# Faceless Interaction—A Conceptual Examination of the Notion of Interface: Past, Present, and Future

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In the middle of the present struggle to keep interaction complexity in check, as artifact complexity continues to rise and the technical possibilities to interact multiply, the notion of *interface* is scrutinized. First, a limited number of previous interpretations or *thought styles* of the notion are identified and discussed. This serves as a framework for an analysis of the current situation with regard to complexity, control, and interaction, leading to a realization of the crucial role of *surface* in contemporary understanding of interaction. The potential of *faceless interaction*, interaction that transcends traditional reliance on surfaces, is then examined and discussed, liberating possibilities as well as complicating effects, and dangers are pointed out, ending with a sketch of a possibly emerging new thought style.

## 1. INTRODUCTION

Human–computer interaction (HCI) used to be about interfaces and their design. Rarely, however, has the field devoted any serious time and energy to a reflective examination of what an interface is or how it could or should be defined. At this time, new technology is radically changing the preconditions for what an interface is and can be. The development of interactive materials, sensors, haptics, touch, or gesture-based interaction: all contribute to a powerful expansion of the interface design space. At the same time, the development toward ever more complex artifacts continues relentlessly. Designers of interfaces are challenged with new possibilities and new

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problems that have led researchers to develop new approaches and proposals (Abowd & Mynatt, 2000; Bakker et al., 2014; Bellotti et al., 2002; Brewster, Murray-Smith, Crossan, Vasquez-Alvarez, & Rico, 2009; Dey, Abowd, & Salber, 2001; Hornecker & Buur, 2006; Ishii & Ullmer, 1997; Steimle et al., 2013).

We believe that our field needs to have a better understanding of one of its core concepts, *interface*, because interaction and interactivity would seem to require an interface. Interaction designers design interfaces. Interactive artifacts and systems have interfaces. We also assume that a better understanding of existing and possible notions of what an interface is enriches the field and might be inspiring to designers in their quest to shape new interfaces.

We argue that an investigation and examination of the notion of interface has never been more needed than now. This article is an attempt in that direction.

The way we do this is by identifying and analyzing what we see as existing *thought styles* in understanding and conceptualizing interfaces. We use these thought styles as a framework for discussing what the present challenges are to the existing understanding of interfaces and particularly what happens when technology changes the preconditions for our understanding. We also examine the notion of *the interface as surface* and the possibilities of (inter)*faceless interaction*. We end with a discussion and reflections on what implications this reformulation and redefinition of interface could have.

## 2. INTERFACE THOUGHT STYLES

Even though there does not exist any serious and generally accepted definition of the notion of interface, there are many different understandings of the concept. These understandings can be seen as building on different traditions, ways of thinking or philosophies.

Instead of going through a large number of individual definitions we examine the notion of interface using the concept of *thought style* (Denkstil) as introduced by Ludwik Fleck (1935/1979). A thought style is that which "determines the formulation of every concept." A thought style is not dependent on one clear definition of a phenomenon; instead it is a consequence of a way of thinking that is socially influenced. Fleck wrote that "the thought style of the collective undergoes social reinforcement" and by having an influence on the collective "it constrains the individual by determining what can be thought in no other way" (Fleck, 1935/1979, p. 99). In some cases, Fleck added, "whole areas will then be ruled by this thought constraint." Working within a certain thought style does not mean a lack of analytic or critical ability—within that thought style. Awareness of different thought styles will have a certain liberating effect, but from the point of view of one particular thought style the claims and goals of other thought styles tend to be reinterpreted and take on a meaning different from the "indigenous."

The notion of interface has developed over a period of several decades and has been influenced by evolving technology and application areas. We have chosen to categorize some earlier and existing ways of thinking about the "interface" as belonging to four different thought styles. These thought styles are not distinctly related to a particular period, particular technology, or type of designs, but they have evolved over time and can be seen as stemming from different traditions. Fleck (1935/1979) wrote, "Every thought style contains vestiges of the historical, evolutionary development of various elements from another style" (p. 100).[1] Today, we can see that all four thought styles continue to be present and influential in our field, sometimes competing, sometimes cooperating with each other. The different thought styles devote interest and focus on different aspects of the interface. We have primarily focused on the question of *what* the interface is thought to be and what *role* it is conceived as playing. Later on, we also have reason to examine *where* it is.

The four thought styles are: the interface thought of as

1. a *surface of contact* between matching objects (from the tradition of industrial machine making),
2. a *boundary* of an independent (self-sustained) object (from biology and traditional artifact design),

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1. Strongly influenced by Fleck, Thomas Kuhn (1970) wrote his book *The Structure of Scientific Revolutions*. Kuhn's famous concepts of "paradigm" and "scientific community" are modeled on Fleck's concepts of Denkstil and Denkkollektiv. Fleck's original concepts, however, are more precise with more clear delimitations, less open to a broad variety of interpretations; at the same time they cover aspects beyond Kuhn's approach (such as Stimmung).

3. a *means for controlling* (operating, checking, steering) an object (from design of complex machines), and

4. a *means for expressions and impressions*, a target of interpretations and affectations (from human communication, architecture, and art).

A fifth thought style might be added, in which the interface is seen as a *channel of communication*, that is, an opening or conduit through which "stuff" passes. This way of thinking about the interface is quite common, especially in HCI. Stuff passes *through* the interface from one side to the other side, often in both directions, and usually selectively (some will pass, some will not be able to get through). Instead of taking this to be a thought style in its own right, however, we have chosen to view it as a common theme with an affinity for each of Thought Styles 2, 3, and 4—the "stuff" being *matter/energy, signals/information*, and *meanings*, respectively. In fact, also Thought Style 1 fits the communication-channel theme once this line of thought is transplanted to the area of software engineering, then with *data* as the "stuff" (more about that next).

In the following sections we go through the four thought styles in more detail, examining them primarily in relation to their historical roots, their context, their applications, and some of their implications.

## 2.1. A Surface of Contact Between Matching Objects

Napoleon's mass armies used muskets with exchangeable parts to facilitate maintenance in the field. This was made possible by introducing precise specifications of the shape of each part where it came into contact with other parts, so that the parts would fit regardless of when, where, and by whom they had been made, as long as they had been made according to the specifications. The traditional gunsmith, in contrast, would rather work by adjusting the parts of an individual, complete gun to each other, filing away a bit here, a bit there, until the whole ensemble of parts fit together perfectly. The parts would then typically have shapes unique for that particular gun— although similar to that of other guns of the same model, not sufficiently alike to be generally interchangeable.

Letting interface specifications govern production has several advantages. First, it facilitates division of work into different specialized tasks and distribution of manufacturing over different, possibly competing manufacturers in different locations, all of which should make for more efficient production. Second, it facilitates maintenance. Third, it makes it possible to provide exchangeable parts that offer variations or extensions in function, like screwdrivers with exchangeable tips in different sizes and for different types of screw heads. Finally, it opens up the possibility to make "parts" that do not belong to any preconceived whole but can be more or less freely combined into a wide, perhaps even open-ended range of objects or systems, like LEGO pieces or full-scale building modules.

This interface concept from industrial machine making has served successfully as a model also for software making. The "shape" of a software part is understood as informational instead of physical: the configuration of input and output parameters,

the data types and protocols used, and so on. In this context the interface concept has been sharpened and elaborated further to suit the needs of the software industry.

It comes as no surprise then that when *user interfaces* first began to draw attention as targets for design, the researchers and developers involved, being schooled in the successful methods and thought style of interface-specification-governed software production, would take software interfaces as their starting point. User interfaces should be made to fit the "shape" of the users, similar to how a piece of software should be made to fit the shape of *its* "users." Determining that "shape" in general (and for special categories of users, and for individual users) became a primary concern. The extension of the field of ergonomics (also known as "human factors," indicating that humans were seen as somewhat problematic components or environment parameters in engineering a system) into cognitive ergonomics continued this line of thought.

This approach is not without merit but tends to disregard that human interfaces differ from hardware and software interfaces in at least two important respects. First, in their attitude and behavior (in contrast to their bodily shape and capacity), humans cannot be said to have a determinate "shape"; rather, they are quite changeable and may adapt to a wide range of circumstances as well as act capriciously or develop new behaviors all of a sudden. Second, humans tend to "see through" interfaces into an underlying meaningful state of affairs and development; they form sense-making models of what they perceive and experience, and those rather than superficial phenomena of the interface, such as the traffic of pixels and key presses, are what drive and guide their interaction.

The role of the surface-of-contact thought style when it comes to modern interaction design can be understood in different ways. For instance, when interaction design faced larger crowds of users and customers, the crafting of each interface in relation to a unique user no longer make sense. The problem facing many interaction designers is very similar to those of the gun makers in Napoleon's army. With many users, diverse contexts of use and with distinct roles and purposes for a design, the idea of creating surfaces that simplify the connection of parts and elements, humans or machines, seems inevitable even though it leads to standardization of material as well as human "elements." It is important to recognize the advantage of having standards. Perfectly personalized, individually tailored interfaces on artifacts have some drawbacks also from the user's point of view. For instance, it might mean that you can't borrow your neighbor's equipment, because it has an entirely different interface. Fixed standards can promote interoperability and save human learning effort.

Seeing an interface as a surface of contact is a thought style that is ubiquitous and taken for granted today. We believe that this thought style has become so commonsensical that it is difficult to make visible and to investigate. It is a way of thinking that has spread outside the traditional professional communities where it was used to almost every area of human activity. The term "interface" has become commonplace in everyday language.

## 2.2. The Boundary of an Independent Object

The interface concept of industrial machine making has served as an important facilitator of production. The interface is then seen as primarily a specification of the relation between two or more parts. From the point of view of actually manufacturing one of those parts, it becomes natural to focus on the part you are making (and perhaps more so when production has been distributed), implying that the interface comes to be seen as a property of the part rather than a relation to other parts, and specifically as its boundary, enveloping the part.

In this style of thought, which no doubt existed well before and independent of industrial machine making, the interface is the *boundary of the object*, wrapping it up, typically with basic responsibilities such as keeping the object together, protecting what is inside from disturbing external influences, protecting the surroundings from potentially disturbing influences from the inside, and mediating functionally important interactions of the object with the surrounding world.

Herbert Simon (1969/1996) considered an artifact generally to be identifiable with its interface to the surroundings, striving to keep certain parameters invariant that are crucial for its proper functioning in the flux of changes in the external world. One of his examples is a clock on board a ship buffeted by wind and waves. Also naturally evolved systems illustrate this concept, for example, a biological cell. The cell membrane keeps the contents together, selects and filters what is allowed in and what rest products are transported to the outside, helping to maintain the cell's metabolism, and maybe also working actively to obtain favorable conditions on the outside (e.g., moving flagella to propel it across rising nutrient gradients).

Other examples that match the view of the interface as a boundary and container are frequent in our everyday lives. We commonly view our homes and cars as containers facing the surrounding environment. The interface, however, is not precisely defined in functional terms—more as a casing or cover that supports and protects what is within. The interface of a building defines what is inside and what is outside, what belongs and what does not. It should keep out rain and wind while preserving a comfortable temperature within, for example. Often there will be arrangements like locks and security systems designed to keep burglars and other potential intruders from getting inside or to control the passage of people or other entities from the inside to the outside (prisoners, livestock, goods in a store, etc.).

Over the years there has been an increasing concern with the external surface of industrially produced artifacts. For instance, machines are today normally covered with chassis or shells. The interface has changed from machinery where all the irregularly shaped parts and their mechanics were visible, to machines provided with an opaque, unifying, and simplifying casing that fully covers the internal mechanism. Some modern cars, for instance, are designed to have a boundary that protects the car from anyone except authorized specialists who may remove the cover.

Simon's view of the interface might also be interpreted in a manner closer to Thought Style 1, the interface as a surface of contact between close-fitting parts. Indeed, he explicitly wrote about the "symmetry" between outside and inside, and even

indicated that the artifact can be seen as having the external environment as its "mold" (Simon, 1969/1996, pp. 5–6). Yet there is clearly still an important difference between outside and inside: The outside of an artifact is a given, and the inside is a made[2]; the outside can be expected to be unruly and unpredictable, and the inside must be designed to withstand or counteract these irregularities to maintain the artifact's vital parameters and functions.

Generally, an important difference between Thought Styles 1 and 2 is that, whereas Thought Style 1 focuses on internal interfaces between the parts of a complex design (such as the gun in the preceding example), Thought Style 2 focuses on an artifact's external interface with its more or less problematic and uncontrolled environment (such as the musketeer, the weather, and the enemy, in the gun example). In the first case, the shapes and properties of the individual interfacing parts are under a common control and coordination, so that the individual part can make more precise assumptions about its neighboring parts. The whole becomes a stable system that is predictable and possible to maintain in a simple and precise way. In the second case, the external interface faces the full range of complexities and contingencies of an unruly and unpredictable "wild" environment.

The earlier remark about one of the important differences between human interfaces and software interfaces—that humans are notorious "shape shifters"—can be seen as a special case: Tame software meets wild humans.

The *boundary thought style* has not played a very important role within HCI until quite recently, with the introduction of mass-produced digital artifacts and the rapprochement of HCI and industrial design. The confluence of physical and digital materials in modern interactive devices and products has led to a radically increasing interest in this way of thinking of interfaces. Materiality and interaction technology makes the design of the overall boundary or cover more challenging and requires new skills and competencies.

## 2.3. A Means for Controlling an Object

Industrial plants, ships, cars, and airplanes are examples of complex machines that (usually) require human monitoring and regulating. Because of limited visibility and accessibility these tasks necessitate the introduction of special instruments and controls, centralized for convenience and often clustered in instrument panels. The operator controls the machine, operating, checking, and steering it via the instrument panel(s), the interface. Often enough, other means of control are being employed, such as engine sound, the visual appearance of products processed, felt acceleration forces, the view of the environment, shifts in body posture, and so on, but these are commonly not considered part of the interface because they are not mediated by the controls and instrumentation.

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2. As a methodological assumption, that is: The outside may well be artificial or artificially controlled, but when the focus is on the design of the inside, the artifact in case, the outside is taken as given and not a current target for design.

The interface is seen as a *means to control an artifact,* steering it toward a set goal, which may also involve problem solving. This thought style plays a dominant role in classical HCI, epitomized in Norman's seven-stage cycle of interaction and manifested in the concept of direct manipulation (Norman, 1986). Unlike Thought Styles 1 and 2, this interface notion is exclusively that of a *user interface*; the focus is exclusively on the "use end," whereas the "business end" and the rest of the artifact's border with the environment is usually left out of the picture. In a car, for example, the dashboard and the steering wheel would be considered to belong to the interface, whereas the tires and the hood would not, even though they interact with the surrounding environment. Still, the tires also create a sound that most "users," maybe unconsciously, actually rely on as a way of staying informed about the driving.

Having originated with big and complex high-end machinery, the control thought style soon found its way into the industrial design of smaller but still complex artifacts targeted for a mass market: household appliances, devices for entertainment, personal transportation, personal productivity enhancers. By the time everyday artifacts turned digital, it had long been the default approach to interfaces in industrial production.

With its focus on control of the machine, this thought style is all about functions and features. The interface becomes a manifestation of what can be done with the machine. The interface controls functionality and is governed by the intention of the user. The user is "using" the machine to achieve something by manipulating and controlling the interface. The possible complexity of the interface is "measured" by examining the interaction effort involved on the part of the user. Such examinations have led to notions of user-friendliness and ease of use. The interface is also analyzed and seen in relation to notions such as skill and competence on the part of the user.

## 2.4. A Means for Expressions and Impressions

The fourth and final thought style considered here is the interface conceived as a means or medium for expressions and impressions, a target of interpretations and affectations. In visual terms, the interface can be understood as the "face" of an object in analogy to the face of a person, but the thought style is not limited to the visual: Sounds, smells, tactile aspects, movements, and so on, are equally valid means of expression and impression, and it is clear that human conversation, also facial and bodily expressions apart, is one of the most important sources of inspiration for this thought style in HCI. The roots of this thought style, however, go back also to art, drama, and architecture, and it has continued to play an important role more recently in industrial design.

Human conversation is at least nominally the source of the *conversation metaphor*, which dominated HCI before the world model or direct manipulation metaphor became a new ideal (Hutchins, 1987). The question is, however, if the conversation metaphor as it was applied owed more to information and communication theory (Shannon & Weaver, 1949) and cybernetics (Wiener, 1948) than to ordinary human conversation. Most interfaces produced in the heyday of the conversation metaphor betray a much stronger influence from the control thought style than from

the expression/impression thought style: Commands were issued, the outcomes of their execution reported back (as in command-line interfaces); or questions were put, answers delivered (as in database query interfaces, user-initiated "dialogues," and computer-initiated "dialogues" where the roles of user and computer are switched).

Meanings, intentions, and emotions are central to Thought Style 4, but the interfaces based on the conversational metaphor, usually quite effective from a control point of view, did not convey meanings in any but the most superficial sense, nor did they pretend to (although users might sometimes be fooled to think otherwise). One notable exception in the same period was Joseph Weizenbaum's (1976) famous Eliza. Here, language was indeed used not to control but to express. Of course, the meanings expressed by the user did not really impress the program, and the expressions of the program were not genuinely meaningful but could still make an impression on the user, whether or not they would innocently take them to be genuine expressions.

Like the boundary thought style, and despite the success of the conversational metaphor, the expression/impression thought style did not play a major role in HCI until the digital artifacts started to make their way into the consumer market and HCI and industrial design took a deeper interest in each other.

In the early days of industrialism, the "boundary" of a machine was not only seen as a way of protecting or hiding the innards of an artifact. Serious time and energy were devoted to the design of the shell so that it would express certain characteristics or properties of the machine. An artifact could be designed to look solid while being hollow, or to look heavy while being light. The purpose was to create an impression on the user or bystander of the nature, function, or quality of the artifact. Architecture, of course, has a longer tradition of thinking in terms of expression and impression, and with the building as presenting a "face" to the world. For instance, courthouses were commonly designed to express power and stability, to impress a sense of subservience on the public.

Similarly, today's digital artifacts are thought of as having an impact by expressing certain qualities and leaving lasting impressions. The interface as a means for expression has been explored in HCI as a matter of "user experience." Emotionally expressive/impressive interfaces, social robots, affective computing, ambient interaction, and so on, are today becoming commonplace notions, all referring to the idea of the interface as mediating expressions and impressions.

With mass-produced digital artifacts, the expression and impression of the artifacts have also become economically important because of the power of the consumer market. Concomitantly, consumers-cum-users develop an increased sensitivity and discernment with regard to artifact expressions. Perceived usability may sometimes be regarded as less important than the hedonic qualities of the artifact. User experience as a consequence of the artifact's expression is seen as vital in most product and interaction design fields (Hassenzahl et al., 2013; McCarthy & Wright, 2004; Tractinsky, 2004).

Of course, the rapid change and exchange of expressions and impressions in ordinary human–human communication is on a very different time scale from the quite static expressions of a building or a smaller artifact like a car or a telephone with regard

to their physical shape and appearance. Also, the process is unidirectional: The public would be suitably awed by the courthouse and tend to "use" it, behave with regard to it, in manners influenced by this expression—still, there would be no reciprocal effect on the building by the public's expressions of respect and subservience (or whatever). The change of the artifact that would take place would mainly be the result of wear and tear, in some cases redesign, and on a very large time scale an evolutionary change of design of the corresponding *type* of artifact. Now, smart, interactive materials and other new technology allow also for dynamical changes of expression by means of physical shape and appearance; future architecture might become more user responsive.

The increasing interest and concern with the expressive aspect of artifacts and their interfaces shows that interaction can be understood as deeply involved with meaning making, something that has been explored lately both in HCI research and in design research (Brewster et al., 2009; Cechanowicz & Gutwin, 2009; Forlizzi & Battarbee, 2004; Krippendorff, 2006; McCarthy & Wright, 2004).

To summarize, we have identified four different thought styles with respect to the notion of interface. It is important to keep in mind that thought styles are not the same as precise definitions and are not necessarily even recognized by those who may be associated with each style. Still, our examination provides a historical background and conceptual framework useful for our further analysis of the interface concept.

Before we move into a more developed discussion of alternative definitions of the interface, it is necessary to say something about the changing conditions that influence the contemporary understanding of what constitutes an interface.

## 3. THE INTERFACE IS IN A TIGHT SQUEEZE

Time and again in the history of HCI and interaction, new technology such as graphical displays and new application areas such as office work have led to new shapes of interfaces. This, in turn, has led to changes in the overall understanding and theorizing about interaction in general. The notion of what might be seen as natural or intuitive interaction has changed when technology has changed (Jacob et al., 2008).

The latest digital artifacts are again stirring up the settled notions of what constitutes the interface. The causes of the present commotion are basically two: (a) *complication*—the proliferation of small and medium-sized artifacts with increasingly complex functions, and (b) *interaction technology*—the recent advances of communication and interface technology: wireless connections, tracking and identification, sensors, actuators, displays, smart materials, and so on.

Generally speaking, artifact complexity tends to increase in order to deliver more and better functionality, whereas the size of the artifacts stays the same or decreases. This means that external complexity in the long run cannot keep up with internal complexity: The available surface of the artifact has room only for a limited number of controls and displays given the limits of resolution of human perception and dexterity. Here, and in the following, we build on the notions of interaction complexity, internal, external, and mediated complexity and their relationships as they have been presented in Janlert and Stolterman (2010).

In considering the effects of the first cause, the artifact-downsizing and function-upsizing trend to interaction, there are two very basic relations to consider: (a) the smaller the size of an artifact, the less surface area is available for the user interface (Relation A); and (b) the ratio between surface area and volume is inversely proportional to the size (Relation B). The tendency toward smaller artifacts will by virtue of Relation A work to decrease user control and/or increase user interaction complexity. Assuming that internal complexity is roughly proportional to volume (for digital artifacts), and that degree of control can as a first approximation be thought of as the ratio of interaction complexity to internal complexity, the tendency toward smaller artifacts will by virtue of Relation B also work to improve the conditions for user control and/or decreased interaction complexity (Janlert & Stolterman, 2010). Which tendency wins out?

The basic technological premise underlying the general downsizing tendency is of course that digital technology can be packed more and more densely while keeping the cost per unit of volume almost constant. Moore's law is a long-term trend that has held good for 50 years, and we have reason to expect the trend to continue for quite some time yet, even if the rate of change might slow down. The ultimate technological limit of density could still be far off. Moreover, an achieved level of artifact functionality—which roughly corresponds to a certain level of artifact complexity—is only rarely sacrificed in order to have a smaller artifact. Downsizing does not typically occur at the cost of decreased complexity. That means that the general net effect will be to decrease user control and/or increase user interaction complexity.

Considering that there is in practice also a lower limit to the size of artifacts that still are under control by a user through the surface of the artifact, these surface-controlled artifacts will stop shrinking somewhere within a comfort zone short of this limit. From that point on they will not get smaller, but internally they could continue to become more and more complex, again with a cost of decreasing user control and/or increasing interaction complexity.

These challenges to the interface can be dealt with in many different ways, and this is already happening in the field. For instance, solutions has been proposed by the use of distributed interfaces (Vandervelpen & Coninx, 2004), or of physical materials (Ishii, Lakatos, Bonanni, & Labrune, 2012), or of using games as inspiration for future interfaces (Isbister, 2011).

Before we discuss these different directions we reflect on some more general considerations that influence any chosen design of interfaces. There are some general design considerations that influence any possible approach to interface design. We specifically examine the consideration that has to do with the question of why artifacts are getting more complicated, or what the motives for complication are. It is obvious that artifacts have a certain complexity as a result of design decisions. Why do designers decide to increase complexity when most designers adhere to the "golden rule" of making designs simple?

The second consideration we examine has to do with control and how control is related to interaction complexity. In almost every design situation, designers face the question of whether to give the user more control or to make the interface less complex. So how does this relationship really work?

### 3.1. Motives for Complication

As we noted previously, technological development has for a long time promised and delivered increasing computational power within a given space. This development has led designers to stuff artifacts with increasing amounts of complexity. What are the driving forces behind these design decisions? Among the general motives for increased internal complexity are the following:

1. Automation
2. Fine-tuning functions with regard to performance, resource use, use situation
3. Elaborating functions
4. Diversifying functions
5. Integrating functions

Each of these motives can lead to complications of different kinds. At the same time they are also normally entertained with the best intentions of improving the artifact and its use.

Complications motivated by *automation* per definition serve to reduce or eliminate user control in order to relieve, disempower, or outperform the user. Although control is removed at one level, this may sometimes lead to increased control at a different, usually higher level, but the net effect will usually be to reduce interaction complexity (Janlert & Stolterman, 2010).

In the case of complications that arise as a consequence of *fine-tuning* there will typically be an increased internal complexity without a corresponding need to raise the interaction complexity to keep the same level of user control. An example of fine-tuning is the use of digital technology to optimize the performance of a car engine with regard to fuel consumption, power output, pollution, and so on.

The third motive is *elaborating* functions. This refers to making the function of an artifact more elaborate, delivering more finely detailed and nuanced outcomes. A historical example is the elaboration of plain text editors into word processors able to handle different fonts, font variations, and font sizes; styles; hyphenation; grammar control; and so forth. The basic function remained the same, namely, to support the production and modification of texts, while many new details and options were being added. Many users wanted to keep the same level of control and thus needed an extended repertoire of operations to be able to do that, whereas other users (or the same users on other occasions) were content with letting the finer details be determined by some default.

The fourth motive, *diversifying* functions, may at first appear the same as the previous motive, but it is different. An example of diversification from the same application area is when word processors were extended so as to include pictures in the text, with various supporting functions for handling and modifying the pictures. Recently we have seen how phones have shifted from being devices for voice calls toward becoming multipurpose communication, information, and controller machines, diversifying their function enormously. The difference between elaborating and diversifying is

related to the *single-purpose versus multipurpose* issue discussed by Buxton (2001) and others (Goldstein, Nyberg, & Anneroth, 2003; Marcus & Chen, 2002; Norman, 1998). The general tendency of the diversification motive is toward multipurpose artifacts (the "Swiss-army-knife syndrome"). As we see, the last motive, integrating functions, has an opposite tendency toward single-purpose artifacts, whereas the elaboration motive remains neutral in this respect.

The fifth and final motive in our list is *integrating* functions. This means the integration into a single artifact of what earlier were functions delivered by separate artifacts used in the same activity, supporting a common end purpose. One early example is the integration of light meter and distance measuring device into the camera. The integration motive can be related to the *structural* versus *functional control* issue elaborated by diSessa (1986, 2000, Chapters 6 and 7) and others (Halasz & Moran, 1983; Young, 1981). The general tendency of the integration motive is toward functional control and single-purpose function. The general tendency of the diversification motive, in contradistinction, is toward structural control and multipurpose function.

In summary, it seems that it is mainly with regard to the purposes of elaborating, diversifying, and integrating functions that increasing artifact complexity present cases where interaction complexity potentially may keep rising without a definite limit other than that fewer and fewer users will find it bearable and worthwhile. Already at this time we can see many examples of small digital artifacts where we really would want the user to have better control and/or less complicated interaction than what seems achievable with current designs.

At this point the second cause for worry and confusion about the interface—new interaction technology—comes into play. When there is effectively little or no available surface for an interface, there will be attempts to make do without it.

## 3.2. Complexity and Control

One way of thinking about possible directions of new interfaces is in relation to the notions of complexity and control. The thought styles previously presented can be seen as approaches on how to handle and design for complexity and control. The different forms of interfaces constitute surfaces that define, limit, or prescribe how control can be exerted.

What is hidden behind a surface and what is shown on the surface is a matter of design. Janlert and Stolterman (2010) proposed a theoretical model of interaction complexity based on four notions: internal complexity, external complexity, mediated complexity, and interaction complexity. These concepts and particularly their relationships can be used to examine the role of the interface in general and the differences between the thought styles discussed earlier.

In the design of any interactive artifact, the designer has to establish how the functionality of the artifact will be presented to the user. Janlert and Stolterman (2010) argued that any design of interactivity is to some degree about the *distribution* of complexity and control. With the different notions of complexity that they introduce, it

is possible to more clearly describe the relationship between the artifact and the user, which in turn also helps define what constitutes the interface.

For instance, when the functionality of an artifact increases, the *internal complexity* also increases, as functionality is usually a consequence of elaborate internal machinery and mechanisms. Functionality can therefore be understood as roughly proportional to internal complexity (at least under ideal conditions). Or, to turn it around, internal complexity—given that there is no dead meat and redundancies have been discounted for—gives a rough measure of the amount of functionality. What becomes visible of this functionality constitutes the interface. If more functionality is made visible to the user, the interface or the *external complexity* grows (unless some smart design choices are made where the interface design combines or condenses large functionality options).

We can now look at two extremes, when the user has *no control* or is in *full control*. Having no control means that an artifact performs its functions without any input or influence from the user. In such a case, the interface exhibits no external complexity—there is nothing to do, nothing to choose, nothing to act on. Any user is as good as any other user. Full control means that it is in principle possible to fully master the complete functionality of the artifact by proper interactions. This usually means that the artifact exhibits high external complexity because it has to be an interface that reflects all possible functionality (the high internal complexity).

Janlert and Stolterman proposed two more forms of complexity to consider when analyzing interactivity. *Mediated complexity* relates to how the "world" or the material that the user is engaged with via the artifact influences the complexity of the interaction. For instance, in playing a musical instrument, the complexity of the score will have a large impact on the complexity of the playing. Mediated complexity, therefore, is a consequence of choices made by the user. It becomes a consequence of what the user chooses to interact with *through* the artifact. It is not a choice that is reflected in the interface, because it does not change the artifact.

*Interaction complexity* relates to the complexity of the actual interaction that is performed by the user. Interaction complexity can be seen as a *consequence* of the design choices concerning the functionality (internal complexity) and the interface (external complexity) and the user choices concerning context/material (mediated complexity). A designer does not have complete freedom when designing an interactive artifact when it comes to this task of distributing control. There are certain trade-offs that are not possible, or at least quite difficult, to overcome.

This means that any design choice concerning control of functionality, or in other words the distribution of complexity of an artifact, is a decision that has consequences for its interface. For instance, if the user desires more control, then the interface needs more space, and probably becomes more complex.

This analysis of complexity and control has shown that there is a strong relationship between the two notions and that a detailed examination of that relationship can lead to analytical clarity that can be used to examine certain aspects of the thought styles just presented.

Looking back at the interface thought styles and the design considerations we just explored, it is not clear what the road ahead for interface design might be. It is possible to imagine a diversity of directions. History shows that we might enter into an era when one thought style becomes dominant or a certain design consideration develops and becomes elevated into a standard or paradigm. For instance, it is possible to see recent developments of interactive artifacts as being directed by a design consideration based on condensing external complexity to satisfy the requirement of more control while dealing with shrinking space, of course, with the consequence of increasing interaction complexity. However, not all directions are equally plausible. Even though it is not easy to predict exactly where they would take us, they will all have consequences and implications that to some extent can be imagined and foreseen.

As we have tried to show in this section, the interface is in a tight squeeze. There are strong motives that push designs to increasingly complex interactions. At the same time there are limiting trade-offs concerning complexity and control when it comes to what can be done.

### 3.3. Interface Extension and Cluttering

An old and widely practiced approach to the problem of limited interface space, such as scarcity of "screen real estate," is the use of modes and interface time-multiplexing. This approach has long been critiqued by the HCI community, from Smith, Irby, Kimball, and Verplank ([1982](#)) and onward (Raskin, [2000](#); Tesler, [2012](#)), but is still common. In the terms of complexity analysis, it amounts to a transfer of external complexity to interaction complexity. The problem is shifted, not solved.

More recently there has been a lot of activity of trying to manage the problem by somehow detaching the user interface from the surface of the artifact (alternatively, if you wish, thought of as splitting it into several, physically distributed parts), often combined with making its presence conditional rather than constant. Examples of technological solutions that have been proposed include projections on a flat surface nearby, projections in midair ("holograms"), augmented reality overlays that let the artifact be extended into a virtually larger object, the temporary "hijacking" of nearby displays and devices, interfaces that can be unfolded and folded, or rolled out and in. These attempts ride on a wave of new interaction technologies. Also, wireless connectivity plays an important role in facilitating the separation of physical location of function and control from physical location of implementation. Although some of the proposed methods already are being tried in practice, they have problems of their own. A shared problem is that of *cluttering*: With an increasing number of devices using this kind of external interface assistance, the user's view is likely to get cluttered and the operations to interfere with real-world actions. Cluttering problems come in two varieties: perceptual cluttering and behavioral cluttering.

*Perceptual cluttering* is when the conglomeration of interfaces belonging to several artifacts in simultaneous use threaten to confuse the user with an onslaught of unrelated, uncoordinated information. In the case of visual displays information may be

delivered on surfaces partially or completely occluding each other as well as parts of the real environment, and thus also to potentially distract from and get in the way of "normal" everyday actions. Reading e-mail on your smartphone screen while hastening to your lunch date, you might walk into a lamppost or get run over by a car. The three general problems of perceptual cluttering in this sense—chaos, occlusion, and distraction—are actually common to all modalities, (sounds can mask or confuse other sounds, smells other smells, etc.), but these problems are particularly evident with regard to our present heavy reliance on all sorts of visual displays and visually guided interactions. Others have recognized perceptual cluttering, and several solutions have been proposed. One kind of solution has been to introduce some kind "lens" or "filter" that makes it possible to manipulate the interface (Bier, Stone, Pier, Buxton, & DeRose, 1993; Looser, Billinghurst, & Cockburn, 2004; Nicholson & Vickers, 2004). However, these solutions are aimed at managing clutter within a separate artifact, whereas our focus is on the simultaneous presence of many interfaces of more or less unrelated artifacts. There are also studies that have attempted to measure visual clutter (Rosenholtz, Li, & Nakano, 2007).

*Behavioral cluttering* is when operations interfere with "normal" everyday actions or with the operations of other artifacts. Simply by *moving* your smartphone you may unintentionally activate various apps, change settings, phone someone, and so on. Slightly more futuristic examples are easy to imagine: You just want to scratch your head a little, or reach for your coffee cup, but some artifact interprets this as a gesture to make a call, cancel something, turn down the lights, switch channel, or whatever.

The problems of cluttering introduced by today's proliferation of digital artifacts can be seen as a repetition of or perhaps rather the result of moving the cluttering problems of the classical virtuality paradigm (Janlert, 2007)—your tasks require many windows, but screen real estate is very limited—out into the real world of ubiquitous and mobile computing. The virtuality paradigm is primarily ridden with perceptual cluttering, whereas behavioral cluttering is being limited to accidently clicking or activating something you did not intend to. Behavioral cluttering has a potential to become a much more serious problem in the real world, as we argue.

An added difficulty with cluttering in the real world is that there is less chance of imposing some uniform and coordinated control regime, as opposed to the virtual worlds where operating systems and coordinated software ensembles create an organized and structuring environment.

Next we reflect further on the directions that are possible to take in order to save the interface from overwhelming interaction complexity, on one hand, debilitating impotency, on the other. We have already mentioned the option of removing the interface from the artifact, but one may also consider dumbing down artifacts, or upsizing them, or trying to find some magical new style of interaction that fit on the available surface but is so much more capable of handling complexity, or—a more radical solution—getting rid of the interface altogether!

## 4. INTERFACE AS SURFACE

As we have noted, there is no commonly accepted definition of "interface." The common-sense notion is that an interface consists of (a designated part of) the *surface* of an interactive artifact. How well do the four different interface thought styles previously discussed match the assumption that the interface should be a surface?

Thought Style 1 is in its inception literally about the shape of matching surfaces. The notion of physical and spatially extended interfaces continues to play a very important role, of course. The extension of this notion to software interfaces is an obvious metaphor: A piece of software does not really have any spatial extension, and there are no real surfaces between software parts. Thought Style 2, too, is rooted in the idea of a physical boundary containing the object, which again has not stopped it from being used metaphorically as well.

But when we get to Thought Style 3, the situation is different: Even though instrument panels were, and still are, a common way of implementing control, nothing in the basic concept of control requires it to be exercised through some physical surface. Indeed, theremin players just use their ears and hands in free gestures to control pitch and volume; blind conductors have been known to successfully lead an orchestra. Similarly, with Thought Style 4—to express and receive impressions, affect and be affected—you do not really need the mediation of a physical surface: A common, everyday example is an ordinary telephone conversation with another person.

Faced with the current interface conundrum, we have decided to go literal and—just as the term implies—restrict "interface" to apply to real surfaces and surface-bound interaction, and not use it when there is no actual surface involved. By avoiding metaphorical interpretations we hope to remove some of the current uncertainty around the interface and what can be done with it, and counteract the overly conservative restrictions on the space of possible designs we think the metaphor has led us into. An important implication of this move is that *interaction* does not necessarily require an *interface*.

Going back to a literal understanding of interface gives us a fresh start, relieving us to think more freely about new ways of interacting that the new situation seems to urgently call for. In software engineering, Thought Styles 1 and 2 have been extended to metaphorically embrace software as parts with "surfaces" and "shapes," but by this time, the interface concept in software engineering has been so developed on its own that the original metaphorical support is no longer needed, indeed no longer even thought of—it has long since been replaced by a mesh of more elaborate and precise concepts adapted to the particular area of software design, such as parameters, data types, protocols, information hiding, and so on.

Let us stop a moment to think about how the ways we perceive and interact with physical objects, natural or artificial, depend or do not depend on the availability of a surface. We can distinguish two main groups of modalities involved.

In the first group we put vision, touch, and direct object manipulations using our hands and body, which we claim all are basically *surface-bound modalities*. Normally, these modalities require at least a minimal targeted surface. To grip an object, we have to lay

our hand on its surface; to see an object, it has to present a visible surface from our point of view; and so on.

In the second group we put hearing, sound production (voice, etc.), smell, heat, wind, breath, balance, posture, and so forth, and free gestures,[3] which might be called *surface-free modalities*. Normally, these modalities do not require a target surface to work. Often, but not always, there is still a *source* in the form of a physically located object. An early and similar distinction between sound and vision and their requirements of surfaces was made by Gaver (1986) when he argued that "sound exists in time" while "vision exists in space." Some more recent examples of research on surface-free interaction relate to speech interaction (Munteanu et al., 2014) and odor and smell (Obrist, Tuch, & Hornbaek, 2014).

This can be elaborated in greater detail. We want to clarify that there will often be a difference between outgoing, or *expressive*, modalities and ingoing, or *impressive*, modalities. For example, hand gestures are an expressive modality that does not require a surface, but to visually perceive such gestures as an impressive modality, again, surface is needed—in this case, the surface of the hand—together with the right conditions for perceiving it. Dancers in the dark do not have an interested audience: They can express themselves but they cannot impress others at a distance. That can be compared to "voice gestures"—using the vocal organs to produce sounds, intonation, rhythm, and so on, without actual words and language being important—which are surface free both ways.

At the same time, we want to point out that a strict distinction between outgoing and ingoing, expression and impression, may be somewhat dubious and that the use of expressive and impressive modalities are often intimately intertwined in actions and activities. Producing an article such as this one would be quite a different thing if we didn't have a surface to present the written text to us as we are working on the article. We might use a surface-free modality such as speech or sign language as expressive modality, but without a surface-bound impressive modality providing more or less instant overview, the whole writing process, including the *thought* process, would change dramatically: It is difficult to see how it would be possible at all without constant rehearsals and painstaking memorizations that would most certainly affect style, structure, and content, not to mention the added difficulty of coauthoring.

We would argue that the notions of surface-free and surface-bound modalities cut through the interactivity landscape in a different way than traditional definitions of forms of interaction. To stay with the strict and limited definition of interface as a surface makes it possible to more precisely examine different forms of interactive technologies.

For instance, in the prior discussion about control and complexity there is a need for a more distinct definition of what constitutes the interface. Intuitively it may seem as if the simplest interface or even no interface might also lead to less complex

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3. "Free gestures" refers to gestures, or really any kind of bodily movements and configurations, that are not restricted by some surface: the gestures of the now so common multitouch interfaces belong to the first group, of course; they are not considered "free."

interaction, but when free gestures are used as a form of interaction and there is no external complexity in the form of a "visible" interface, no surface, the analysis breaks down.

## 5. FACELESS INTERACTION

When the interface is defined as a surface, it is obvious that most interactions today are with surfaces of some kind, with the screen as the most dominating. It is also clear that most work in HCI has been done based on an understanding of interfaces as surfaces and that there are fewer examinations of surface-free interactions, or "faceless" interactions.

So what is a faceless interaction? We may define a *weak sense* of faceless interaction as an interaction either devoid of any expressive surface-bound modalities or devoid of any impressive surface-bound modalities (but not lacking both). Typing on a keyboard is clearly a surface-bound expressive modality, and using a data screen is clearly a surface-bound impressive modality, so the ordinary graphical user interface doesn't provide faceless interaction, but if the keyboard is replaced with speech recognition we can have faceless interaction in the weak sense with, for instance, a word processor. If we want to use a text cursor to move around in the text and to make selections, we will have to find some surface-free device to replace the mouse, as it is also clearly a surface-bound modality: Special voice commands are a possibility, or perhaps eye tracking. A possible objection to eye tracking is that it is virtually impossible to direct your gaze with any precision and accuracy unless you have some visual feature to fixate or at least use as landmark, which in practice means a (not entirely featureless) surface to look at. Does this mean that "eye pointing" or "looking" is always a surface-bound expressive modality? We think the answer is no. The thing you are looking at is not an *instrument* for looking (pointing); you can still look anywhere you choose to. Eye tracking rather illustrates the often close intertwining of impression and expression; the way we look is informed and guided by what there is to look at.

Still, in this word-processing example we would depend heavily on the data screen as impressive modality, which is surface-bound. That is also true for the new generation of gaming devices, like Kinect and Wii,[4] where free gestures are used for expression, whereas a TV screen is used for impression, which is in fact conceptually very similar to some of Myron Krueger's early experiments in the 1970s such as Metaplay and Videoplace (Krueger, 1991).

That brings us to the *strong sense* of faceless interaction, which can be defined as interaction without using *any* surface-bound modalities, that is, using exclusively surface-free expressions *and* impressions. The screen then has to go, too, from the standard graphical user interface. That would imply a major rethink and refashion

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4. In the case of Wii there is a controller you hold in your hand—however, it is the free hand movements that constitute the expression. Also, the controller actually has some buttons, so it isn't completely surface-free.

of the word-processing task, as we argued earlier—a major weakness of surface-free impressive modalities would seem to be in providing instant overview of a complex state of affairs (as of a written article in the making, the status of an industrial plant, or the airspace at a busy airport). Still, considering that an ordinary telephone conversation exemplifies faceless (human–human) interaction in the strong sense, there is nothing uncommon or strange today about the notion per se.[5]

Faceless interaction (in either sense) is not a new phenomenon. For instance, people with different forms of handicaps, out-of-office work situations without traditional office technology, parallel activities that occupy hands or eyes, have all led to various designs with different forms of faceless interactions. These examples show that ever since new technology and new applications started the move away from the classical use scenario of the virtuality paradigm (user in an office fixated on a screen with keyboard, engrossed in some abstract situation in a symbolic world not directly related to their own real-world situation), an abundance of user-situated surfaces available for interaction could not be taken for granted anymore.

Audio-based interaction, for instance, has been used in a number of specially constrained situations and applications: It might be that the user is visually handicapped or that the user's eyes and/or hands are occupied with other things. Suppose, for example, that you are using an overhead crane to move heavy pieces of equipment or goods. Typically you would have a control box hanging from the crane with a set of buttons for lifting/lowering, moving the crane left/right along the traversing beam, moving the beam forward/backward. Both hands are occupied: one hand to hold the box, the other to push buttons. Often, however, you would want to use your hands to adjust the final orientation and exact position when you set something down. This could be solved by replacing the control box with a voice command interface, freeing your hands for manual adjustments.[6]

Reflecting a bit on this crane example, as there apparently is no impressive modality as part of the *user interface*, it should qualify as strongly faceless interaction. Of course, the interaction will involve visual perception of the surfaces of the crane as well as of other physical objects in the room. Most likely, your attention will primarily be not on the crane itself but on the object craned and objects close to it.

Let us go back to the traditional, usually implicit distinction made in HCI between the designated "user interface" and the rest of the artifact's total interface with the world, what might be called the "world interface," and consider how the concept of faceless interaction plays out in that context.

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5.  But it must have been very different when telephony was new. Marcel Proust (1921) described in *Le Côté de Guermantes* how the telephone brings before us, "invisible but present, the person we want to speak to, still sitting at his table, in his hometown, . . . under a different sky, perhaps in different weather, . . . in the midst of circumstances and preoccupations of which we know nothing . . . when suddenly transported hundreds of miles together with [his] whole environment up close to our ear" (our translation).

6.  We are aware that this may be problematic if the environment is noisy, and that there may be security issues with a voice-controlled system, but it works as an example for our discussion.

Many traditional everyday objects do not have a user interface, in this sense. They have surfaces, of course, that are involved in our interactions with them. If you want to change the position of a chair, just grab it anywhere and lift or drag it into position, shove it in place with your knee or foot, or whatever: The surfaces involved are arbitrary, the operations an indefinite motley of moves. The interaction is faceless in the strong sense with regard to the user interface, because there really isn't any, even though in some sense the seat and the back of the chair could be contrived to make up a "user interface"—that is at least what comes in contact with the user when the chair is being used for sitting—still, our interactions are not limited to sitting.

In traditional tools it is usually easy to distinguish a "use end," which should correspond to user interface, from a "business end," corresponding to that part of the world interface through which work is effectively being done (often leaving a smaller or larger part of the world interface to itself, a sort of unproductive no-man's-land in-between business end and use end). Still, there is not a very strict border between the ends, and there is room for relatively smooth and undramatic extensions and "transgressions" of handling procedures; the use end might even temporarily become business end, in effect, and vice versa. An example of this is the hammer. A hammer has usually a well-defined use end (the handle) as well as business end (the hammer head). But as anyone knows who has used a hammer, it is actually used not only to hammer but also to bend, pull, or draw: Any part of the hammer can temporarily become the user interface and any part can serve as the business end.

Talking about the user interface of simple, traditional objects is an anachronistic projection of the modern conceptual framework of HCI onto simple, precomputer artifacts. It usually works more or less, but with some reluctance and ambiguity as we have tried to show with the aforementioned examples. The comparison and contrast with traditional objects is becoming very relevant as many digital artifacts now become more and more thing-like. When the whole surface of an object is covered by some digital touch-sensitive-display-paint on top of some smart, shape-changing materials we are back in a situation where potentially any part of the surface can serve as "user interface" but with the heightened sensitivity and activity of a live entity—it is as if objects potentially might turn into sentient, dynamic organisms.

It is quite clear that faceless interaction as defined here may lead to consequences that are not necessarily intuitive from our present point of view. Based on the preceding discussion, we continue with some speculations on the nature of faceless interaction and on what can be seen as potential approaches when it comes to the design of faceless interactions.

## 5.1. Interfaced and Faceless Interaction Compared

As a first consideration, we venture to claim that a move from surface-bound to surface-free interaction has opposite general effects on impressive and expressive modalities, in terms of speed and capacity of information delivery (Thought Style 3) or meaningful content (Thought Style 4).

Going from surface-bound to surface-free *impressive* modality, there is a potentially large *loss* of capacity. Vision is our most important sense by virtue of the

combined scope, range, sensitivity, and rate of information intake. Not having any visual display of some kind generally implies a much lower maximum capacity. Note that the effect is similar for a tactile dynamic display (such as a blind person might use), although it cannot really compete with a visual dynamic display in terms of how many details and how large an area with how little delay can be covered and detected. Generally, we think that if you need to keep an up-to-date overview of a complex and perhaps quickly changing state of affairs, facelessness is at a disadvantage.

Going from surface-bound to surface-free *expressive* modality, there is a potential *gain* of capacity. The use of our body is always more or less severely hampered when it has to comply with various surface-bound devices and contraptions that tend to have strictly confined degrees of freedom and whose dimensions of manipulation not exactly match what is most natural to do with the human body but rather are ruled by technical convenience and simplicity—whereas "free gestures" allow you to use your body in any way you can and care to. Although it may not be obvious how we are going to use it and what it would mean—after all, so much of our bodily practice is in fact concerned with manipulating various technical artifacts—special cases of bodily articulations, such as facial expressions or dance might provide some useful ideas about it.

With faceless interaction, the traditional surface disappears and interaction has to move away from the surface. A surface has the property of being clearly located, which means it can be determined and positioned in a larger space, such as a room or as part of the total surface of an artifact, so as to be separable and not to interfere with other activities using that same space. Still, as we noted earlier, when several surfaces are in simultaneous use, several of which might be mobile, and especially in busy real-world situations with many concurrent but unrelated activities—the possibilities to coordinate and arrange the surfaces to avoid cluttering seem rather limited.

Thus, with regard to visual cluttering, surface-free impressions should generally come as a relief—but only at the potentially high cost of giving up the richness of visual impressions, and there is still the worry about perceptual cluttering in the alternative surface-free modalities, like sound. If you are walking or biking with music in your ears, you might not notice the ring signal from your phone or the warning sound of a car horn. Of course, research and development is now going on to introduce what might be called "open-air" operative systems for coordinating resources available and needs and requests pending. For sem-iopen environments like inside a car or in a home, there are now systems that, for example, can make the phone automatically silence the radio; the range of artifacts and conflict types that can be handled and resolved is strictly limited. The difficulties of handling the *full* range of digital artifacts in an *open* environment are huge: Different kinds and makes of artifacts can enter and exit the scene in an incessant stream; at any time new and hitherto unknown devices might make an unscheduled appearance. How priority decisions between conflicting requirements and requests should be made is still a completely open issue.

With regard to behavioral cluttering, we believe there is a reverse effect: Surface-free expressions will tend to exacerbate cluttering precisely because it will be harder to associate interaction behavior with specific locations and objects. Chances increase

that actions performed as part of some real-world activity interfere with actions performed as part of interaction with some digital artifact, or that interaction with one artifact interferes with interaction with some other artifact—and more so in an open environment where all sorts of artifacts are around, not all of them perhaps familiar or recognized by a user.

Although perceptual cluttering problems could generally be alleviated by faceless interaction, it seems as if behavioral cluttering may become more of a problem in faceless interaction by opening up for a greater freedom of actions with more ambiguous relationships to the situational context. Behavioral cluttering in the real world may also be more consequential with less easily reversible or irreversible results than it was in the relatively safe and forgiving abstract symbolic space of the virtuality paradigm.

When there is no distinct surface to turn to, users may feel as if they are communicating with everything or nothing instead of addressing a particular locatable entity. A loss of sense of directionality may lead to insecurity and mistakes.

## 5.2. Expression Examined

The way we have chosen to interpret "expressive" and "expression" in the descriptions of Thought Style 4, it becomes a notion that is wider than interpretations found in some linguistic and philosophical analyses of the use of language, such as speech act theory, where language expressions normally are seen as targeted to specific recipients, or to specific tasks or purposes (Austin, 1962; Searle, 1969).

The "expressions" of the expressive–impressive thought style do not have to be targeted in this sense. This does not mean, however, that the "sender" or utterer of the expression cannot have specific goals. "Oh, how I wish for some coffee now!"—that could be a more or less spontaneous expression not directed to anyone in particular (there is perhaps not a person within earshot), and not being produced with the intention or hope of actually somehow having the effect of getting you some coffee.

This is a sense of "expression" that perhaps lies closer to its use in art. Something comes out of the artist, in a sort of to-whom-it-may-concern spirit—something is produced, an expression—then let's see what the world makes of it, what impression it might give, what impact it might have. But how it is received is a different story, and some artists do not even seem to care much. Expression can be extremely idiosyncratic, egocentric, and even verging on the solipsistic.

Sometimes there is a choice between doing something and expressing something (with pragmatic intent), with essentially the same outcome. It is a matter of choice of instrument or tactic. Sometimes the point is just to express without any other goals, whereas there really is no obviously equivalent, nonexpressive action. Sometimes things can be done that we would not know how to or bother to express. Expressing yourself can also be a bore.

The possibility of nontargeted, or very vaguely targeted, varieties of expression may have implications for our examination. Faceless interaction may well develop into forms where interaction with particular artifacts is not a very adequate way of describing or thinking about what is going on, either from the user's or the designer's point

of view; you may not be aware of any specific targeted artifact (with a specific location, boundary, appearance, etc.), and technically speaking it might be a rather ad hoc and dynamically changing constellation of a number of "artifacts" that cooperate or—a possibility that must also be seriously taken into account—compete to take care of and respond to your expressions. How will letting go of the objects, so to speak, change our thinking and behavior as users?

It might, for example, cause disorientation and some anxiety about how to express ourselves. When we travel through our everyday landscapes we are already experiencing some aspects of this new form of interaction. We may wave our hands in the air in a public bathroom with the hope that it will turn the water on or give us paper towels. We may approach a door with the hope that it will recognize and understand that we want it to open. We do not know if we have to direct our attention to any specific surface or object. We do not know if we should use our voice, gestures, or body movements. We act with the hope that the environment will understand our expressions and act accordingly. It is already common to see people in public spaces desperately searching for a surface to interact with. Many times we end up looking lost and even silly when our expressions do not lead to the expected outcome.

It is obvious that expressions in a faceless environment present serious design challenges. Today we are seeing a lot of excitement when new faceless interactive technologies are introduced, such as the Kinect, but when these technologies are competing for space and attention, a new level of design complexity arises. Whether these new environments are possible to design in a fashion that supports everyday intuitive and simple interactions is still to be seen.

## 5.3. Impression Examined

Like the expressions of the expressive–impressive thought style, the "impressions" are not limited to spring from some user-identifiable source in a particular object or direction in space. Impressions can sometimes rather be thought of as a weighted sum of many small perceptual cues and features in several modalities, combining to give a more or less holistic sense of the situation, perhaps an atmosphere, an aura, a flavor, a mood, and so on. An example might be when you are driving a car and get, without really thinking about it, a sense of the character of the traffic—busy, hectic, aggressive, nervous, tight, calm, smooth, slow, sleepy—presumably as a result of hearing sounds, seeing vehicles and their movements, experiencing your own car's movements and your own activities to keep going, and maintaining an appropriate relation to the rest of the traffic.

Of course, for that kind of impression, you would normally not expect it to be an immediate response to your own expressions. With the kind of directed and more precisely targeted impressions that we expect in traditional digital artifact interaction, the situation is different. But in a shared environment, impressions will largely be shared, too, and that may include impressions caused by digital artifacts. If an impression cannot easily and reliably be connected with a particular surface, chances increase that impressions relevant to one user but irrelevant or misleading to another might be

mixed up. Users might mistake an impression as a response to their own expression or more generally as targeting them, whereas in fact it was aimed for some other user. Mark Weiser (1991) foresaw many of these consequences in his seminal text about ubiquitous computing. Some of these issues have also more recently been recognized in the area of ambient computing, especially in relation to evaluations (Hazlewood, Stolterman, & Connelly, 2011; Mankoff et al., 2003).

In science fiction movies, some of these problems have been addressed. For instance, in the movie *Minority Report*, the environment recognizes the eye of each person in the immediate space and then produces messages and information that can be perceived only by that person. The main character even goes through an eye replacement to avoid being tracked. In the movie, public screens can show different content for different individuals even though they are in the same space. It is possible to imagine a similar form of faceless but directed messages based on exact location in a space or some other technology.

However, without advanced technology that can situate each user in a precise way, the problem with disorientation with regard to impressions becomes a real issue. Is that message intended for me? Where should I look? What should I look for (listen for, etc.)? Is that impression (vibration, sound, wind, etc.) meant for me? Am I ultimately the cause?

Living in a state of complex impressions is not a new situation; we experience that in our everyday lives. For instance, the combined movements of ordinary objects are usually not a big problem for us: Driving a car in heavy traffic, there is a lot of perceptual information to take in, but we can handle it because it is still rather orderly. But even if we can handle a certain amount of complex and sometimes conflicting impressions, it is still a design challenge. We have already seen new laws addressed at reducing the complexity of impressions, such as making it illegal to drive and talk on the phone at the same time. However, it is still commonly believed that the problem is solved by making the car phone conversation faceless by using hands-free. Although faceless impressions may reduce the need for directionality and attention to surfaces, it may still be ridden with other forms of complexity and problems.

### 5.4. A New Thought Style Emerging?

Faceless interaction in general makes way for interaction that is not restricted by the location or direction of a well-defined, well-delimited source or target, the existence of an embodied and precisely situated interactant.

Perhaps a new thought style is now forming as we speak—a thought style with an "ecological," "contextual," or "ambient," character. In such an interactive environment, "users" are immersed in an ecology in which they are not conceived as interacting with particular, targeted objects one at a time but rather are moving in situational and interactional "force fields," causing minor or major perturbations in their environment by their moves and actions while being guided, buffeted, seduced, or affected in any which way by constant movements and changes in their environment taken as a whole.

With the different efforts in the last decade or two to move beyond straight-forward artifact interaction to ambient computing and ubiquitous computing, it is possible to argue that this transformation to a new thought style is already well under way. The underlying attempt in these areas has for some time been to "hide" the computational artifacts with the ambition to design environments with invisible computational abilities and interfaces.

A fitting label for such a thought style might be "field." The perspective of individual objects, their interfaces, and one-on-one interactions is abandoned in favor of thinking about interaction in terms of fields, somewhat similar to how modern physics may switch from the perspective of individual particles and their interactions to a perspective of fields and waves. A field in its turn can be thought of as generated by the totality of entities within it. A particular entity may be singled out, and its behavior in relation to the field can be studied: how it is affected by it, and its own impact on the field. Whereas it is natural to pick a user for that role, this perspective can be applied from the point of view of *any* object—natural or artificial. From the point of view of earlier thought styles and traditional HCI, the most striking differences are that any user action potentially affects many objects at the same time and that user perceptions are the resultants from potentially many objects. From the point of view of the field thought style itself, the attention on individual objects is discouraged.

Although we refer to physics, the intellectual inspiration for this style of thought probably comes as much or more from "ecological thinking" in various forms, such as ecological psychology (Gibson, 1986), situated action (Suchman, 1987), distributed cognition (Hutchins, 1995), cognitive science (Clark, 2010), and other areas addressing aspects of the relationship between an environment and its inhabitants.

With regard to the four thought styles we have previously discussed, the field thought style comes closest to Thought Style 2, interface as boundary, but then with the roles reversed so that the *user* is in the center and with a focus as much or more on the environment outside the boundary of the user—or rather the *agent*. The term "user" is an obvious relic from Thought Style 3, which in the field thought style becomes even more incongruous than it already is in the expressive–impressive thought style.[7] However, whereas Thought Style 2 assumes the existence of a determinate and fixed boundary, the notion of "field" makes no such assumption. Of interest, the old commonsense notion that the human body constitutes the physical boundary of the human mind is currently being challenged from various directions (Clark, 2010; Clark & Chalmers, 1998). If the perceived boundary of the user arguably is in a state of expansion and dissolution, or perspectival indeterminacy and possibly dynamic fluctuation, it certainly seems to fit the field thought style quite nicely.

Both ubiquitous computing and ambient computing are still struggling with a quite traditional *systems view* (related to Thought Styles 1 and 3, in particular) that seems

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7. For example, the idea that you are "using" another person you are having a conversation with does not normally occur in ordinary, everyday discourse. Of interest, the kind of situations where it *does* make sense—as in *commanding* or *interrogating* someone—is precisely the situations that inspired the practical applications of the conversation metaphor.

to be hard to shake off. In many cases such a systems view is driven by a top-down perspective where the ubiquitous environment is to be designed as a whole. Although the field thought style accepts dynamic, overlapping, and messy environments, the ubiquitous approach often (though not always) clearly defines what the environment in question is, what belongs, and what doesn't.

Let us be clear that we do not imagine this possibly emerging new fifth thought style to be in any way the newly discovered quintessence of interaction—but we believe it is an inspiring new possibility with hopefully a great future, as a complement but not necessarily always superior to the other thought styles. Strictly speaking, of course, the field thought style, just as the expressive–impressive thought style, has moved beyond being a thought style for *interface* to become rather a thought style for *interaction*.

## 5.5. Interaction Richness and Precision

Faceless interaction may seem to open up for smooth or analog interaction more than surface-bound interaction does, but perhaps that is a false impression. Spoken natural language has a dominant digital component in the phonemes, morphemes, words, phrases, sentences, and so on, although there remains an analog component as well in the form of intonation and prosody (but note that tone in itself can be used for digital communication as well, as in Mandarin, where there are four distinctive, semantically significant "tones"). There are also important examples of analog surface-bound forms of interaction, such as drawing and painting. The richness that is inherent in analog interaction usually comes at the cost of skill. The ease by which users can handle complex interactions via surface-bound digital expressions by clicking buttons without a lot of skill required, is a strength that faceless interaction may lack. So, even though the richness of analog and faceless interaction is appealing, it may also lead to lack of precision.

For instance, playing the theremin, an electronic musical instrument, seems to be much harder than playing the violin. The completely free gestures that are the form of input to the theremin are hard to make precise in the sense of exactly repeatable.

To support precision, it seems as if there is a need for some kind of physical support and resistance. This can be delivered by precise haptic feedback, but that may necessarily mean surface-bound interaction. What would then count as surface-bound interfaces becomes messy. For instance, is flying a kite surface-bound? Holding the string gives haptic feedback that can be seen as coming from a surface.

Free gestures seem to leave room for endless variations and subtle nuances, also open for more or less spontaneous expressions and reactions. At the same time, they are, just as much as the vocal apparatus, a usable basis for creating digital expressions and impressions; consider, for example, regular sign languages and smaller sign vocabularies developed for specific uses, for example, hand and arm signs used by military personnel.

Auto-Tune is an audio processor that can correct the pitch of singers singing slightly out of tune, in other words, to digitize the pitch of an analog voice. Something similar could no doubt be arranged for the theremin. The use of Auto-Tune has been

criticized both for making inept singers sound as if they actually can sing and for flattening—"Photoshopping"—the human voice. It should be noted that it also has been used as a creative device by artists like Cher and Snoop Dogg. That you *can* sing off-key shows there is richness of expression, but if you don't develop your ability to control pitch you cannot exploit that richness. It is quite clear that small, tightly controlled deviations from the nominal pitch is an important expressive device in vocal music (like indeed in much instrumental music), which can take the form of a vibrato or an accent in performing an espressivo, for example.

It seems as if faceless interaction has a tendency to influence the relationship between richness and precision. If this relationship also has the quality of being a trade-off is less clear. What is clear is that any designer making decisions about faceless interactions has to consider the relationship between richness and precision, between digital and analog, in a more developed way than what is required for traditional interfaces.

## 6. FACELESSNESS: WHAT LIES AHEAD?

First, let us make it clear that we do not foresee the demise of the "traditional," strictly circumscribed interface: Digital artifacts with clearly demarcated interaction areas occupying a limited part of the artifact's surface will most probably still be around even when (and if) faceless interaction has become common.

Strictly circumscribed user interfaces have the general advantages of decreasing the risk of accidental interaction and simplifying the handling of the artifact as a physical object. Keeping the object's "smart parts" clearly separated from the "dumb parts" in this manner may help users to maintain their sense of security regarding when and which interactions are actually made, and make them feel more confident of being in control.

The downside—disregarding the problems of fitting enough complexity in a small space, discussed at length earlier—is that the user may need to seek out the user interface, to manipulate the object to get at it and orientate it properly. Displays, keyboards, and many other traditional interaction devices typically have a preferred orientation for operation.

### 6.1. Things, Beings, Fields

At this time we can envision three potential directions for the development of faceless interactions: one that will lead to "things," another that will lead to "beings," and a third leading to "fields" and a more diffuse sense of interaction liberated from the directedness toward some clearly identifiable and identified object that we find in all earlier notions of interaction and interface in HCI.

The things approach means that the traditional surface-bound interfaces disappears and the resulting artifacts can be interacted with, in similar ways to traditional, small, or medium-sized "dumb" things, natural or artificial—that is, by being moved,

squeezed, thrown, shaken, rubbed, bent, and so on, just like a chair can be inter-acted with in many ways without having a designated, strictly circumscribed surface for interaction.

The beings approach means that digital artifacts become more behavioral and intelligent. When we have the kind of objects we imagined earlier that are covered by some touch-sensitive display layer on top of some smart, shape-changing materi-als, we leave the realm of traditional objects and move into the world of sentient or intelligent beings or robots—objects you might shoo at or pat, or strike up a con-versation with. Interaction ceases to be a question of having detailed knowledge about manipulation via a designated interface and instead becomes a matter of understanding objectives, intentions and plans of the "being" and of behaving in a relevant fashion in relation to it.

The fields approach means that interaction is not done with a clear direction to any particular artifact or object. The notion of "user" becomes less appropriate, and it may be more relevant to see the human as an inhabitant, traveling though a field of interactive forces (as described earlier).

Each of these possible lines of development of faceless interaction generates new design challenges. First, there is a decision to be made about what services and func-tions are best served by being designed as a "thing," as a "being," or as part of a "field"—or as a more traditional interactive object.

One way of thinking about this decision is from the perspective of how obedient and controllable interfaces are versus how independent and autonomous. There are probably categories of objects that are suited to be designed as more obedient artifacts, as things we can control with greater ease in a traditional manner, which is different from the category of things that "talk back," act on their own initiative, and are better handled in terms of intentionality and agency. Within this kind of future, maybe one of the core design ambitions will be to decrease the risk of *accidental interaction*. For instance, by making it more clear to users which parts can be handled like any dumb thing and which parts cannot.

The three potential directions we have sketched here may be complemented with others. We are still far from a full understanding of all possible forms of interac-tion and what faceless interaction might lead to. Even though most of our traditional design principles and guidelines will still apply, interaction design will once again be broadened and require new skills and competences.

## 7. CONCLUSION

This article aspires to challenge HCI research to investigate some of the basic and often tacit assumptions about interaction and specifically about interfaces. We have proposed a way of thinking around interfaces that is not hampered by the metaphorical extension of "interface" to situations where no or little surface is offered.

In our attempt to examine the notion of *interface* we have introduced and dis-cussed a number of concepts (among others, interface thought styles, complexity and

control, forms of complexity, faceless interaction), each of which opens up a particular kind of analysis. The overall idea of this article is not to develop a final comprehensive definition of interaction and interfaces; instead our aim has been to further explore the richness that can be found if a common concept such as "interface" is opened up for closer examination with the purpose of developing a deeper understanding of its complexity and richness.

The introductory presentation of the different thought styles has made it possible for us to disentangle several aspects and forms of interaction not commonly examined. For instance we have extended the traditional understanding of the interface as a surface by adding the metaphorically extended Thought Styles 3 and 4. This extension made it clear that interfaces are today commonly thought of as *abstract* surfaces.

As a way to increase precision in definitions we have introduced the notion of *faceless interaction*. The quite strict definition of the notion of "interface" that we developed has made it possible for us to further investigate the thought styles. The stricter definition has also made it possible for us to introduce a fifth thought style that in many regards deviates from the traditional way of thinking about an interface.

We have also explored the richness and complexity that new forms of interaction bring to a design situation. In this article we have not tried to bring our insights to some clear implications for design in the form of guidelines or principles. We are convinced that it would be possible to do that based on our examination and analysis, but that is for another time and place. However, we are convinced that the kind of analysis we present in this article is of value to the field of HCI and interaction design not just from a theoretical point of view but also from a practical design perspective.

## NOTES

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