The Offenbach Model

Human-Centered Mobility Design

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The Offenbach model, developed as part of a design research project aimed at promoting environmentally friendly mobility at HfG Offenbach, places people and their needs at the center of a transportation system that brings together climate-friendly mobility options.[01] This design research is not focused on the organization and planning of traffic flows and systems, but rather on the configuration of an intermodal, environmentally friendly transportation system with its data and physical environment. It also considers shared transport modes and spaces while in use, as well as the mobility experience. Since the actual space in which users move is already digitally supported to a great extent and thus increasingly overlaid with online information, this mobility experience is being expanded to include the virtual dimension, and the digital expansion of mobility space has been incorporated accordingly in the Offenbach model.

As a means of introduction, the concept of human-centered design will be explained below. Next, this essay will focus on the Offenbach Model developed from this concept. This model aims to capture and define terms that guide the design of intermodal mobility systems. In the section following, the development of terminology is presented in reference to findings from design studies, social science mobility research, and urban and traffic planning. This essay concludes with an overview of the future challenges of design that considers the way information increasingly pervades physical space and how this affects mobility design.

Human-Centered Design

Design mediates between users and their environment (products, systems, technologies, services) and anticipates new forms of use, for which it shapes their aesthetic impact and articulates their symbolic meanings as relevant offers. Design enables interaction and influences the behavior of users through form-making decisions. Accordingly, design shapes the user experience (Vöckler and Eckart 2020). Design refers to the affective impact (the aesthetic dimension), usability (the practical dimension), and meaning (the symbolic dimension) of artifacts as they are developed and formed through design (Vöckler 2021). This corresponds to the analysis of the design task in the creation of artifacts developed at HfG Offenbach in the 1970s as the theory of product language (»The Offenbach Approach«) (Gros 1983; Fischer and Mikosch 1984; Gros 1987). In this approach, the human-object relationship is defined in design theory as the actual design task; it is only through the interaction of human and object that meaning emerges (Gros 1976). Meaning—and thus the understanding of designed objects—encompasses the aesthetic impact of the formal structuring that unfolds through perception, with its accompanying affects. These play an essential role in determining to what extent the interaction is already evaluated positively or negatively on the perceptual level: feelings of pleasure or displeasure, as they are modulated, for example, through a clear or even confusing structure (formal-aesthetic functions). In addition, there is also the understanding of how objects can be used and what they offer (indicating functions, i.e. of possible uses; this corresponds largely to the affordances introduced into design theory by the cognitive scientist Donald Norman. See Norman 1988; Jensen in this volume). Furthermore, artifacts have social and cultural references; they generate opportunities for identification, which in their symbolic meaning fosters self-assurance (symbolic functions; see Vöckler 2021). They are a means of social distinction (status), but also facilitate identification in or with a culture (here: mobility culture; see Götz et al. 2016). Accordingly, artifacts create meanings that go far beyond their practical functions (Krippendorff and Butter 1984; Steffen 2000). Beyond their formal structure, the effect of designed objects and spaces also reveals symbolic meanings that relate to their sociocultural context. They can bring about new and fascinating ways of seeing, and thus of valuing, the (designed) environment. At the same time, design can express respect for its users through the symbolic meanings of the materials used as well as through the language of form.

The interaction of humans with objects (human-object relationship) was further developed in design theory in the concept of the interface. Today, an interface is usually only understood as an interface between a human being and a technical device (as well as between technical devices). In principle, however, the term *interface* refers to the interaction of users with a product in a course of action (Bonsiepe 1996). Accordingly, the space of interaction is understood as the interface. If the focus of design is on the interaction itself, then it becomes clear that the understanding of designed objects is never completely predetermined or preformed, neither in the subject nor in the object (Krippendorff 2006).[02] Moreover, with the focus on interaction, the scope of designing products has expanded to include processes, situations, and (technical) systems. Human-centered design therefore generates a fundamental understanding of the interplay between perceptions, actions, and the emergence of meaning in the interaction between humans and their (designed) environment (Krippendorff 2006). Meaning emerges through application, in use, and in the interplay of perceptions and actions. For this reason, designers must be able to grasp how users understand products and how design decisions can have a positive impact on this understanding.

The focus of the Offenbach model of human-centered mobility design is on interaction with the concrete physical space in which users physically move. However, with the utilization of a technical medium that is mobile and connected to the body, such as the smartphone in common use today, the perception of the environment has changed, especially to the extent that it stages new environments (in particular as an enveloping private sphere). This affects self-positioning: both functionally in orientation (navigation), but also symbolically and emotionally in the form of self-representation in informational space, which at the same time has a reciprocal effect on self-positioning in real space—validating me as an individual in interaction with the digitally augmented concrete environment. Even if the smartphone being carried is not used or is only used temporarily, this has an impact on the subjective sense of security in real space and increases the sense of one's own self-efficacy (autonomy) (Colomina and Wigley 2019). Personalized access to the mobile internet offers great opportunities for positively influencing mobility behavior through motivational feedback strategies or even gamification approaches (see Göbel et al. in this volume). Accordingly, the specific effects of digitally supported extensions of the interaction space have been taken into account in the development of the model and its guiding concepts. Major changes can be expected in this area in the future (see the outlook section at the end of this essay).[03]

Modeling and Definition of the Interaction Areas

Models serve as bridges between theories and real-world applications. Crucial for the development of any model is how the phenomenon to be modeled is abstracted. This abstraction process is accompanied by a corresponding concept formation. Concepts are understood here as tools with which we describe (and order) phenomena, and which make those phenomena accessible to us by opening up new perspectives, thereby structuring the design exercise (Eckart 2021). The model presented here follows a pragmatic approach that focuses on the interaction between users and the mobility system, that is, on subjective actions: human-centered mobility design. At the same time, this approach allows the mobility system to be designed to ensure successful interaction. However, this also requires a more precise definition of the different types of interactions.

In two specialist workshops, key concepts were identified that are essential for determining design parameters (↳Fig. 1).[04] These were assigned to three interrelated interaction areas that capture different qualities of interaction with the mobility system. These are

- the *access*, which encompasses all the factors that make successful and barrier-free use possible in the first place, essentially relating to the functional side (the practical dimension);
- the *experience* had with and during use, with the social-emotional influencing factors of its affective impact (the aesthetic dimension);
- the *identity*, which enables identification with the mobility system and conveys its meaning, thus promoting an emotional bond (the symbolic dimension).

Guiding principles were developed for a mobility-space design oriented toward user needs, by incorporating cognitive and design science findings regarding interactions during usage acts, which emphasize the importance of noninstrumental factors (Desmet 2002; Norman 2004; Ortony et al. 2005). These concepts are assigned to the three levels of interaction. If mobility behavior is essentially (co)determined by noninstrumental, symbolic, and emotional factors, then these must be considered in the design of intermodal mobility systems. Here, the goal is to enable a smooth and satisfying interaction during usage and to achieve a positive (emotional) evaluation that has a meaningful effect beyond the usage act itself. Consequently, meaning is formed and formulated through the design.

01 The research project »Infrastruktur—Design—Gesellschaft« (2018 to 2021) was funded by the Landes-Offensive zur Entwicklung wissenschaftlich-ökonomischer Exzellenz (LOEWE) in the German Federal State of Hesse with the following lead project partners: the University of Art and Design in Offenbach (design, consortium lead), the Frankfurt University of Applied Sciences (transportation planning), Goethe University Frankfurt (mobility research), and the Technical University of Darmstadt (media and communication technology/architecture).

02 Originally developed in the 1990s in the context of human-computer interaction (HCI) in parallel with computer science and product design, the term human-centered design defined a process for involving users in the design process and the problems involved with computer display work. In economics, human-centered design is also discussed as a component of management techniques (design thinking).

03 Smartphones (and other wearables) are technologies commonly used today to mediate between the informational and physical environments; what specific requirements for the design of such user interface (user interface design) will not be discussed separately. Although information available while on the move is increasingly being requested in a progressively more complex manner (for example, via gestural or mimic and acoustic control mechanisms), it still forms a largely delimited space that must be operated via input media. Nevertheless, it is necessary to correlate the information provided digitally with the information in the physical space in order to achieve as clear an understanding as possible among users; that requires coherence in information design at both the digital and analog levels.

04 The workshops were led by Kai Vöckler, who prepared and conducted them together with Julian Schwarze and Janina Albrecht. Kai Dreyer, Peter Eckart, Anna-Lena Moeckl, Thilo Schwer, and Knut Völzke were also involved in the workshops.

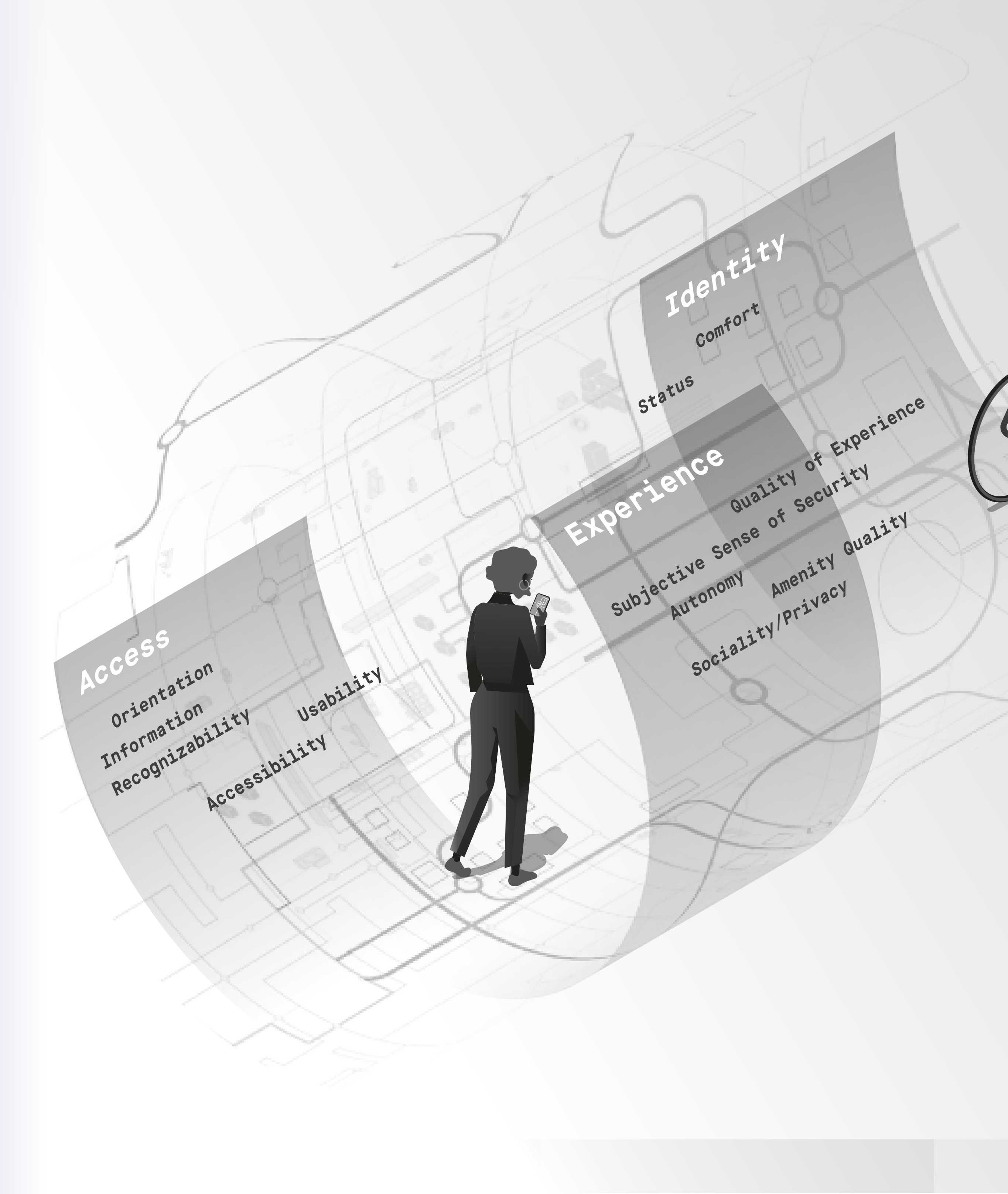
Identity
Comfort
Status
Experience
Quality of Experience
Subjective Sense of Security
Autonomy
Amenity Quality
Sociality/Privacy
Access
Orientation
Information
Recognizability
Usability
Accessibility

Fig. 1 Offenbach Model: Diagram of user interaction with an intermodal mobility system together with the concepts guiding its design, which have been assigned to three interlinked areas of interaction (Source: DML/HfG Offenbach; concept: Peter Eckart, Julian Schwarze, and Kai Vöckler; graphics: Beatrice Bianchini and Ken Rodenwaldt)

The Offenbach Model: Areas of Interaction and Guiding Concepts

Access

The basic prerequisite for the utilization of a publicly accessible intermodal mobility system is that access is functionally enabled (for all users). This concerns recognizability and accessibility (barrier-free access), the provision of necessary information, the design of orientation elements, and the usability of the objects that people interact with. It is the goal of the design to ensure a trouble-free process that can be mastered with minimal cognitive effort. This includes, for example, a comprehensive information and guidance system, recognizable links and connections, and ticketing (digital and analog). Additional factors are the structuring of circulation spaces and the positioning of spatial elements that provide orientation, as well as operational elements that can be understood intuitively.

Recognizability It is essential to design the entire intermodal, environmentally friendly mobility system (with its different interlinked mobility services and resultant variety of spaces along a route) as a recognizable coherent structure (coherence of design). Recognizability is a fundamental prerequisite for establishing symbolic meaning (see the Identity section below). Significantly, this also includes the transparency of the data that enable digitally supported interactions, which must be communicated in a recognizable way—through the link to physical space.

Accessibility Inclusive mobility system design also permits people with physical and cognitive impairments to use the system without assistance (accessibility). This applies particularly to aspects of traffic safety and routing during use. Consequently, it is necessary to design visual, acoustic, and tactile information according to the two-senses principle. An inclusive design also takes into account, in the sense of »design for all« (universal design), the effects of age, educational level, and cultural familiarity, up to and including economic restrictions on access.

Usability focuses on the actual usage situation, on the effectiveness and efficiency of use, with the objective of ensuring that mobility processes run smoothly. This is to be achieved primarily through the self-explanatory character (intuitive use) of the system. Therefore, comprehensibility that requires minimal cognitive effort is a central design objective. Usability, in relation to specific practical functions, is one of the operational prerequisites of usage. Ergonomic aspects play a central role in this context by optimally supporting use and minimizing strain or disturbance. An important prerequisite for the usability of mobility systems is traffic safety, which must be appropriately conveyed through design (see the above section Accessibility).

Information Comprehensive analog and digital information linking the various mobility services and spaces (information and routing systems; pictorial and written symbols such as pictograms, maps, written and numerical information) is the basis for intermodal and multimodal mobility. In addition to information on mobility services, this also includes information on routing, travel times, and distances (including travel costs, if applicable). Among these are signs indicating escape routes, alarm devices, and hazard markings, which must all be designed in a clear and comprehensible manner to ensure traffic safety. In addition, there is further information on useful facts such as spatial location (site plans), as well as on additional services (e.g., gastronomy), and experiences to be had. Mobility-related information must be clearly differentiated from additional information (such as advertising or entertainment options) for the sake of the recognizability needed for mobility purposes.

Orientation Wayfinding is a central component of orientation, which on the one hand is supported by an information and wayfinding system (see the section Information), and on the other hand should occur intuitively when interacting with the space (as flow), as a reflection of usability. This corresponds to clear spatial organization and routing via space-defining architectural elements together with objects positioned to provide orientation in conjunction with posted information (routing systems). This includes the formation of visual reference points (landmarks), which guide action and lead to the nodes, where decisions on further routing are necessary (see Schwarze et al. in this volume). These orientation elements enable intuitive wayfinding and hence the linking of different mobility options.

Experience

Socioemotional factors are essential for positive mobility experiences and pertain to the requirements for (»subjective,« i.e., perceived) safety, experiential and amenity quality, and privacy and social interaction. Design measures can, for example, provide for the visual control of a space, thus creating a sense of security through the establishment of visual relationships and appropriate lighting. However, these can also create spaces for retreat as well as interaction within the spatial organization. In addition, the design of objects that are essential for the stay (waiting times), such as seating and leaning options, convey a sense of quality and thus of value through their materials and design language. It is also important to create experiential quality through attractive visual relationships among contextual features in the interplay of the spatial configuration, objects, and signs. Last but not least, the goal is to create positive self-awareness (self-positioning in terms of spatial perception) and thus a sense of self-efficacy (autonomy) within the flow of barrier-free and intuitive use. Mobile access to the internet also influences the sense of security and location (sense of direction and self-positioning). Accordingly, the association with real space (recognizability) should be designed in conjunction.

Amenity Quality A sense of well-being is strongly affected by the intrinsic value of the environment as conveyed through its design, which is experienced as being purposeful when its usage is stress-free. Essentially, this involves the design modification of functional requirements to ensure amenity quality in transport, transfer, and waiting areas (weather and noise protection, seating and standing areas, lighting, and materials), with the overall atmosphere of the space, objects, lighting, and information reflecting their inherent value.

Quality of Experience Stimulating mobility experiences contribute to positive emotional assessment. Thus, the design focuses on communicating and accentuating the experiential qualities that result from movement in physical space. The joy of locomotion and being on the move can be designed in relation to the usage context, for example, through the formulation of visual relationships to the surroundings. Or, by arousing interest and curiosity in the process itself as well (by making it possible to experience the rhythm of locomotion).

Autonomy The feeling of freedom engendered by deciding for yourself which route and mode of transport to take strongly influences the emotional assessment of the mobility experience. Here, the decisive factor is designing a process that is as free of disruptions and as clearly recognizable as possible, and thus comprehensible. Self-efficacy is also experienced through positive self-perception, in that finding your own way is facilitated by an appropriately designed spatial experience. In this context, the connection to digitally available information is to be designed for as well, in respect to operational choices, processes, and self-positioning.

(Subjective) Sense of Security Design interventions exert considerable emotional impact on the subjective feeling of safety (such as fear of harassment or criminal assault). For example, the design and illumination of the mobility space can create visibility and thus provide an overview, which allows for visual control of the space. This also includes the formation of spatial areas of retreat and protection (»back protection«) and visible means of avoidance and escape. A design element such as lighting, for example, can exert a calming effect through a warm light temperature. Cleanliness, which is important for the subjective feeling of safety, can also be supported in terms of design by appropriate materials, although their value and the symbolically conveyed appreciation associated with them must also be put into perspective. The digital expansion of personal action space in addition offers a variety of possibilities for conveying confidence in the safety of the mobility process, which also applies to questions of traffic safety (as part of the information about the process and possible disruptions).

Sociality and Privacy Sociality and privacy are two mutually dependent needs that are to be treated differently in terms of design, which consequently must be brought into relationship with one another. On the one hand, there is the need for social interaction beyond the mobility function, which enables a sense of community. This means a communication-oriented spatial organization that favors self-determined social interactions (such as appropriately positioned seating). In principle, there is also the option of allowing for digitally supported communication between actors in usage contexts. On the other hand, it is essential to consider the need for privacy and to create opportunities for spatial separation and demarcation (distances).

Identity

A coherently developed design (including in relation to digitally available information) fosters a sense of well-being when in use, which conveys a feeling of respect (comfort) in its emotional impact. The symbolic effect of the design language conveys meaning that can be engaged with. In this way, a positive experience of social positioning is made possible (status). Both aspects with their symbolic significance must already be considered in the actual design. Together, they help users identify with the mobility system. In particular, the public character of the intermodal mobility system requires a symbolic design that articulates its social significance.

Comfort The quality of the design in its aesthetic effect, in concert with the interaction of forms, colors, materials, light and spatial design, communicates an overall appreciation of user needs. This space is permeated by digital (and increasingly personalized) information, which must be suitably incorporated into the general experience. This essentially concerns the symbolic-emotional effect of the mobility system in use, which is experienced as appreciation.

Status The design of the mobility system conveys symbolic meaning. What does an intermodal, ecologically beneficial system stand for? Important themes to be expressed through the design are environmental friendliness, innovativeness, and sustainability. Here, sustainability means durable design that is not oriented to commercially exploitable, short-lived fashions, but rather is committed to a public design language that serves the common good. As a central part of public life, the design of an essential public mobility articulates its significance for society as a whole. In this way, social recognition is also conveyed to the users, which results from participation in this form of progressive and sustainable mobility.

Elaboration of Key Terms in Relation to Mobility Research and Transportation Planning

In principle, the importance of symbolic-emotional influences on mobility behavior has been recognized in mobility research as well as in urban and transportation planning, but it has not yet been adequately systematized and modeled in a way that could guide design practice. The Offenbach model intends to accomplish this in a first step, while remaining mindful of the lack of empirical validation (see Schwarze et al. in this volume).

The modeling here was based on existing models of interactive design, which are grouped together in design research under the term *user-centered design*, an approach that combines utility and usability (Norman 1988). This was subsequently expanded to *user experience design*, which focuses on positive user experience through the design of digital and analog artifacts, while broadening this to incorporate emotional factors (Norman 2004). The user experience also includes the effects that a product has on users before they use it (anticipated use) and after they use it (identification with the product). Accordingly, it also refers to emotional and aesthetic qualities (from the user's point of view) and not only to functional characteristics (Hassenzahl and Tractinsky 2006). The concept has already been standardized with ISO 9241-210 as a norm for the human-centered design of interactive (technical) systems, whose terms were accommodated insofar as they concern the direct interaction with the product and not, for example, organizational-technical or even resource-related aspects such as the question of the efficiency or effectiveness of the system (ISO 9241-210: 2019). For the Offenbach model, other terms of user experience design were also adopted (Morville 2004; Hassenzahl 2018). The starting point is user needs, which are to be communicated within a usage context (with its technical, physical, social, cultural, and organizational components). However, the selection is limited to the usage process (interaction with the mobility system) (see also Desmet and Fokkinga 2020 with their further development of Maslow's hierarchy of needs and a redefinition of the guiding concepts in a meta-analysis of the relevant psychological literature). Yet there is still no agreement within design research as to which conceptual system is considered to be the most viable. In addition, the various definitions of user experience design, which are not always systematically elaborated, also refer to different contexts of use (interactive technical or analog products). For the terms used in the modeling process, see the matrix of terms discussed (↳Fig. 2).

Social science mobility research into the factors influencing the use of transportation focuses on, among other things, attitudes toward transportation (Anable and Gatersleben 2005; Steg 2005; Hunecke 2006). This attitude reflects the subjective stance, mixing rational and emotional factors. In addition, attitude indicates an associated behavioral tendency. However, here attitude relates to the use of transportation (and the implicitly linked evaluation of the transportation infrastructure or the mobility system). The psychological construct *attitude* is operationalized differently in the studies considered; for example, a distinction is made between instrumental, affective, and symbolic factors (Steg 2005), or the noninstrumental factors are summarized as symbolic-emotional factors (Hunecke 2006; Haustein in this volume). Structurally, this also corresponds to the division into the three areas of interaction in the Offenbach model, with the instrumental (*access*, the practical dimension) as well as the noninstrumental factors of influence (*experience*, the aesthetic dimension in its affective impact, as well as *identity* as the symbolic dimension). However, classifying them into instrumental and noninstrumental factors has proven to be difficult, as a number of terms cannot be clearly assigned to either category (Pripfl et al. 2010; Busch-Geertsema 2018). For example, autonomy can be classified as independence in the sense of self-efficacy as part of the symbolic-emotional factors or it can also be defined as freedom in terms of the private availability of a means of transport playing an instrumental role. Overviews that systematize the developed terms in a summary manner are therefore confronted with the problem of having to consider partly conflicting definitions of the same terms. Nevertheless, even with different classifications and limitations, there is a large overlapping of terms that may be identified as being significant for mobility activity (see the meta-analysis by Pripfl et al. 2010; Busch-Geertsema 2018; ↳Fig. 2). For application-oriented design research, it is sufficient to be aware of the factors that influence attitudes toward the use of transportation (and thus indirectly also mobility actions) and to consider them as critical user needs in modeling. In doing so, all factors were excluded that cannot be directly addressed in terms of design. This applies, for example, to important influencing factors such as the availability and reliability of the mobility services provided, which primarily affect the planning and organization of personal mobility. In this context, however, it is important for the design to convey the information to users in a comprehensible way. One example here is travel expenditure. From the user perspective, information about travel time as a fundamental consideration (the time required to cover a distance) must be available when choosing between different mobility services, which is therefore considered under the guiding concept of information, as are the factors mentioned above. Yet, time also plays an essential role in the quality of the experience, since the experience of a *flow* is to be understood qualitatively as a trouble-free, seamless flow of locomotion.[05] Influencing factors such as environmental awareness (which we instead understand as a social norm) as well as health (as a personal norm) were not taken into account, since these can or should be part of the symbolism to be formulated in terms of design, but certainly do not apply to all users.

In transportation planning, the importance of design has been neglected so far (Hofmann 2019). In English-language publications on the topic of design, planning and engineering issues are usually dealt with from an instrumental point of view, such as in the planning of road layouts and alignments, which do not adopt a design perspective based on user needs (Cervero and Kockelman 1997, who introduced in their frequently cited article the planning-relevant »3 Ds«: density, diversity, and design). Emotional and symbolic aspects are scarcely considered in the planning of public transport facilities (Hofmann 2019). Studies and manuals on the planning and design of multi- and intermodal mobility, in particular on mobility stations and interchanges, point out the need for design—for example, with regard to their urban spatial impact. However, this is essentially limited to functional aspects such as recognizability and accessibility, although the symbolic impact in the urban spatial fabric is still discussed to a limited degree. However, no clear recommendations are made, nor is there a systematic elaboration of the design requirements (BBSR 2015; Zukunftsnetz Mobilität NRW 2015). The guidelines of the Road and Transportation Research Association (Forschungsgesellschaft für Straßen- und Verkehrswesen—FGSV) name important design factors in the planning and design of local public transport connection facilities (FGSV 2009), such as quality of experience, which is also addressed in its symbolic effect (in the use of high-quality materials expressing appreciation, which we assigned to comfort) as well as with regard to its public character (in our view, part of sociability as the need for social interaction and proximity). In addition, the perception of security (subjective security) and the associated need for privacy, which is important for social acceptance, are also mentioned. The FGSV (2009) also considers important functional requirements such as barrier-free accessibility and the importance of information and orientation as a prerequisite for access when using transfer points. It highlights the fact that these are generally central places in urban life, offering aesthetic quality and symbolic impact that provide a means of identification. These central factors were incorporated into the Offenbach model and have been consistently developed conceptually from the user perspective. However, the FGSV does not differentiate between management activities (such as cleaning services), urban and traffic planning (such as compact building structure, weather protection, and direct routing), and design activities (architecture and design), which convey the functional requirements in a user-centered (and inclusive) manner while also significantly contributing to the emotional and symbolic impact of the mobility system.

In conclusion, it can be said that a sufficiently systematic and conceptually defined modeling of the requirements for the design of intermodal, environmentally friendly mobility systems has not been undertaken to date. Based on the findings of mobility research and transportation planning, the Offenbach model is presented for discussion here as a scientifically derived design proposal for structuring design requirements in the context of public mobility.

Outlook: The Design of Future Interaction Spaces (Post Human-Centered Design)

Digital transformation has fundamentally changed mobility space. This concerns not only the currently possible, expanded, and personalized options for user engagement through the mobile internet, but also the future development of the mobility system into an adaptive and responsive system increasingly controlled by artificial intelligence. Through the development of a technological system that is data-based, operates in real time, is decentralized, personalized, and self-optimizing, the transportation system will become dynamic through the use of algorithms and thus adapt to user behavior in an anticipatory manner. »Intelligent environments« will emerge that not only provide options for user action, but also adapt services individually in advance on the basis of available personal data, thereby optimizing the user's ability to act (Eckart and Vöckler 2022a). This transforms the interface between humans and the (artificial) environment as well as the technical system that is interwoven with it. Technology is no longer a tool that enhances the human capacity to interact with the environment, but rather information and communication technology creates new environments within the informational penetration of physical space. But this means that the acting human is no longer the focal point in the environment—they are deprived of their »uniqueness« (Floridi 2014). And this is despite the fact that the digital penetration of the environment will allow it to be adapted to individual needs in ways that could hardly have been imagined previously. For design and design theory, this also requires a reformulation of the human-centered approach such that it becomes an ecological one, which goes beyond the anthropocentric to consider the coaction of things (Morton 2018).

The design of a »post human-centered interface« merges with the material environment and consequently disappears as an identifiable interface (Weiser 1991), thus requiring mediation of this new arrangement through design (Redström and Wiltse 2019). These ambient intelligences thus act independently via their material presence as well. In order to convey their performative qualities, a theoretical reconceptualization of affordance (and indicating functions) through design will be needed (Jensen et al. 2016). In doing so, the interaction space itself, the relationships created within it, and its digital linkages will have to be designed and thus mediated—also in the sense of empowering users (Easterling 2016). In short, the artifacts that will be interacted with in the future can no longer be seen as being closed, or fixed, nor as being set apart from oneself. This will require not only the development of new cultural techniques, but also their creative mediation. The decisive factor here will be that it is not so much the »what,« the object—which does not disappear, but is part of the expanded interaction space in its interface function—but the »how,« that is, the rules, connections, and protocols that must be communicated (Easterling 2021). This is also a political question: the design of digital infrastructures must preserve the personal rights of citizens and should ultimately facilitate informational self-determination (Eckart and Vöckler 2022b). As yet, no theoretical design concepts guiding design practice have been created for this emerging development—this will have to be addressed in the future. However, we think that the systematic recording and modeling of design parameters presented here can help to clarify the design challenges and serve as a basis for further research. Against the background of

05 A good example is the Cykelslangen bicycle bridge in Copenhagen with its curved path, which is totally pointless from a functional standpoint (increased travel time), but allows for a memorable mobility experience offering varying, attractive vistas; it has thus been accepted with great enthusiasm (and at the same time has made a strong symbolic impact as an iconic symbol of environmentally friendly mobility).

Pripfl et al. 2010 [1]	Busch-Geertsema 2018 [1]	Desmet and Fokkinga 2020 [2]	Hassenzahl 2018 [2]	
User-friendliness*			**Usability**	
Travel time*	**Time***			
Travel costs*	**Money***			
Comfort* (travel comfort, transport option, weather independence)	**Weather***			
Availability*	**Flexibility***			
Accessibility*	**User-friendliness***			
Reliability*	**Reliability***			
			Trust	
Autonomy**	**Autonomy*****	**Autonomy**	**Autonomy**	
		Competence	**Competence**	
		Impact		
Status**	**Status******	**Recognition**	**Meaning**	
		Relatedness		
Experience**	**Experience*****	**Stimulation**	**Experience**	
			Surprise	
Privacy**	**Privacy*****		**Sense of security**	
Freedom from stress**	**General sense of well-being*****	**Comfort**	**Sense of well-being**	
	Relaxation***		**Problem avoidance**	
Security/safety**	**Security/safety****	**Security**	**Perceived security**	
Environmental awareness**	**Environment****	**Morality**		
		Purpose		
	Health/fitness**	**Fitness**		
		Beauty		
		Community	**Proximity**	
* Purposeful-rational factors	* instrumental – direct			
** Social-emotional factors	** instrumental – indirect			
	*** affective			
	**** symbolic			
[1] Factors influencing attitudes toward transportation use				
[2] User needs in general/when interacting with products				
[3] User needs when interacting with digital products				
[4] User needs when interacting with public transport facilities				

	DIN EN ISO 9241-210: 2019 [3]	Morville 2004 [3]	FGSV 2009 [4]	Correlation in the Offenbach Model
	Usability	**Usable**		**Usability****
			Reachability	**Information***
				Information*
			Information and orientation	**Information*and orientation**
	Context of use		**Multifunctionality**	**Amenity quality****
	Efficiency			
		Findable	**Accesses (recognizability)**	**Recognizability***
	Accessibility	**Accessible**	**Accessibility for people with movement limitations/ transport safety**	**Accessibility* (transport safety)**
	Effectiveness	**Useful**		**Usability****
	Satisfaction	**Credible**		**Status*****
				Autonomy**
				Autonomy**
		Valuable	**Identification (image and identity)**	**Status*****
	User experience			**Quality of experience****
				Quality of experience**
				Privacy/sociality**
				Amenity quality**
			Social acceptance/subjective sense of security	**Subjective sense of secu-rity****
		Desirable		**Comfort (valuation)*****
				Sociality/privacy**
				* Access
				** Experience
				*** Identity

Fig. 2 Matrix of critical terms in the selected literature. Comparability is limited because the analyses listed refer to different contexts. The matrix of terms used served as orientation in the development of the guiding terms to identify overarching patterns. (Source: DML/HfG Offenbach; Kai Vöckler)

the future dissolution of input interfaces and the emergence of personalized »intelligent environments,« the model proposed here will have to be further developed towards the design of an informationally enhanced »Human-Environment Interaction« (Encarnação et al. 2015), in which humans, the environment, and technical systems will enter into a new relationship. This must be conveyed through design in order to facilitate understanding and create meaning.

Literature

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