Affordance, Role, and Script as Complementary Concepts of Artefact-User Interaction, Illustrated by the Example of an Egg Separator

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Abstract

This article suggests employing the affordance concept, the role concept, and the script concept in a complementary manner as analytical tools for investigating artefact-user interaction at three different levels of stability, abstraction, and interrelatedness. It argues that the affordance concept is best suited to describing general possibilities for action constituted by common technical features in combination with common taken-for-granted knowledge of how to use them. The script concept, in contrast, is best suited to analysing the most concrete situations of interaction between artefacts and users: those situations in which the interaction is defined by one particular course of action. In between, there is a middle level characterised by artefacts and users being involved in several interrelated activities for which the role concept provides the tools for analysis.

Keywords: affordance, role, script, role theory, artefact-user interaction, actor-network theory

Introduction

The concept of affordance has become popular as a concept for analysing and understanding the interaction between technology and users. It is valued as a conceptual tool that allows the material dimension of sociotechnical constellations to be taken seriously and, thus, for social determinism to be avoided without falling back into technological determinism (Hutchby, 2001: 444-445, 453; Treem and Leonardi, 2013: 146-147; Davis and Chouinard, 2016: 246; Evans et al., 2017: 37). Early social constructivist approaches such as Pinch and Bijker's (1987) social construction of technology approach indeed leaned towards social determinism by exclusively focusing on how new technol-

ogy is shaped by social factors and ignoring how the technology in turn shapes social settings.

However, this missing part was soon added to the picture, most prominently by actor-network theory (ANT). To describe the heterogeneous ensembles of sociotechnical constellations in a way that equally considers social and material agency, the authors of ANT and related work developed a concept of script and referred to concepts from role theory. Similar to the concept of affordance, these are relational concepts for describing the interaction between technological artefacts and users, developed with the explicit intention of providing an alternative to both social

constructivism and technological determinism (Latour, 1988: 307-308; Akrich, 1992b: 208).

The affordance concept and the script and role concepts follow different paths. Norman (2002 [1988]) introduced the affordance concept into design studies to refer to the most general and enduring relational properties in the interaction between artefacts and users. In contrast, Akrich (1992b), Latour (1988) and Callon (1986a) introduced the concepts of script and role into ANT to show how there are no artefact-user relations based on stable properties of humans or nonhuman objects. By pointing out how the relations between artefacts and users are based on scripts and depend on how users and artefacts comply with the roles assigned to them, they disclosed how both these relations and the properties of the human and nonhuman entities involved are co-constructed and are continuously "in the making" (Latour, 1987: 1-17).

In the meantime, the scopes of both the affordance and the script concepts have changed. The affordance concept has been expanded considerably, including more specific and changeable relational properties of artefacts for users. Scholars now include relational properties that depend on individual perceptions and capabilities, and on social positions (Davis and Chouinard, 2016: 245-246), on diverse goals, and on different contexts (Treem and Leonardi, 2013: 146). Additionally, affordances are construed as properties that may occur at multiple levels of scope and abstraction (McVeigh-Schultz and Baym, 2015).[1] Conversely, the script concept has been applied to quite general and enduring aspects of artefact-user relations. The concept of gender script, for instance, focusses on how gender stereotypes and long-established gender relations are inscribed in and reproduced by technological objects (van Oost, 2003: 195).

Contrary to the tendency to extend the concepts, I advocate using them in a narrow and focused manner, applying each of them to capture those particular aspects of artefact-user interactions for which they are best suited. Accordingly, this article suggests employing the concepts of affordance, role, and script in a complementary manner to distinguish three different levels of stability, abstraction, and interrelatedness in

artefact-user interaction. The affordance concept can best be used to analyse general possibilities for action where the artefact has common technical features aligned with the users' culturally shaped common knowledge about how to use that artefact. The script concept can best be used to analyse the most concrete situations of interaction between artefacts and users where the interaction is defined by one particular course of action. The role concept covers analysis of artefact-user interactions at a middle level of level of stability, abstraction, and interrelatedness where artefacts and users are involved in several interrelated courses of action within particular fields of action.

The remainder of this paper is structured as follows. In the following section, I describe the roots of the affordance concept. It discusses some conceptual problems related to applying this concept to the relation between artefacts and users and suggests a use of the concept. Then, I cover the roots of the concepts of script and role and analyses similarities and differences between the two concepts. This analysis leads to viewing them as closely related but focusing on the interaction between artefacts and users with respect to either particular courses of action (script concept) or particular fields of actor positions (role concept). After that, I amalgamate these considerations and present my suggestion of how to employ the concepts of affordance, role, and script in a complementary way. The final section briefly summarises the paper.

Affordance

The affordance relation

Gibson invented the term affordance to name a particular relational notion of how the environment provides resources to animals (Gibson, 2015 [1986]: 119). According to his original definition, "[t]he *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill. These affordances *have to be measured relative to the animal*" (Gibson, 1979: 127 [emphasis in original]). The physical properties of the environment become resources or restrictions only in relation to the characteristics of an animal species. For heavy terrestrial animals, for instance,

terrestrial surfaces provide support and enable them to walk or to run while a water surface does not. For water bugs, however, water does provide a surface, which they can stand on and cross (Gibson, 2015 [1986]: 119-120). Thus, the stand-on-ability provided by a surface for an animal is a relational property, an affordance.

In Gibson's view, affordances result from the interaction between physical properties of the environment and species-related properties of animals. Species-related properties include shared physical attributes and abilities such as weight, size, or locomotion abilities. They also include shared behaviours as defined by the species' way of life. These attributes, abilities, and ways of living determine how the environment with its physical properties becomes valuable for the animal (Gibson, 2015 [1986]: 130-132). For Gibson, affordances are invariant to the actual needs and perceptions of the individual animal (Gibson, 2015 [1986]: 121). They exist for the animal whether or not it pays attention to them or feels the need to refer to them in the actual situation. This invariance arises from affordances reflecting the relation between environmental properties and properties of animal species and not the relation between environmental properties and the individual animal with its actual perceptions and views.

Gibson also applies his affordance concept to humans, which is unproblematic as long as the affordance relation is a relationship between environmental properties and the attributes and abilities of the human body. For instance, because of the morphology of the human hand, certain objects afford grasping them (Gibson 2015 [1986], 34-35). However, most of the characteristics and capabilities of human actors that make objects valuable to them are not just characteristics and abilities of the human body itself but are acquired by learning and training within and as part of particular cultural contexts. Thus, most of the time, the value of objects for humans is not defined by characteristics humans share as a species but by particular sets of cultural knowledge, skills, beliefs, values, etc. The same applies to the ways of life of humans. Since "man is by nature a cultural being", as Gehlen (1950: 86) puts it, even the most basic species-related needs are culturally shaped. Consequently, the affordance concept is not easily

transferable from animals to humans, as we will see in the next section.

Affordances of artefacts for users

The rise of the affordance concept in design and technology studies began with Norman utilising it as a tool for distinguishing between good and bad design of objects. In Norman's reformulation of Gibson's concept, "the term *affordance* refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used" (Norman, 2002 [1988]: 9). Affordances are the "possible uses, actions, and functions" (Norman, 2002 [1988]: 82) of objects for users. And they are "jointly determined by the qualities of the object and the abilities of the agent that is interacting" (Norman, 2013: 11). Norman's view on affordances has strongly influenced the concept's subsequent development. Most of the current definitions focus on the interaction between artificial objects – mainly technological artefacts – and human actors in their capacity as users. Most of them share the view that affordances are possibilities for action and that they are relational properties (Evans et al., 2017: 36, 39; Hutchby, 2001: 444; Treem and Leonardi, 2013: 146; Davis and Chouinard, 2016: 241).

Norman is especially interested in what he calls "perceived affordances" (Norman, 1999: 39), affordances that can be deduced directly from the visible[2] structure of the objects without the user needing further information: "Affordances specify the range of possible activities, but affordances are of little use if they are not visible to the users. Hence, the art of the designer is to ensure that the desired, relevant actions are readily perceivable" (Norman, 1999: 41). Designed objects are generally supposed to be used in particular ways. The task of the designer is to enhance the visibility of the respective possibilities for action but not of all the other affordances and especially not of those seen as unwanted ways of using the object. For example, a designer would want to render visible the particular kind of graspability of a porcelain cup but not necessarily its throwability.

Perceived affordances are affordances that are advertised directly by the physical shape of the object (Norman, 2013: 18). According to Norman, a

flat plate mounted on a door signals by its physical appearance that the door affords pushing. In the same way, a doorknob signals that the knob affords turning, pushing, and pulling; or a slot signals that it is for inserting things into (Norman, 2013: 13). Norman sharply distinguishes between perceived affordances and perceptions of possibilities for actions that are based on cultural knowledge of some kind: "A doorknob has the perceived affordance of graspability. But knowing that it is the doorknob that is used to open and close doors is learned […] The same devices on fixed walls would have a different interpretation […] The interpretation of a perceived affordance is a cultural convention." (Norman, 2013: 145)

There are two major conceptual problems with Norman's strict distinction between perceived affordances as "properties of the world" and the "arbitrary, artificial and learned" (Norman, 1999: 42) cultural conventions:[3]

(1) Not one of Norman's examples actually supports his claim that the physical shape alone without additional knowledge-based interpretations allows people to figure out how to use the object. Consider, for example, the physical shape of a slot, which according to Norman signals that it is for inserting things into. Actually, however, there are many objects with slots, where inserting things into would not be the best of ideas – the slots of a radiator grill for instance. Whether slots really are for inserting things does obviously not follow directly from their physical shape but requires learned knowledge. Nor does the physical shape of a slot indicate which kind of things to insert. Even if, as in the case of coin-operated machines, the slots are precisely adapted to the size of the accepted coins, a number of other objects could still fit into the slots (e.g., foreign coins, folded bills, chewing gum).

Truly, most people do not need further instructions to use coin slots properly; however, not because the slot itself signifies how it should be used but because people have become accustomed to using coin slots and the corresponding knowledge has become part of the tacit everyday knowledge of our technological civilisation.

Harry Collins (1990: 106) nicely illustrates this by comparing different generations of slot machines:

> What were once explicit rules can become part of a society's unexpressed *taken-for-granted-reality* […] Shifts of this sort can be seen by looking at the changing instructions on simple machines in the public domain. For example, an elementary pinball machine, built in the 1830s […] has instructions that include the following: […] '1. Place coin or free play token in coin slide and push slide all the way in until balls have cleared then pull slide all the way out. 2. Push RED knob to elevate ball to playing surface. 3. Pull back BLACK knob on plunger and release'. Nowadays, everyone knows how to put money in a pinball machine and how to make the balls run. The 1980s version has only the following rudimentary instructions in the place of what went before: 'Insert coin to start machine', 'Insert coins for additional players'. (Collins, 1990: 106)

(2) Norman does not clarify whether possibilities for action provided by artificially fabricated physical properties of artefacts can count as affordances. Consider, for instance, the mechanism enabling users to unlock doors by turning doorknobs clockwise or counter clockwise. Without doubt, how to turn the doorknob is learned knowledge and, thus, a cultural convention. Changing this convention, however, would also require changing the mechanism itself. Consequently, the mechanism is part of the cultural convention. Thus, according to Norman's binary distinction between affordances and conventions, the "unlock-ability" provided by the door locking mechanism is not an affordance. More generally: If a possibility for action can be technically implemented in different ways, and thus requires different learned knowledge of how to use the respective artefact, that possibility cannot be considered an affordance. For good reasons, Norman avoids raising this consequence. In a world filled with artefacts of this kind, it simply makes no sense to distinguish in this way between affordances and conventions.

Both of these conceptual problems point in the same direction: When analysing the affordance relation between humans and their environment, it is not helpful to distinguish between properties of the world and artificially fabricated properties. This distinction creates more problems than

benefits, especially when the objects of interest in the environment are artefacts. For objects with artificially fabricated properties, cultural knowledge necessarily affects the affordance relation. If an artefact's mechanism represents the technical side of a cultural practice, the respective possibility for action exists only for users who know this practice. Thus, culture-specific needs, views and practices are involved in defining the range of possible activities offered by the design of these objects as well as the range of possible uses considered by their users.

Affordances and taken-for-granted knowledge

The strength of the affordance concept lies in its ability to capture the most stable and context-independent use-related properties of objects and, nevertheless, to conceive of them as relational properties. For Gibson and Norman, affordances are simultaneously stable and relational properties because they conceive the affordances "as organism-environment relations" (Davis and Chouinard, 2016: 244). However, as argued above, due to the cultural orientations and perceptions involved, the relation between users and their artefacts is not of this kind. Attempts have been made to deal with this problem by counterbalancing the relativity of user perception with the fixedness of materiality. Accordingly, Treem and Leonardi argue "that the affordances of one technology are often the same or similar across diverse organisational settings because the material features of the technology place limits on the kinds of interpretations people can form of it and the uses to which it can be put" (Treem and Leonardi, 2013: 146 with reference to Leonardi and Bailey, 2008 and Leonardi, 2011).

Artefacts' perceivable material features do matter as signifiers of possibilities for action. But they do not work as unmediated as assumed by Gibson and Norman (Bloomfield et al., 2010: 415). Obviously, the physical shape of an artefact can be used in design to narrow down the options of how to handle it. Consider, for instance, a door without any bar, knob, or handle providing a grip for pulling but instead equipped with a metal plate where the average-sized standing human would put their hand to push. Most people will quite

naturally push this door to open it. Its physical shape narrows down the options of how to physically manipulate the door from pulling or pushing to pushing only (Donald A. Norman, 2013: 15, 60, 133-134). However, it has this effect only because most people know what doors look like, what their intended use is, and that they are usually opened by either pulling or pushing.

The more such use-related knowledge is part of users' tacit and taken-for-granted everyday knowledge, the more effortless it comes to mind when people perceive the artefact's corresponding feature. The more common this knowledge is, the more general can these features be employed as signifiers. Many technical features are so common and so closely related to common everyday practices of use and to the corresponding tacit knowledge that they have turned into universally understandable signifiers. An example is the coin slot mentioned above. Not only physical features but also symbol-based technical features turn into universally understandable signifiers in this way. Consider, for instance, the technical feature for deleting files, which is provided in countless computer programs by a small space on the screen with a symbol showing a wastebasket to where files are dragged and dropped to delete them.

In some crucial respects, the relation between users and an artefact is different to the organism-environment relation. Consequently, the concept of affordance is not simply transferable without losing conceptual clarity. The considerations presented here are an attempt to preserve the core content of the original concept while adapting it to the characteristics of artefacts and humans (in contrast to objects of the environment and animals in general). Accordingly, the term affordance should be reserved for those relational properties offered by artefacts for human users that result from common technical features in combination with common taken-for-granted knowledge and know-how, making them easily understandable and useable for large user populations.

There are other concepts that address the importance of established common understandings of how to use technological artefacts. Williams et al. (2005) argue that the influence

of established understandings on "both the design and the appropriation of new technologies" (Williams et al., 2005: 123) is comparable to the influence of genres in film production and consumption. "Film studies emphasized the elaborate codes, grammars and rules of production developed by cinema and the mature ability of viewers to decode the film text" (Williams et al., 2005: 123). In a similar way, the familiar and widely applicable knowledge about particular classes of technological artefacts such as the slot machines or the typical elements of graphical user interfaces mentioned above also represent genres. "Such genres serve as an important resource for designers (in reducing uncertainty about consumer acceptance) and for users (in terms of facilitating understanding of the uses and affordances of artefacts and thus their ease of uptake and usability)" (Williams et al., 2005: 123-124; cf. Löwgren and Stolterman, 2004: 103, 166). Based on these considerations, Hyysalo (2010) characterises the "genres of prevailing technological culture" as "cultural stabilization of meanings" or "cultural maturation" (Hyysalo, 2010: 13). The "conventions, images, 'grammars,' and narrative structures" provided by cultural maturation, he argues, "can be trusted by designers to be decoded in fairly nuanced ways by all those people who have basic competency in a given technological culture" (Hyysalo, 2010: 13).

The concepts of genres of technological culture and cultural maturation share with the reformulation of the affordance concept I have suggested above the view that the taken-for-granted knowledge of established technological cultures matters. Because it provides orientation at a general level where it is applicable to the many situations of using technology that presuppose the respective technological literacy. However, the main focus of the concepts of artefact genre and cultural maturation lies on cultural stabilisation of meanings, while the affordance concept allows for a more explicit account of the socio-material character of the general and generic possibilities for action discussed here. From this perspective, these possibilities for action are not simply a result of common knowledge that informs both the design and the use of technological artefacts. Rather, they result from

common technical features in combination with common taken-for-granted knowledge. Though it is true that these technical features are not just physical affordances in Norman's sense but are also shaped by cultural conventions, it is also true that they are not entirely conventional. The technical features also rely on the material properties of the artefacts' components and processes. The possibilities for action they provide are also a result of material agency (Pickering, 1993) which is beyond the reach of cultural conventions. For instance, cultural conventions have prompted designers to construct bicycles for women on which the user sits aside just like the equestriennes of former times sat on the side-saddle (Pinch and Bijker, 1987: 38). In the early days of the bicycle, this materialised cultural convention may have given some groups of women the option of riding bicycles without violating the conventions of modesty of their time. However, without the conservation of angular momentum that prevents the moving bicycle from tipping over – a physical property of the bicycle's spinning wheels that exists independent from any cultural convention – this option would not exist at all.

Script and role

Callon and Latour developed ANT to overcome shortcomings of earlier approaches in the social study of science and technology. Their "general symmetry principle" (Callon and Latour, 1992: 348) results from a critique of how the social constructivists privileged social factors (Latour, 1987: 143-144; Callon, 1986b: 197-198). To describe technological innovation in a way that takes social and material agency equally into account, Callon and Latour draw on notions from role theory. With the same intention, Akrich (1992b: 206) developed her concept of script, which soon became part of the analytic tools of actor-network theory.

According to Callon (1986b: 211), a successful innovation is a result of a process "by which a set of interrelated roles is defined and attributed to actors who accept them". Innovators at first envision a scenario (Callon, 1986a: 26; Akrich, 1992a: 174, 1992b: 208), which defines roles for a set of human and nonhuman entities that are supposed to assume them. Developing and

implementing a new technology then is a process of enrolling these entities, that is, of making sure that they adopt the proposed roles. This does not mean that innovators are necessarily successful in enrolling the relevant entities according to their plans. But when a successful technological innovation eventually occurs, it is because, somehow, a sufficiently consistent and coherent set of interrelated roles has emerged.

Similar to Callon, Akrich argues "that when technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make the world into which the object is to be inserted. Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways." (Akrich, 1992b: 207-208) Accordingly, designing technical artefacts means inscribing "this vision of (or prediction about) the world in the technical content of the new object" (Akrich, 1992b: 208). Inscribing a particular role into a technological artefact implies prescribing corresponding roles to human actors. Adopting Akrich's terminology, Latour (1988) points out that prescription "is very much like 'role expectation' in sociology, except that it may be inscribed or encoded in the machine" (Latour, 1988: 306). Just as role expectations cannot guarantee that people behave in a role-compliant manner, prescriptions also do not determine behaviour (Akrich, 1992b: 208; The Berlin Script Collective, 2017: 13-15).

Both the script concept and the role concept are relational concepts. Just like the affordance concept, they describe the possibilities for action provided by technological artefacts as relational properties. The backdrop against which this notion is established is the relation of distributed agency. The script and the role concept capture the relation of distributed agency from two different perspectives. From the perspective of the script concept, it is a relation of distributed action while, from the role concept's perspective, it is a relation of distributed actor positions.

The script relation

According to Akrich, the script is the innovators' idea about how a new technological artefact

shall work as inscribed in its technical content. The artefact's technical features and properties embody the designer's concept of how and for which purposes the artefact should be used. "Thus, like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act" (Akrich, 1992b: 208; Akrich and Latour, 1992). The script as inscribed in the artefact "implies a sharing of competences between the artefact proper, its user, and a body of social and technical elements constituting their common environment" (Akrich, 1992a: 174). Depending on how the users subscribe to what is prescribed to them or try to negotiate adjustments or changes (Akrich and Latour, 1992: 261), the script becomes stabilised, modified, changed, or even abandoned.

The script concept has been criticised for overestimating the importance of the designers' intentions and interests. Together with Woolgar's notion of the designer configuring the user (Woolgar, 1991), it has been accused "to convey a somewhat mechanistic 'linear' view of how those embedded values and scripts are likely to be reproduced when those artefacts are subsequently consumed." (Williams et al., 2005: 96) It thus "remains at the level of materialized interests and influences and does not reach into what happens in the encounters between materials and humans" (Hyysalo, 2010: 246). To some extent, Akrich has anticipated these objections by emphasising that "the user, as imagined by the designer" (Akrich, 1992b: 209) is at first just a hypothesis and that it is subject to "the negotiations between the innovator and the potential users" (Akrich, 1992b: 208) if and how these hypotheses become reality. However, as long as the script is construed as being primarily the brainchild of the designer and as long as inscribing scripts into technology is considered the main way of implementing them, the script concept still reflects a designer-centred view that hinders to pay due attention to other sources of scripts and other ways of inscribing them.

This bias can be avoided by acknowledging that every script able to govern a particular kind of distributed action as a whole will have to be sufficiently inscribed into all of the main components that make up the respective interrelated set of distributed activities. It will have to be

inscribed not only into technology but also in human practices and in situational requirements of the action. Accordingly, it should be obvious that every script of this kind is the result of heterogeneous engineering (Law, 1987). It may rely on forms of human conduct as much as on technological means. And since "design is rarely a process of invention *ab initio*" (Williams et al., 2005: 118), it may rely on pre-existing routines or new ideas of how to do things as much as it may rely on pre-existing or new technological means. Thus, who and what the 'authors' of a script are, if they can be identified at all, is an empirical question.

The most striking examples of artefact-user interaction governed by scripts are provided by single-purpose technologies, that is, by artefacts that are designed to be used in one particular way, for one particular purpose, and in one particular situation. Consider, for instance, the bulb-shaped egg separator. It looks similar to a honk ball, consisting of a silicone ball that fits into the hand with a small opening at one side. The single purpose of this artefact is to separate the yolk of an egg from the white. To separate the egg, the user has to squeeze the ball, to place the opening of the device directly over the yolk of an egg that has been cracked into a bowl and then to release the ball. This action causes the yolk to be sucked up. To empty out the yolk, the user has to squeeze the ball again.

As this example shows, the script of a distributed action can precisely prescribe what users have to do and what conditions must be met to make use of the possibilities for action inscribed in the artefact. And vice versa, the script can precisely prescribe the technical features of the artefact that are required to fit with the corresponding human conduct. This is because all the inscribed and prescribed activities are the components of one particular course of action that is governed by the script. From the perspective of the script concept, the properties of technological artefacts are relational properties because they contribute to particular courses of action. Being useless and meaningless on their own, these contributions become useful and meaningful as components of the overall courses of action to which they contribute.

Another criticism of the script concept is that artefact-user interaction is seldom governed by individual scripts because users nowadays interact much more often with complex heterogeneous ensembles than with single-purpose technologies. As Hyysalo puts it:

> The 'stage' of socio-technical encounters is almost never cleared to include only the designers' script (or "program for action") and users' response to it (e.g., possible anti-programs or "compliant nonalignment"). Further, many technologies indeed are heterogeneous ensembles that tend to have more complex affordances rather than clear scripts (Hyysalo, 2010: 245).
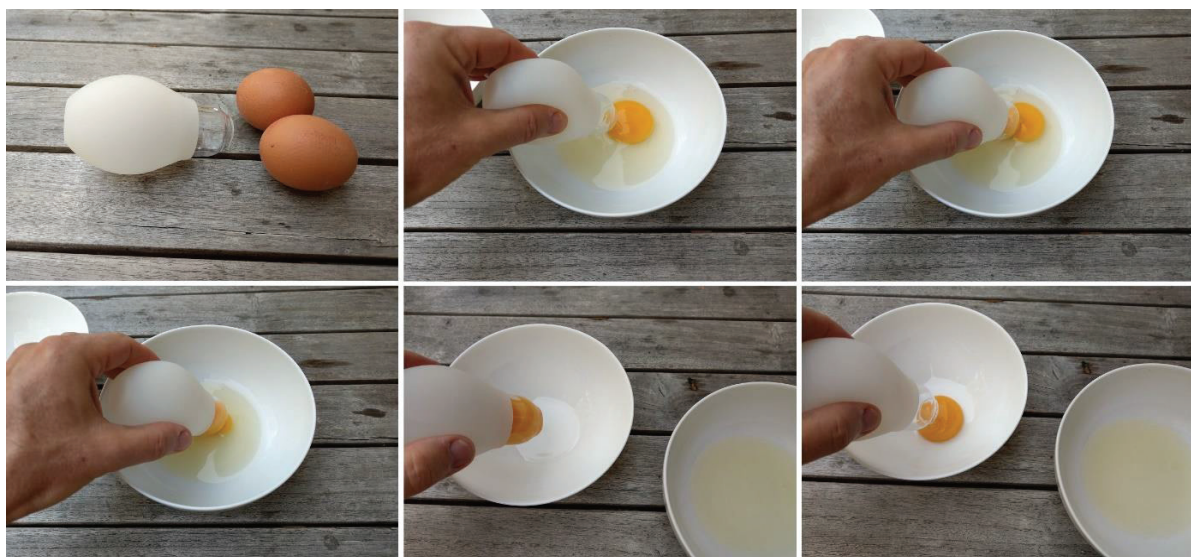

Figure 1. The script of the bulb-shaped egg separator

I agree and disagree with this criticism. I disagree because there actually are numerous single-purpose technologies not only in the world of today's physical artefacts but also in the world of digital artefacts where they are often less visible because they manifest as individual functions within more comprehensive software systems. However, the spell-checker of a text processing software, the file management subprogram of office software, or the noise filter of audio editing software are single-purpose technologies just like the washing machine, the tooth brush, or the railway gate.

On the other hand, I agree that many technological artefacts are components of more complex socio-material ensembles in which users are addressed in different ways and which have different meanings for the different groups of actors who are involved in them. As Williams et al. put it:

> Users are not unitary […]. Different aspects of the representation of the same users are important for different players in the development process. […] They can also be interpreted in different ways. For example, while commercial managers may be concerned with the activities of an organisation, interface designers are concerned with activities of individuals. (Williams et al., 2005: 117)

These heterogeneous ensembles are necessarily the result of "different layers and different modes of configuration" (Hyysalo, 2010: 245). Thus, the scripts in which the human and non-human components of these ensembles are involved become interrelated and intermingled in more or less complex ways. To capture this aspect of artefact-user interaction, I draw on sociological role theory.

The role relation

Sociological role theory (Linton, 1936: 113-131; Merton, 1957; Dahrendorf, 1968 [1958]) describes and analyses how the behaviour of human actors is shaped by "patterned expectations of others" (Merton, 1957: 110), which are linked to the social positions the actors occupy, a social position being a "place in a field of social relations" (Dahrendorf, 1968 [1958]: 34). The patterned expectations of others to holders of positions are called role expectations and the corresponding bundles of behaviour are called role behaviour. Role expectations and role behaviour are relational phenomena. They result from relations between social positions. Role expectations are expectations that individuals, as holders of interrelated positions, have of each other. Roles, therefore, are bundles of position-related behaviours where human actors react to position-related expectations of other actors. "Positions merely identify places in fields of reference; roles tell us about how people in given positions relate to people in other positions in the same field" (Dahrendorf, 1968 [1958]: 36). Social positions are also relational phenomena. They are defined by the role expectations directed at them from other social positions in the same field of positions. Positions are, so to speak, the nodes of a network that results from the relations between theses nodes.

What is a prescription from the perspective of the script concept is a role expectation from the perspective of role theory. What is an inscription from the first perspective is the implementation of a role behaviour from the second perspective. The notion that inscriptions imply prescriptions translates into the notion that the role behaviour of the holder of one position implies role expectations regarding the behaviour of the holders of other interrelated positions. Applying role theory to the relation between artefacts and users, however, requires modifying the original sociological concept and viewing not just humans but both humans and artefacts as holders of positions. Accordingly, both have to be construed as entities that direct role expectations at other entities and are subject to role expectations directed at them (Schulz-Schaeffer, 2016: 6-11). And thus, the behaviour of both humans and artefacts can be described as role-compliant or role-deviant behaviour. Obviously, this extension of role theory to nonhuman actors fits well to ANT's general symmetry principle.

As an example, consider Akrich's (1992b: 217-218) case of a particular type of electricity meter that failed to fulfil a small but crucial part of the expectations placed on it by the electricity company. The role assigned to electricity meters in customers' households is to measure the amount of current consumed. The electricity meter in question was perfectly suited to this task. However, it possessed a feature the company

really did not want: it could easily be deactivated by tapping it, allowing customers to consume unbilled electricity. Thus, "the meter failed in its prescribed role" (Akrich, 1992b: 218). In terms of role theory, not to be easily manipulated by the customers is a role expectation directed at a meter by the supplier. Conversely, allowing easy deactivation is a role-deviant behaviour.

I suggest referring more thoroughly to role theory than do the proponents of ANT and especially putting more weight on distinguishing between roles and positions (Schulz-Schaeffer, 2016: 10-13). This distinction reflects how, in a network of interrelated roles, every actor at one of the network's nodes is subject to different bundles of role expectations from the actors at other network nodes. In this way, role theory takes into account that holders of positions do not face a single homogeneous set of expectations from others.

To return to Akrich's example: Not to be easily manipulated is an expectation of the electricity meter from the electricity company's position as a seller of electricity. From the customers' position as buyers, however, it is probably more important that the device is correctly calibrated and is not used by the company as a means of overcharging them. These different role expectations of the meter are closely connected to the role expectations predominant in the relation between the positions of seller and buyer. This relation is constituted not primarily by trust but by contractual rights and obligations and by the corresponding possibilities and limits of enforcing them. This in turn shapes the different role expectations addressed from both the company's and the users' positions to the position of the device that measures the households' electricity consumptions.

Sociological role theory focusses on relationships actors have as holders of interrelated positions. Thus, role theory is not interested in every behaviour the holder of a position shows but only in those behaviours that correspond to role expectations of other positions. Applied to the behaviour of artefacts, this means that only those materialised functions and features deserve attention that are related to patterned expectations of end-users, service-providers, installers,

maintainers, producers, connected artefacts, and other interrelated positions. However, designers of technological features do not just react to pre-existing expectations from one of these interrelated positions but develop functions and features for imagined future users. These functions and features thus do not reflect existing role relationships but rather assumptions about or suggestions for role relationships that have yet to be established. To put it another way, such functions and features assume or suggest future role expectations. As such, they are relevant from the point of view of the role concept because the dynamics of role relationships is defined by the stability or change of the role expectations involved.

There is a significant difference between physical artefacts and information technology with regard to functions and features that are not actually met by corresponding role expectations. With physical artefacts, it is much more likely than with software that features for which no usages evolve will eventually vanish from the artefact because of the effort it takes to physically produce and maintain the respective features. With software, however, it requires little extra effort to keep technological features of previous versions, and it is often easier to keep them than to remove them. Also, it takes much less effort to add functions and features that have been already developed elsewhere. Consequently, software programs often resemble toolboxes leaving it to the users, which tools to use or to ignore. Especially with respect to software, role-based analysis thus has to take into account that artefacts may include features that never have been and never will be relevant for most of the users. It also has to take into account that when artefacts resemble toolboxes, different users may choose quite different sets and configurations of the available tools (DeSanctis and Poole, 1994).

Differences between script-governed and role-governed artefact-user relations

The distinction between positions and roles reveals some important differences between the script concept and the role concept. The script concept focusses on the interrelatedness of distributed activities in particular courses of action. The role-concept draws attention to the fact that

the interaction between artefacts and users are rarely defined just by one script. Rather, as soon as the relation between artefacts and users includes more than two interrelated positions, the holders of these positions are involved in different courses of action in different actor constellations. Accordingly, there are different constellations of interrelated role expectations, which become manifest in different scripts, inscriptions, and prescriptions.

For instance, in its position as a seller and in relation to the customers as buyers, the electricity company employs the electricity meter to implement a script that is intended to prevent the customers from consuming unbilled electricity. The customers in their position as buyers, on the other hand, are interested in scripts that prevent the seller from overcharging them. They may mobilise the support of regulatory bodies (yet another position) to ensure that the meters are properly calibrated, thus inscribing a script in the device that prevents the seller from cheating on them. There are several other positions, which, in relation to the meter's position, lead to further scripts, inscriptions, and prescriptions, such as the company's interest as the provider and maintainer of the meters in devices that are easy to install and maintain.

As artefact-user relations are embedded in increasingly complex sociotechnical constellations, the number of positions and role relationships also increases. The development from conventional electricity meters to smart meters and to the smart grid infrastructure provides a good example of this. When conventional meters are replaced by smart meters capable of transmitting data about power consumption in real-time and these smart meters become part of smart grid infrastructures "a number of new roles are available for the future smart grid 'users' across the energy supply chain" (Silvast et al., 2018: 10). Between producers and users, a number of intermediate user (or producer) positions evolve such as service providers, which use the data from the smart meters to provide producers, suppliers, and end-users with new options of monitoring and managing energy production, distribution, and consumption. Moreover, in many complex sociotechnical constellations "the" end-user is no longer just one position. In smart grid infrastructures, for

example, the private household as a user position may become quite different from the position of commercial energy users. These are differences, which "the umbrella term 'user' masks" (Silvast et al., 2018: 11). They become visible only from a perspective such as the role concept, which allows analysing the co-evolution of the components and the relationships of such constellations.

Artefact-user relations that include several interrelated positions differ in two major respects from those that are constituted essentially as relations of distributed agency with respect to a particular course of action. First, artefact-user relations that are constituted by a single script are much easier to establish, to change, and to dissolve than those that include several interrelated positions. The latter require more effort to coordinate the distributed activities. Not only are there different courses of action to oversee but it must also be ensured that they are sufficiently adjusted to one another so as not to interfere with each other. However, when they become adjusted to one another, then the resulting constellations of positions, roles, and distributed activities tend to be more stable and more resistant to change than constellations defined by a single script. This stability arises from each position being defined by the role expectations directed at them from several other positions. Thus, if one script fails and one role relation is destabilised, the corresponding positions do not dissolve automatically. They are still involved in several other role relations with other positions, which also define them. When the positions involved and the corresponding roles and scripts are sufficiently adjusted to each other, it also becomes more difficult to successfully change, remove, or add a position or relation without having to modify a number of other positions and relations. This adds stability to the positions and role relations.

Second, the role concept draws attention to the fact that new technologies and the associated new scripts and role relations are most often not created ex nihilo but build on already existing positions and role relations. Artefact-user relations that are defined by several interrelated positions may (and mostly actually do) include already existing positions. In Akrich's electricity meter example, this is the case for the positions as seller

and buyer. Obviously, these positions and the corresponding roles precede the development of the power supply infrastructure. At the same time, they strongly influence many of the role expectations addressed to the meter.

Though it is true that positions are stabilised by the role relationships between them and vice versa, it is – at least in post-traditional societies – also true that they are constantly subject to change. Thus, to some extent the components of sociotechnical constellations and the relationships between them are still in the making. Thus, even after a sociotechnical constellation has been stabilised to some extent, it is still subject to "series of configurational movements" (Hyysalo et al., 2019: 13-14). This is not only because the introduction of new technology may lead to new or changing positions (Barley, 1990), but also because of the active involvement of users of all kinds in innovation processes (Kohtala et al., 2020). Again, the smart meter provides a good example. As a device that allows suppliers and users remote readings, the smart meter occupies a position that is in many respects still similar to that of the conventional meter though it enables new uses such as remote monitoring of household consumption and raises new concerns e.g. with respect to privacy issues. As part of future smart grid infrastructures, however, the position of the device may change dramatically and its original determination as a device for measuring power consumption may become but one of its many new uses (Silvast et al., 2018: 8-10).

Affordances, roles, and scripts: different levels of stability, abstraction, and interrelatedness

The strength of the affordance concept is that it grasps the most stable and common use-related properties of artefacts. As argued above, the affordance relation results from common technical features in combination with common taken-for-granted knowledge of how to design and to use them. The script concept, in contrast, is especially well suited to describing the most fluid, unstable, and arbitrary aspects of artefact-user relations. Thus, it is best suited to analysing how new sequences of distributed activities are nego-

tiated and built by attempts to align new technical features with new practices of use. The role concept comes into play when analysing distributed actions, which gain in stability to the extent that they are related to other courses of action within a field of positions. Integrated sets of interrelated courses of action represent a level of stability and durability of artefact-user relations that lies between the script level and the affordance level, thus necessitating a different, role level, analysis.

Affordances, roles, and scripts represent not only different levels of stability but also different levels of abstraction and interrelatedness. Affordances are the most abstract artefact-user relations. They are general possibilities for action with a wide range of possible applications including different artefacts and contexts of use. In contrast, the script of a single-purpose device represents the most concrete and situation-specific artefact-user relation. The meaning of the artefact's technical features and the meaning of the corresponding user activities are largely derived from their contribution to a single course of action within a particular situation. The middle level arises for artefact-user relations that are part of a set of interrelated positions and roles. To the extent that the holders of positions are involved in role relations with the holders of different other positions, they are involved in different situations and their existence and their behaviour becomes less situation-specific. Accordingly, the artefact-user relation will be defined by a number of possibilities for action for different situations of use. However, the range of possible applications is limited by the boundaries of the sociotechnical constellation described by the respective set of interrelated positions. Within these boundaries, a common basic understanding of the artefact-user relation can emerge.

For an illustration of how the concepts of script, role, and affordance support analysing artefact-user interaction at three different levels of stability, abstraction, and interrelatedness, consider once again the egg separator. Separating eggs is interrelated with many other courses of action in the field of cooking. The corresponding actor positions are well integrated. Many of them are rather stable, such as the position of the cook, the stove, the cookware, or the consumer of meals.

However, though separating eggs is a deeply embedded activity, there are different procedures to achieve this. Probably, the most common procedure uses no other devices than the two eggshells between which the egg is tossed after cracking it open. But there are numerous other procedures. Besides the procedure with the bulb-shaped separator described above, there is, for instance, a procedure where a separating device that looks like a small coarse mesh sieve is used. Here, the intended use is to spoon the yolk of an egg cracked into a bowl and to drain the white by lifting the device from the bowl. Each one of these procedures is unstable in the sense that they are easily replaceable by another. Why is that?

The reason is that, first, the differences between these procedures are mainly determined by the script of the respective procedure and, second, these scripts do not substantially affect other positions and role relations within the field of cooking. This is not to say that the actor positions defined by the egg-separating procedures do not come with role expectations towards other positions in the field of cooking. On the contrary! All of these procedures presuppose people as cooks who are skilful enough to crack eggs without damaging the yolks; all of them presuppose that eggs and suitable bowls are at hand; all of them presuppose consumers willing to eat food that contains egg yolk (or egg white), etc. All these role expectations, however, address already existing role behaviours of already established positions in the field of cooking. Thus, the existing network of positions does not have to be significantly adjusted to include one or other of the procedures of egg separation. In turn, this means that the existing network of positions does not contribute to defining the actor positions specific to the different egg-separating procedures. Consequently, the existing network does not stabilise any of them more than any other one. This puts the different egg-separating devices into positions where they are easily replaceable.

In this respect, the position of any of the artefacts serving as egg-separating devices is quite different from, for example, the position of the kitchen bowl. Though it is surely possible for several cooking activities, where one usually uses bowls to use something else, this exchange would not endanger the overall position of the bowl. This is because the bowl's position is stabilised by its roles in many different courses of action and its role relations with several other positions. The kitchen bowl plays a role not only in separating eggs but also, e.g., in mixing ingredients, in serving as dinnerware, or in storing food leftovers in the refrigerator. Thus, removing the kitchen bowl from one or another of these tasks or implementing new scripts, which prescribe additional roles to it, may cause adjustments, but would probably not substantially affect the bowl's position in the kitchen.

Even for people who often cook, it is far from obvious what the intended use of a bulb-shaped egg separator is when they first encounter the device. In contrast, the bowl's property to hold non-solid ingredients such as liquids and powders in place while providing a wide opening allowing manipulation is made use of in many common cooking practices of combining, mixing, and portioning ingredients. Thus, even people who only cook occasionally share a common basic understanding of the intended and other possible uses of bowls.

Moreover, one can reasonably argue that this knowledge is not only shared within the field of cooking but that it is universal knowledge. Consequently, the possibilities for action provided as described by the physical shape of the bowl in combination with common practices of processing non-solid materials and the corresponding know-how are affordances in our analytical framework. To say that bowls afford combining or mixing non-solid materials, thus, is to say that the respective sequences of distributed action and the corresponding artefact-user relations depend neither on a particular script nor on a particular network of positions and role relations. Rather, they depend on the taken-for-grantedness of common knowledge of how to make use of particular physical features of bowls.

In a similar way, the possibilities to suck in and to press out nonsolid materials by releasing or squeezing the rubber ball are affordances of the bulb-shaped egg separator that exist independent of the script and the role relations in which this device is involved. Based on common knowledge about squeezable containers with narrow orifices,

such as squeeze bottles or pipettes, unknowing users exploring how to use a bulb-shaped egg separator will eventually conclude that its proper use might somehow include squeezing and releasing the ball. However, this conclusion still leaves countless options open. Affordances can reach a level of abstraction that requires additional field-specific knowledge or knowledge provided by a particular script that relate them to particular contexts of use.

Affordance, role, and script as analytical tools

Affordances, roles, and scripts, as I have presented them in this paper, are meant to serve as analytical tools for investigating artefact-user relations. As analytical tools, they are abstractions, simplifications of an empirical reality, which obviously is more entangled and less well sorted than these concepts reflect. The rationale for using concepts of this kind is to construct pure types of the empirical phenomena under observation, which "compared with actual historical reality […] are relatively lacking in fullness of concrete content" but "compensate for this disadvantage" in that they "offer a greater precision of concepts" (Weber, 1978 [1922]: 20). In the previous section, for the purpose of demonstrating how the three concepts are complementing each other I chose an empirical example, which in itself is relatively simple and well-sorted. This section provides a few considerations to support the claim that the approach suggested here is also apt for analysing artefact-user interaction within more complex sociotechnical constellations.

A characteristic of more complex settings is that the new technological artefacts involved are rarely developed from scratch but mostly rely somehow on pre-existing technological components, on routines of use established with technological predecessors, and on other more or less given aspects of the social or material world. Thus, not all components of such socio-material ensembles are "in the making" but some of them are "ready made" (Latour, 1987: 1-17; Schulz-Schaeffer, 2008, 146-148). How do all these "pre-configurations" (Hyysalo, 2010: 247) influence the emergence of new patterns of distributed action

and how adequate is it then to describe these patterns as scripts?

When new technologies rely on pre-existing components, for instance on off-the-shelf components, they also inherit, as Williams et al. (2005: 118) argue, the scripts inscribed into them. However, though the original intention thus is still inscribed into the design of the re-used components, new layers of meaning will obscure them and they will eventually be forgotten. Consequently, neither the designers, nor the users or the analysts "are in the position to read off these 'imported scripts'" (Williams et al., 2005: 118), which in the opinion of these authors speaks against the usefulness of the script concept. However, the problem raised here looks different when scripts are conceived as patterns of meaning that govern particular distributed actions as a whole and are not inscribed only into the technical components. From this perspective, characteristics of technological (or other) components that reflect prior scripts may relate in different ways to current scripts. They may influence current scripts by making it easier or more difficult to implement them or they may be irrelevant for current scripts.

Take for instance the Ferraris meter, an electro-mechanical electricity meter, which is still by far the most common electricity meter in German households.[4] The device has an aluminium rotor disc, which via electromagnetic induction is accelerated in proportion to the electricity consumed. For measuring the consumption, the device counts the rotations of the disc. Long ago, the designers of this device decided to make the edge of the rotor disk visible to the users and to provide it with a scale. This technical feature visualises power consumption in real-time, which may have been used in particular ways in the past. But for today's usages the visible scaled rotor disk has become rather irrelevant. Thus, any attempt to derive assumptions about how Ferraris meters are actually used today from this technical feature would be misleading. However, this would pose a problem for the script concept only if one believes that for identifying scripts it is sufficient to look at what is inscribed into technology.

The electromagnetic meter is an ancient component of the power system, a heterogeneous ensemble par excellence (Hughes, 1983,

1987), which has changed considerably, since this kind of meter became part of it. Inscribed into the device is the practise of pricing power consumption based only on the quantity consumed. Meanwhile, other billing scripts have been developed, for example novel tariffs for dynamic pricing, which are expected to lead to considerable energy savings by peak load reduction (Faruqui et al., 2010). However, they prescribe tasks to electricity meters, for which the conventional meters are unfit. Thus, with the main intention to promote energy efficiency (Kochański et al., 2020: 18) the EU has implemented since 2009 a policy to replace these meters by smart metering systems. According to present estimates, 43% of all electricity metering points in the EU-28 will be equipped with smart meters by 2020 (Tounquet and Alaton, 2020: 19-20). However, together with the conventional meters the old billing script is still in place in many European households, being an obstacle for establishing energy saving consumption practices. As this example shows, prior scripts surviving in re-used components may still play an important role and should be taken into in account in analysing current artefact-user interaction.

Another characteristic of heterogeneous ensembles is that the "the trajectories of artifacts become mingled with the trajectories of other artifacts, people, procedures, and so on. The scripts in the artifact become intertwined (added to, contested by) other scripts" (Hyysalo, 2010: 247). This poses the problem of possible differences between the expectations and requirements at artefacts (and other components) that are associated with the respective scripts. Admittedly, the example I used in the previous section did not allow to address this problem sufficiently since it was about an already established set of interrelated actor positions. Role theory, however, is a very suitable concept for analysing how the different scripts within more complex socio-material settings interrelate. With the concept of role conflict and of social mechanisms for dealing with role conflicts (Merton, 1957), it provides useful tools for analysing these issues.

A role conflict occurs, when the holder of a position is confronted with conflicting expectations represented by other actor positions. One of the social mechanisms of dealing with role conflicts is by differences of power of those representing the different expectations (Merton, 1957: 113-114). The fact that Germany lags behind in smart meter installation is in part a result of such differences of power. Smart metering is not only about promoting energy efficiency but also about data protection, privacy, and cybersecurity since smart metering requires electronic data communication between the smart meters, power providers, and users. Defining the respective regulatory framework, however, lies in the power of the national regulatory agencies and not in the power of the European policy makers. Thus, though the technological means and the related use strategies for saving power via smart metering already existed for years, it was not until the end of 2018 that the first smart meter was certified for use in Germany. Only then, the agency responsible for IT security in Germany had specified and approved the quite concrete scripts for the performance of the devices, their operation, and the data transmission that shall ensure the security of smart metering (BSI, 2020). Everybody and everything else had to wait.

Another mechanism for reconciling different expectations (as long as they are not contradictory) is to employ technological (or other) components in different scripts so that they fulfil different expectations at the same time (Pinch and Bijker, 1987: 44-46). An example is the claim raised by European energy market policy, that smart metering not only helps to safe energy but also promotes final customer empowerment by allowing customers "to receive accurate and near real-time feedback on their energy consumption or generation, and to manage their consumption better […] and to lower their electricity bills" (European Union, 2019: 132). Interestingly, not only the same technological components but to some extent also the same patterns of use are claimed to provide the means for both goals. For instance, the same script of dynamic prizing may govern an action that aims at saving energy or at saving money (or at both). Thus, the role analysis has to take into account that a particular role behaviour may satisfy different role expectations simultaneously.

Finally, I want to emphasise that the role concept does not imply a harmonistic view. There are mechanisms of dealing with role conflicts without solving them such as the mechanism, which Merton has described as "[i]nsulation of role-activities from observability by members of the role-set" (Merton, 1957: 114-115). To the extent that the nature of the relationship between particular positions is unknown to the holders of positions with competing role expectations the role conflicts implied remain latent. The layered structure of many complex sociotechnical constellations (Silvast et al., 2018: 5) provides many opportunities for rendering invisible conflicting activities. Just consider how many of all the features of artefacts, which are designed to make manufacturing more efficient, escape the attention of the average customer even when they interfere with some of their expectations of the respective artefact. However, latent conflicts may turn into manifest conflicts at some point in time, which may destabilise a sociotechnical constellation if no other way of dealing with them is found.

Conclusion

A basic understanding in science and technology studies is that technology and society evolve in processes of mutual shaping. Scholars in this field, thus, are in need of relational concepts that help them analyse the co-constitution of technological artefacts and social practices, orientations, and contexts. For some time, ANT (including related approaches) has been the most prolific source of relational concepts of this kind. In recent years, however, the affordance concept has become increasingly popular. In this article, I have shown that the conceptual roots of these relational concepts are different. While the concept of affordance is rooted in the organism-environment relation, the concepts of script and role are respectively rooted in the relation of distributed actions and the relation of distributed actor positions.

These different conceptual roots make the main focus of the three relational concepts different: The affordance concept focuses mainly on the relation between features of artefacts and common properties of users. The main focus of the script concept is on how the contributions of artefacts and users to particular courses of distributed action are negotiated and ensured. The concept of role widens that focus to settings of distributed activities that include more than two actor positions and, consequently, several interrelated scripts and role relations. To sharpen our conceptual tools for describing the interaction between human and material agency, we should make use of these different perspectives; we should employ the concepts of script, role, and affordance to analyse artefact-user relations at three different levels of stability, abstraction, and interrelatedness.

Acknowledgements

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Notes

1   This extension of the affordance concept is one of the reasons for its frequently lamented lack of conceptual clarity and analytical integrity as well as for its inconsistent use in research (Evans et al., 2017: 36-37; Parchoma, 2014: 360-363).

2   Though many of Norman's examples focus on visual information, he uses the term 'visible' in the broader sense of "being directly perceivable", thus taking into account that "affordances may be perceived using other senses as well" (Gaver, 1991: 82).

3   In addition, there is the practical problem that this distinction severely limits the scope of the affordance concept. As Norman (1999: 42) concedes, it renders the concept inapplicable to most of today's technological artifacts as far as they include digital components that are symbolic and thus knowledge-based (Jucker et al., 2018: 93-95). For obvious reasons, most scholars and practitioners using the affordance concept have ignored this consequence.

4   Cf. https://de.statista.com/statistik/daten/studie/298727/umfrage/verteilung-der-zaehlertechnik-in-deutschen-haushalten/ (accessed on 26 October 2020).