamo 1996).

Over the years, these issues have not only been on the agenda of (feminist) techno science critics, they have also entered the field of human-artifact interaction and computing in general. Newer concepts like "embodied cognition" mark a turn toward embodiment in parts of artificial intelligence. The manner in which concepts like emotion and embodiment are realized against the background of computer science is of major interest for the analysis of the Virtual Human interface[33].

1.3. The Embodied Agent Interface

1.3.1. Interface Metaphors

A concept of the interface based on gaps, along with the plan-oriented model of human agency, is linked not only to Donald Norman and his colleagues. It is also pervasive throughout the history of human-computer interaction[34]. Over the years, the bridging of the gap between human and computer has taken on different forms of representation, depending on differences in technical possibilities and sociocultural context. Regarding human-computer interaction, the main question for Hutchins et al. is which metaphor to follow:

> "There are two major metaphors for the nature of human-computer interaction, a conversation metaphor and a model world metaphor. In a system built on the conversation metaphor, the interface is a language medium in which the user and system have a conversation about an assumed, but not explicitly represented world. In this case, the interface is an implied intermediary between the user and the world about which things are said. In a system built on the model world metaphor, the interface is itself a world where the user can act, and that changes state in response to user actions. The world of interest is explicitly represented and there is no intermediary between user and world. Appropriate use of the model world metaphor can create the sensation in the user of acting upon the objects of the task domain themselves." (Hutchins et al. 1986, p. 94)

Ideally, this effect is achieved by rebuilding – at least to some degree – everyday environments, which occurs, for instance, when the desktop metaphor is used in

33 See Chapter 3.

34 This comes as no surprise, given Western culture's intellectual history of dichotomous structure and the modernist worldview (Fausto-Sterling 2002).

order to mirror a person’s workplace environment. Accordingly, the computer users find themselves acting within a mirror-world. This world is very limited as a matter of course, but it refers to day-to-day experiences of how to deal with certain tasks through physical action, rather than through linguistic input alone. In the command-line interface, the user has to learn the computer's language, employing a specific syntax that is opposed to everyday language. Wolfgang Coy stresses that, since its establishment in the 1980s, the GUI has been predicted to be nearing its end, but that this prediction has not yet come true. This is despite the not-so-fitting metaphor of the screen as desktop, which nevertheless gives the user more support than any other realization thus far (Coy 2008, p. 315).

Graphic user interfaces follow the approach of “direct manipulation” (Shneidermann 1982; Hutchins et al. 1986), which, as the term implies, ideally leads to a scenario in which users feel directly in touch with the task they want to accomplish. According to Ben Shneidermann, the distinctively new qualities of direct manipulation are: “(1) Continuous representation of the object of interest. (2) Physical actions or labelled button presses instead of complex syntax. (3) Rapid incremental reversible operations whose impact on the object of interest is immediately visible” (Shneidermann 1982, p. 251).

Thus, when the interaction is successful, the object and its representation coincide in the user's experience. Direct manipulation interconnects human and machine very closely – at least on a phenomenological level. A sense of close interconnection and direct manipulation is established when the user's finger circulates on the touchpad of a laptop computer and the arrow symbol on the screen circulates simultaneously. Or, as I write a text with word processing software, the words appear directly on screen. To reach this effect, a further distancing from the basic working mode of the computer is pursued. The interconnection between the computer's own working and the user's side of the interface ought to be as unnoticeable as possible. While the command-line interface constantly reminds the user that she has to speak the language of the machine, direct manipulation presents an interface that aims at making the fact of the user’s interaction with the machine drift into the background. This experience is qualitatively different from the knobs and dials of early computing machinery (although it does reintroduce interaction with the computer through touch, or at least through “drag and drop”).

Today's experience of computer usage comes very close to the notion of the “invisible computer” (Nadin 1996) in so far as computational principles recede and the computer becomes, in experience, the interface (Schelhowe 1997, p. 148). This trend continues and is extrapolated with tablet computers, touchscreen technology, mobile computing, tangibles, and the “Internet of things“. The command-line’s conversation metaphor addresses the user's abstract language skills and cognitive abilities. The wording used to interact with the computer does not necessarily reflect the user's everyday language. The world metaphor brings objects and symbols to the screen. It creates the interface as a semi-physical space with windows to open and close, with objects in the background and in drawers, and with waste in a paper bin. Following this, the graphical user interface anticipates embodied interaction concepts[35]. In physical space we can move and interact with the whole body. Objects want to be touched, dragged, and dropped. We take a book from a shelf; we do not talk to the book about it. Again, this brings attention to the media artifact itself, such that awareness of interaction with the computer recedes. We could say – though at risk of oversimplification and dependence on suspicious dichotomies – that the conversation metaphor addresses the realm of the mind, whereas the world metaphor addresses the materiality of everyday environments and eventually brings the whole body into the interaction.

In his discourse analysis of interface concepts throughout history, Jörg Pflüger elaborates three basic phases of interaction with the computer: conversation, manipulation, and delegation (Pflüger 2004, p. 368). These three phases consist of Norman's conversation metaphor, the model world metaphor (as in direct manipulation), and as the model of delegation (which Pflüger introduces). This last phase, although inherent to the computer's history of taking over or substituting for human abilities (Nake 1992), gains major importance with the increase of storage and distribution power, as well as with the spread of information and communication technologies.

The shifting of metaphors also means that different senses are addressed. Issues of visibility and of what is represented on the screen vary with different interface scenarios. While direct manipulation privileges the gaze and puts an emphasis on visual relations, the conversation metaphor focuses on dialog, abstraction, and precise language skills. In this sense, direct manipulation works under the "order of the gaze" (Pflüger 2004, p. 386). Heidi Schelhowe stresses that language presumes a distance from the world of objects, whereas direct manipulation seeks to establish closeness – as with the aforementioned merging of object and representation – through immediate physical action (Schelhowe 1997, p. 166).

The effects and the success of graphical user interfaces demonstrate the convincing character of the phenomenon of direct manipulation. Even young children, who are not able to type, can interact with the touch technology of devices like smart phones or tablets. Still, what is problematic with the "world metaphor",

35 Of course, all interaction is embodied. I do not want to impose a false dichotomy between command-line interface as disembodied and graphical user interface as a gateway to embodied interaction. But the concept of non-verbal interaction, or multimodal interaction with a computer, nonetheless introduces a new level of what interaction in computing contains.

from an epistemological perspective, is the fact that objects do not speak for themselves. Their meaning also has to be learned in sociocultural settings, and so the meaning will vary in accordance with the variation of these settings. The emphasis on "ease of use" within the discussion that accompanies the world metaphor thus runs the risk of losing sight of the complexity, the aboutness, and the error rate of the world. Everyday surroundings and communications are, for the most part, pictured as well-functioning, easily understandable, comfortable, and universally accessible.

1.3.2. New Functionality, New Look: The Embodied Agent Interface

From the constructor's point of view, embodied interface agents are designed to serve various purposes. Though they "are just one way of thinking about a different kind of relationship between humans and computers – it is really all about multimodal interfaces"[36], they are presented as the most "natural" way of making computer technology accessible and manageable for non-expert users. Human-human interaction is taken as a model for human-computer interaction. Since humans are experts in communicating daily through use of their whole body, a technological mirroring of their appearance and agency is pursued. Ideally, an embodied interface agent is thought of and designed as a human-like machine alter ego. Furthermore, the agent serves – depending on its area of application – as the human user's delegate, extension/substitute, and/or autonomous counterpart. In 1998, Helmut Prendinger listed various scenarios:

> "Life-like characters are used
> – as (virtual) tutors and trainers in interactive learning environments [...]
> – as presenters and sales persona on the web and at information booths [...]
> – as actors for entertainment [...]
> – as communication partners in therapy [...]
> – as personal representatives in online communities and guidance systems [...] and
> – as information experts enhancing conventional web search engines […]"
> (Prendinger, Ishizuka 1998, p. 10)

36 This remark was made by Thomas Rist, of the German Institute of Artificial Intelligenz (DFKI), Saarbrücken, at the AAMAS conference, *http:www.aamas05.nl*, checked on 20/12/2013, Utrecht, July 2005. Multimodal interfaces may comprise any device in which the interation with a computational system goes beyond that of the keyboard/mouse interaction.

An aspiration for ease of use is only one characteristic of the new interface. The virtual helper, due to its character as an agent, also promises new functionality.

One major reason for the construction and employment of agents is linked to the development of information and communication technology. As Brenda Laurel puts it: “Few of us would hire an agent to push the buttons on our calculator; most of us would hire an agent to scan 5,000 pieces of junk mail” (Laurel 1990a, p. 357). Accordingly, new information and communication structures call for new interface solutions that reach beyond the desktop metaphor. Already in 1998, Terry Winograd stated that with the increasing use of the Internet, the phenomenological and semantic aspects of the computer’s mediation will outstrip the technological aspects of the device (Winograd 1998, p. 152).

Pattie Maes, who works at MIT's Media Laboratory and was an early agent advocate, points out that:

> "The Internet is part of the motivation for agents – it's going to be impossible, if it isn't already, for people to deal with the complexity of the online world. I'm convinced that the only solution is to have agents that help us to manage the complexity of information. I don't think designing better interfaces is going to do it. There will be so many different things going on, so much new information and software becoming available, we will need agents that are our alter egos; they will know what we are interested in, and monitor databases and parts of networks." (quoted in Meek 1995)

The rise of the Internet, as well as the need to model increasingly complex real world scenarios, explains the boost of popularity that agent technology has experienced since the mid-1980s[37]. The scenario of the “embodied interface agent” became popular at a time when computing technology became both more pervasive and more accessible. The agent is presented as the “user's little helper” in times of information overflow and complex data structures. Human time is valuable. Thus, in a new form of time-sharing, routine tasks get delegated to the agent (Pflüger 2004, p. 394). The direct manipulation interface is non-obtrusive. It is conceived as a passive environment waiting for human input. In contrast, agent technology introduces pro-activeness to the interface. Part of the new functionality is that the agent “knows” when to interact with the user – for example, by giving reminders of important dates or notifying the user when a task is completed. With the command-line interface, the formal conversation between human and machine is not represented on the screen – it has a fleeting character (ibid.). Moreover, the anthropomorphic agent presents the possibility of conversing with a computer that has been cast into an actual embodied form. Following the phases of conversation,

37 Agent technology is a relatively young research area, dating back to the 1970s, but basic research started in the 1980s (Reif 2001).

manipulation, and delegation, the embodied agent interface demonstrates a new phase of negotiation. The agent and the human now interact in a hybrid interspace, one that follows the model of human-human interaction and that is marked by conversation and social processes of renegotiation (Magnenat-Thalmann 2004, p. 2).

The idea of a personal agent, however, is not a new one. The history of human-computer interaction is not linear, it is instead characterized by overlapping or parallel developments, by sudden cuts, and by dead-end technological developments. In the 1950s, John McCarthy favored the idea of a "soft robot" – a software equivalent to a robot moving through physical space (Kay 1984). Oliver Selfridge[38], who also worked at the MIT at the time, coined the term “agent” a couple of years later in order to describe a software program that functions like a little worker inside the grand machinery.

Following this, agents provide a fitting idea for an application that is capable of roaming[39] the World Wide Web. The embodied agent comes into play as a form of materializing the concept of the abstract agent – a form that the human user can address more easily. It is an agent with a familiar face. Since they directly address the users, embodied interface agents, like social robots, provide the field of agent technologies with an example that is much easier (than more abstract or hidden applications) to grasp. They visualize, as a new form of interface, a change in the paradigm of computing (Wooldridge 2008). According to agent technology experts, agents provide a new metaphor, as well as new corresponding techniques, that co-evolve with computational systems.

In 1997, Oliver Selfridge wrote that “the concept of an intermediary that would act as an agent doing things you wanted done, still thrives today. Still, I am dreaming of agents that can understand and interpret high level goals and purposes. What is important? What is correct? What should be done? I want an agent to remind me, 'hey boss but yesterday you said...' or 'Professor, you want me to lie to the IRS...' or 'But, honey that's wrong....'” (Selfridge 1997). In Selfridge's vision, the agent uses natural language as input and output, just like the Librarian in the novel *Snow Crash*, where the interface agent is envisioned as fully embodied. In the novel the interface actually consists of a mixed-media world, where the agent is “fully fleshed out” (Laurel 1990a, p. 357):

38 In 1968, Robert Taylor and J.C.R. Licklider suggested the development of an Email-client agent named – in honor of Selfridge – as OLIVER (Pflüger 2004, p. 394).

39 Cp. Alan Turing's considerations on Intelligent Machinery. In 1948, he reflects on a machine that would "imitate any small part of a man [...] In order that the machine should have a chance of finding things out for itself it should be allowed to roam the countryside, and the danger to the ordinary citizen would be serious. [...] Thus although this method is probably the 'sure' way of producing a thinking machine it seems to be altogether too slow and impracticable." (Turing 1948, p. 9)

> "A man walks into the office. The Librarian demon looks like a pleasant, fiftyish, silver-haired, bearded man with bright blue eyes, wearing a V-neck sweater over a work shirt, with a coarsely woven, tweedy-looking wool tie. The tie is loosened, the sleeves pushed up. Even though he's just a piece of software, he has reason to be cheerful; he can move through the nearly infinite stacks of information in the Library with the agility of a spider dancing across a vast web of cross-references." (Stephenson 1992, p. 107)

The narration of the Librarian sums up characteristics that are central to the "embodied agent as interface concept", or to its deployment in a hybrid interaction space: ease of use; autonomous, intelligent sorting and presenting of information; pleasant appearance and trustworthy behavior. The scenario is an augmented reality world, a concept that reaches far beyond the desktop metaphor (Cassell 2000a; Krämer, Bente 2002). After the conversation metaphor, where human and computer are engaged in dialog, and direct manipulation, where the computer serves as a task-oriented tool in a media environment, the agent metaphor serves as a solution that integrates and supersedes both concepts (Pflüger 2008, p. 323). Furthermore, the agent metaphor fits the development of human-computer interaction as it moves beyond the personal computer. Hans Dieter Hellige describes a paradigmatic shift away from the GUI and toward the point of "smart interfaces". Now, it is not only that the interface is equated with the computer, it is also that, ultimately, the whole world may serve as interface. The working modes of the machine, or the computational principles, become more and more inaccessible – often losing any sense of transparency – for the average user. Hellige describes the "total interface":

> "Through the ultimate equipment of computers with software intelligence, the 'total interface' or 'intelligent interface' is said to overcome the current disparity between people and computers, and eventually enable a 'conversation' amongst almost equivalent intelligence levels. Whereas with the 'concept of dialogue' the computer must always wait first for a highly specific input from the user, and return the feedback visually, the actively intelligent interfaces now can continuously capture all speech utterances, gestures, facial expressions, emotions, bodily movements, as well as bodily conditions and environmental conditions, interpret them and react proactively. The user is, therefore, no longer chained to the PC and its monitor, since now the human body itself and 'real world objects' serve as 'the total UI'."[40]

40 "Das 'totale Interface' bzw. das 'intelligente Interface' soll durch die Ausstattung des Computers mit Programm-Intelligenz endgültig die bestehende, ja inzwischen noch verschärfte Disparität zwischen Mensch und Computer aufheben und am Ende eine 'Konversation' auf annähernd gleichem Intelligenzniveau ermöglichen. Während beim 'concept of dialogue' der Computer immer erst auf die äußerst schmalbandigen Eingaben des Users warten muss und die Ergebnisse visuell rückkoppelt, erfassen die aktiven intelligenten Interfaces nun permanent alle sprachlichen Äußerungen, Gestik, Mimik, Emotionen, Körperbewegungen sowie Zustände des Körpers und der

At least on the level of concept, this means that the demarcation line between human and machine dissolves. Their relation becomes intimate. Anything, from the everyday surroundings of the home to the human body, may serve as interface. Whereas "graphical interfaces still separate the real world of the users from the virtual world of computation, PSAs[41] would set out a more natural way to move back and forth across this boundary'"[42]. Embodied agent technology demonstrates an interface solution that seeks to completely transgress the idea of the interface. Thus, as the quote by Hellige suggests, agent technology is treated as an act of liberation. Future scenarios picture, on one hand, secretive, intelligent everyday objects and, on the other, an anthropomorphic interface agent that guides users in a technologically mediated world marked by vast information and storage facilities and by an always available worldwide connectivity.

Prospectively, the embodied interface agent combines the good looks and smooth movements of an avatar with the functionality of agents[43]. The tendency to anthropomorphize inanimate machinery (or animals) is not a new move (Papapetros 2012; Schott 2011). In computer science, however, there have been strict adversaries of stressing this idea (Dijkstra 1989; Weizenbaum 1984). Enhancing the tendency to animate or anthropomorphize by means of design has been considered problematic. Others, though still critical, emphasize that the character of the computer inherently promotes anthropomorphic metaphors (Nake 2000, p. 175; Petri 1983). Brenda Laurel states:

> "All of the computer-based personae that weave through popular culture have one thing in common: they mediate a relationship between the labyrinthine precision of computers and the fuzzy complexity of man. Why is this tendency to personify interfaces so natural as to be virtually universal in our collective vision of the future? (Laurel 1990a, p. 355)

Following this, the fact that computers have agency and implement specific actions and formal behaviors contributes to their anthropomorphization. With the embodied agent interface, and in line with artificial intelligence's research agenda, this trait is actively pursued further.

Umgebung, interpretieren sie und reagieren proaktiv. Der Benutzer ist hierbei nicht mehr an den PC und seinen Bildschirm gekettet, denn nun dienen der menschliche Körper selber und 'real world objects' als 'the total UI'." (Hellige 2008, p. 69)

41 Personal Service Assistants is an alternate term for Virtual Humans or Embodied Conversational Agents.

42 "graphische Interfaces nach wie vor die reale Welt des Nutzers von der virtuellen Welt der Berechnung trennen, würden PSAs einen natürlichen Weg darstellen, ‚to move back and forth across this boundary'" (Pflüger 2008, p. 370)

43 Actually, an interface agent may consist of several sub-agents or sub-systems, depending on the definition and the technology.

1.3.3. The Spark of Life

According to Brenda Laurel, "an interface agent can be defined as a character, enacted by the computer, who acts on behalf of the user in a virtual (computer-based) environment" (Laurel 1990a, p. 356)[44]. There exist a variety of terms relating to this research area of human-computer interaction. Avatar, personal service assistant, embodied conversational agent, Virtual Human – all of these comprise virtual forms of embodiment. Although the concepts and technologies are actually gradient, the strict distinction that is made in the field of research between avatars and agents is noteworthy. Avatars are mostly seen as graphical user representations – as "dead bodies" or mere "puppets" – whereas agents are considered intelligent entities displaying personality, emotion, and social behavior (AAMAS CFP 2002). The precise point at which, and the manner in which, the artifact is considered to be animated is of importance. The avatar needs the power of the user to come to life, whereas the agent is considered lifelike by itself. Or, as Justine Cassell puts it, embodied interface agents are *More than just a pretty face* (Cassell et al. 2001). She gives an account of the transition from manually steered "pretty faces" to autonomous agents:

> "I built the very first embodied conversational agent as NSF visiting faculty at the University of Pennsylvania, in the 'Center for Human Modeling and Simulation'[45]. [...] Previously professional animators manually synthesized conversational behaviors for animated figures based on their intuitions, and they "hard wired" facial expressions and gestures. Although the intuitions of such animation artists are excellent, and hard-wiring is a satisfactory approach to regular animation, their approach cannot be extended to the generation of these behaviors in systems running independently of a human designer. My work introduced the first rule-governed, autonomous generation of verbal and non-verbal conversational behaviors in animated characters. Secondly, previous conversational interfaces or dialogue systems concentrated on the content of the conversation -- the statements and questions that advance the discourse. My work introduced for the first time a conversational agent capable of generating and understanding both those propositional components and synchronized interactional components such as back-channel speech, gestures and facial expressions." [46]

This shift from inanimate objects to animate artifacts becomes clearer by reconsidering the development of agent technologies. Although software agents usually are not "fleshed out" (Laurel 1990a, p. 357) in the manner of the Librarian in Stephenson's novel, they share, as a basic theme, an important shift in conceptualizing the way humans interact with computer technology (Wooldridge 2008;

44 See also Brennan (1991).
45 See: *http://www.cis.upenn.edu/~hms/home.html*, checked on 20/12/2013.
46 See: *http://web.media.mit.edu/~justine/research.html*, checked on 25/07/2013.

Reif 2001). Agents add a spark of life to the digital embodiment that is not realized with the avatar.

Interestingly, the fictional characterization of a daemon in *Snow Crash* (Stephenson 1992) matches the description of software agent technology. A software agent is considered to function as an autonomous, pro-active system. Decision-making is based on internal states, context-awareness, situated action – the exhibition of goal-directed behavior – and the ability to interact and cooperate with others. Consequently, all of these are considered to be important traits (Wooldridge 1997). Embodied agents, when serving as an interface solution, address users directly and are designed to be human-like in behavior and appearance (Cassell 2000a). The tendency to anthropomorphize the artifact, however, is inherent even to the most abstract or "hidden" agent applications.

To begin with, agents provide a new concept as well as new corresponding techniques for the development of computational systems, where "agents provide designers and developers with a way of structuring an application around autonomous, communicative components, and lead to the construction of software tools and infrastructure to support the design metaphor" (Luck et al. 2005b, p. 7). Agent technologies are considered suitable for the development of complex, open, and dynamic systems. They seem fitting for the modeling of "real world problems" and are thus said to result in applications that are capable of dealing with changes in the "state of the world" around them; whatever is characterized as "world" here is thereby integrated to be perceivable:

> "As we all know, but seem not to have fully understood (at least in the way physicists have), the world is complex and dynamic, a place where chaos is the norm, not the exception. We also know that computational systems have practical limitations, which limit the information they can access and the computations they can perform. Conventional software systems are designed for static worlds with perfect knowledge – we are instead interested in environments that are dynamic and uncertain (or chaotic), and where the computational system only has a local view of the world (i.e., has limited access to information) and is resource bounded (i.e., has finite computational resources). These constraints have certain fundamental implications for the design of the underlying computational architecture." (Bratman 1987)

From this perspective, the agent metaphor appears like a technology that is derived from co-evolution with today's globalized, multi-structured, complex world. It provides a technological metaphor that matches an epistemological stance that differs from the stance of modernist approaches. The use of agents presents itself as being closer to postmodernism or poststructuralism[47]: partialized perspective, localized and situated knowledge, regard for changing viewpoints, decentralization,

47 See the works of Michel Foucault, Jean-François Lyotard, Hélène Cixous, and Judith Butler.

and communication are all on the agenda. The embodied interface agent and the abstract system component have a different – yet ultimately similar – obligation: they assist the human in a place where the overload of available information and the complexity of data structures leads to an experience of chaos and excessive demands. The Librarian helps to sort through and manage information, while the agent allows the programmer to build and maintain an adequate computational system. In both cases, the human is able to delegate tasks and the artifact acts on behalf of the user or programmer. What is certain is that computer technology always functions as a kind of "Stellvertretertechnologie" (*substitute or delegate technology*) for specific human abilities[48].

However, with the agent metaphor, the power of computer artifacts to interact is emphasized and gains a new quality. The idea is that programmers using agent technology do not build a functioning, but still somewhat passive, object; what they instead initiate is an entity that is responsive in the most comprehensive way. Borrowing its epistemological stance from artificial intelligence research, agent technology thus attributes liveliness to the computer.

This paradigmatic shift becomes even clearer when contrasted with the method of object-orientation. The latter also works with a concept of software entities that obtain a certain internal state and are able – to some degree – to act upon this state (and even to interact through the passing of messages)[49]. Objects, however, do not occur as a technological analogy to the human. In *Intelligent Agents*, Michael Wooldridge summarizes that agents, in contrast to objects, have a higher level of autonomy, for they "decide for themselves whether or not to perform an action on request from another agent". In order to illustrate this, Wooldridge interestingly quotes the slogan, "objects do it for free; agents do it for money", which enhances the perception of agents as smart little workers or helpers (Wooldridge 1999, p. 35f). Probably unintentionally, this introduction of the agent into the monetary order simultaneously introduces a sexual innuendo (Braun 2012).

Furthermore, agents are said to be "capable of flexible (reactive, pro-active, social) behavior, whereas the standard object model has nothing to say about such types of behavior" (Wooldridge 1999, p. 35f). Apparently, significant boundaries are drawn here: animate agents / inanimate objects; proactive agents / passive objects. The agents obtain a subject status, whereas objects stay true to their name.

Since more and more areas of the "complex and dynamic real world" find themselves pervaded by computing technology, it comes as no surprise that approaches mirroring this unpredictable state of the complexity of the real world are favored, and that matching metaphors and subsequent technologies are developed.

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48 Frieder Nake describes the history of information technology as the "mechanisation of mental labour" ("Maschinisierung von Kopfarbeit"), see Nake (1992).

49 For a feminist analysis of object-orientation, see Crutzen (2003).

Along these lines, we can say that agents are software programs that work, according to their internal structure, independently from further human input. They gather and process information, and they may “travel” across platforms or stay as local agents on their system's platform. Agents execute tasks autonomously as well as in collaboration with other agents (Luck et al. 2005a). This collaborative execution of tasks, which entails the design of multi-agent systems (MAS), is one of many challenges. When it comes to coordinating diverse agents and their interaction, the notion of the agent’s *social ability* is established. The picture thus painted is no longer one of precise computing machinery, which operates like clockwork, it instead becomes one of a social society with intelligent behavioral units. This society is characterized by reasonable decisions that are made according to the internal structure of the agent in coordination with the agent's sense of its environment and the behavior of other agents. In multi-agent systems, the “components act more and more like 'individuals' that deserve attributes like autonomous, rational, intelligent, and so forth rather than just as 'parts'” (Weiss 1999, p. 7). Once again, what is noteworthy is the transition from machine-like parts to personification and individuality.

Certainly, transfers between the meanings of the social and the technical are not a one-way process. According to Jörg Pflüger, the concept of social interaction becomes autonomous and pervasive regardless of whether it is characterized as human-human, human-artifact, or artifact-artifact:

> "To date, we have only encountered agents in interdependence with their users, that is, as interface-agents. Here, the archetypes of an interactive negotiation between expectations and outcomes, delegation and cooperation are accommodated. The agent paradigm, though, generalises the concept of interactivity and detracts it from the coupling of human and machine. The concept of the interaction, developed in the ‘interspace’, is incorporated into the world of the program and distilled by modules into fundamental operation procedures. Agents ought to communicate with their own kind in similar ways as they do with their users: they ought to interact with one another, debate and cooperate."[50]

A complete leveling of human and non-human actors is a significant epistemological move. When it comes to realizing multiagent systems, however, sociality means applying strict norms and rules that constrain the behavior of the agent

50 "Bislang sind uns Agenten nur in Interdependenz mit ihren Usern begegnet, also als Interface-Agenten. Hier hausen die Urbilder einer interaktiven Aushandlung von Erwartungen und Leistungen, von Delegation und Kooperation. Das Agentenparadigma verallgemeinert jedoch die Idee der Interaktivität und entzieht sie der Kopplung von Mensch und Maschine. Das im 'Interspace' gewonnene Konzept der Interaktion wird in die Programmwelt eingemeindet und zur fundamentalen Operationsweise von Modulen erklärt. Agenten sollen mit ihresgleichen in ähnlicher Weise verkehren wie mit ihren Usern: sie sollen miteinander interagieren, verhandeln und kooperieren." (Pflüger 2004, p. 397)

(Boella et al. 2005; van der Hoek, Wiebe et al. 2005). Still, on the level of concept, human and machine agency basically become the same. We could say that, with the transference Pflüger describes, a vitalistic spark derived from the human gets added to the machine. Consequently, the artifact appears animated in a way that was not formerly realized. The anthropomorphizing effect shows itself, *inter alia*, in the language used. The shift from object to subject status is much more prevalent when it comes to the case of the embodied interface agent. This move may be considered as forming a new intimacy between human and machine. And, with this, Licklider's aforementioned vision of a “man-computer symbiosis” comes to mind.

Throughout the history of human-computer interaction, this symbiosis is of ongoing significance, although it progresses in a way not anticipated by Licklider. He and his colleagues suggested a further development of the conversation metaphor and proposed natural language interfaces as a solution. The conversation metaphor puts humans in dialog with the machine – and it is the term dialog that is misleading. Any “conversation” with a computer has a formal character. Susanne Maaß characterizes the computer as a "virtual communication partner with formal communication behavior"[51]. She stresses, furthermore, the virtual nature of the realization of the human-computer interface:

> "From the moment on, in which the user initiates a dialog with the computer system, a special image of the machine is offered to him on the basis of his user identification, and a special virtual machine is made available to him. This machine is virtual insofar as the user has no connection to the actual internal machine processes, but only perceives the abstract functions that the system realizes for him."[52]

In the conversation metaphor, the representation on the screen is rather lean and minimalist. With direct manipulation, the intermediary process between human and machine becomes substantial for the design of the interface. In contrast to the command-line interface, the users do not need to memorize the interaction possibilities. A new layer evolves from the space created between human and machine and presents interaction possibilities right on the screen. A quite paradoxical situation thus occurs: on one hand, the interface as an intermediary between user and artifact is significant in its materiality when it comes to design and construction;

51 "virtuellen Kommunikationspartner mit formalem Kommunikationsverhalten" (Maaß 1984, p. 8)

52 "Von dem Moment an, in dem der Benutzer einen Dialog mit dem Computersystem beginnt, wird ihm aufgrund seiner Benutzeridentifikation ein spezielles Bild der Maschine geboten und eine spezielle virtuelle Maschine zugänglich gemacht. Virtuell ist diese Maschine insofern, als der Benutzer losgelöst von den tatsächlichen internen Maschinenabläufen nur die abstrakteren Funktionen wahrnimmt, die das System für ihn realisiert." (Maaß 1984, p. 31)

on the other, the best interface is considered to be the one that is not felt as such by the user. As Yuang Zong and colleagues write:

> "In a sense, an interface is a necessary evil. The ideal user interface would let us perform our tasks without being aware of the interface as the intermediary. The longevity and ubiquity of the now two decades old graphical user interface should not mislead us into thinking that it is an ideal interface. Among many possible Post-GUI interfaces, multimodal interface is supposed to be the most potential one. Multimodal interface uses the character agent as the middle layer between between user and computer, interacting with user and controlling the device." (Zong et al. 2000)

This can be read, following Christina von Braun, as symptomatic for the historico-cultural development of Western society's relationship with technology, whereby “culture as a state of nature” is established. In this sense, the most successful technologies are those technologies that become naturalized in experience. Von Braun states "that simulation technologies aim consistently at making the technology itself invisible. As nature is revealed to the eyes of science, technology shows evidence of exactly the opposite: it veils itself from the eyes of the users, in order to become perceived as a natural state"[53].

Against this background, the embodied agent presents a special, almost inherently logical, interface solution. It is, or it aims to be, human in form and expression: an interface solution inspired by human nature in order to shield the user from having to deal with the technological character of the computing machine. And, with regard to the conversation metaphor and the model world metaphor, the embodied agent can be viewed as a scenario that realizes both of them. Ideally, the human can talk to it without having to learn specific commands, and it acts on the human’s behalf in a computer-generated or augmented environment. Just like the fictitious Librarian in Stephenson's novel, the embodied agent can take the books off their virtual shelves for the user and, more generally, help with information retrieval and organization (Berners-Lee et al. 2001). The incommensurability of the conversation metaphor and the model world metaphor, however, has been questioned at an earlier point in the development of human-computer interaction. Already in 1990, psychologist Susan E. Brennan found that the opposition between the two metaphors is a false one. For her, human-human communication, just as it is the credo of embodied interface agent research, is the model after which

53 "dass Simulationsstechnologien immer wieder darauf abzielen, die Technik selbst unsichtbar zu machen. Entschleiert sich die Natur vor den Augen der Wissenschaft, so läßt sich für die Technologie genau das Gegenteil diagnostizieren: Sie verschleiert sich vor den Augen des Benutzers, um als Naturzustand wahrgenommen zu werden" (Braun 2001, p. 103)

human-computer communication should be designed. Thus, a combination of metaphors and corresponding technologies is required:

> "[R]eal conversations actually fulfill many of the criteria for direct manipulation. For example, two people talking to each other continuously represent the things of mutual interest within their separate mental models. They can refer to anything that's within their common ground, and they can do this with less effort than it takes to point to a screen with a mouse. As they talk, they introduce new material to each other, relate it to old, coordinate their attention, and negotiate their understanding, step by step. When they understand each other, they end up behaving as if they shared a single mental model – a virtual workspace containing entities available for inspection and manipulation by both." (Brennan 1990, p. 393)

Still, for human-computer interaction, it makes a difference not just which models the users have in mind, but also what is represented and supported by the interface. It is remarkable that, within the field of human-computer interaction, the human and the humane have gained increasing importance. Furthermore, it is important to take note of what counts as human and what does not. For the most part, human is used as synonymous with nature and natural (as in easy or effortless) communication. Human/nature is set in contrast to the abstract, formal, precise, and disembodied world of the computer. Agents provide a metaphor that challenges this border. The embodied interface agent emerges as a means to *heal* the split in human-computer interaction by providing a gestalt that dresses up technology as nature.

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