Chapter 2
Introduction to Interaction Design

Abstract In this chapter, the field of interaction design is introduced, and the different disciplines involved in interaction design are considered. Main concepts such as usability and user experience are defined, and design objectives for usability and user experience are considered.

Automotive design has been around for a hundred years. Throughout the decades, the greatest focus has been on the technical aspects of the car. Interaction design in automobiles, on the other hand, has not been raised to a high level. This is because, compared to the rest of the industry, automotive systems were too simple and therefore the challenge for interaction design was not very strong. But with the advent of assisted driving systems and the development from partially to fully automated driving, the technology has become more platform-based, creating new and unprecedented challenges, and proper interaction design has gained importance. In the last two decades in particular, interaction design in cars has attracted increasing attention.

It is always a challenge to get the interaction design right in the car. Generally speaking, we divide in-car systems into two parts. One part is directly related to driving and the other part is not. The part that is not directly related to driving includes various infotainment systems, etc. In between there is the in-car navigation system, and various functional systems associated with geographic location, which are not related to the driving operation itself, but to the car as a means of transport, since modern people's driving has become increasingly dependent on electronic navigation systems. In the future of driving, more and more infotainment systems will be introduced into the car. The personalised, intelligent design of the car is the way forward and a challenge for the future.

In relation to automated driving, the different levels of automation, in terms of the technical performance of the car, are divided into six levels (Fig. 1.1), but for interaction design, we are really only concerned with two states: the car is driving itself or a human is driving. From L0 to L2, the car is driven by a human, L3 is a car that can drive partially automatically, but in many road conditions, the car is still driven mainly by a human, and at L4, the car is basically able to drive automatically in nearly all road conditions, but a human can take over the driving. At L5, the car is basically driverless and can perform all driving tasks. This shows that at different

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levels of automation, the role played by humans in the whole driving process is different and the interaction design will face different problems.

2.1 Misconceptions and Challenges of Interaction Design

Interaction design is often misunderstood as just the design of the user interface, a part of art design, and therefore many people think that the focus of interaction design is aesthetics, to make people's five senses feel pleasant and comfortable. Accordingly, many colleges put interaction design in art schools, and many companies branch out into interaction design according to people's five senses: hearing, vision, smell, body sensation (vibration), or confuse interaction design with interaction technology, thinking that interaction design is all about voice technology, gesture input technology and so on. In fact, interaction design is a highly integrated and applied discipline based on in-depth understanding not only of the technologies involved, but also of human cognitive psychology and human physiology, social science and aesthetics.

Interaction designers need to have in-depth knowledge of the needs of people, the possibilities of technology and the context in which it may be applied. By having a good understanding of people and a good knowledge of technology, the designer applies this knowledge to deliver good design outcomes. Therefore, this book takes a look at several aspects, including cognitive psychology, some basic physiology, methodologies for studying human needs, design methodologies and methods for evaluating the design of different systems, standards and so on.

Interaction design in the car is a rapidly evolving discipline, and the challenges and problems it faces seem to be increasing. Nowadays, people deal with many products that require interaction on a daily basis, such as our mobile phones, our computers, kitchen appliances, televisions, air conditioners and many more. There are countless products that require interaction between humans and machines. If the user's needs, preferences, abilities and limitations are systematically studied and the insights applied in the design process, these products should be easy, smooth and comfortable to use. However, there are many products on the market that people feel do not work well and don't know how to use. These products often do not take into account the human factor, the operational characteristics of people when using the product. To make the product work well, to make it more convenient and simple, to make the user feel competent and happy, is the aim of the interaction design engineer. Of course, not every product is designed to be easy to use. High-end, expensive cameras are not meant be as easy to use as a simple camera. But even in those cases good design can help the user to master the challenges without getting frustrated, and the resulting feeling can be a sense of achievement.

With the development of electronics and networking technology and the improvement of intelligent technology, more and more functions are being introduced into cars and human–machine interaction is becoming more and more complex. Interaction design in cars requires more than just simple usability, it also requires safety. This safety is not only for the driver and passengers, but also for other road users. Therefore, designing the interaction with in-car systems introduces additional challenges compared to the design of general consumer electronics.

It is only in the last decades that so much attention has been paid to in-car interaction design in the world. One of the authors remembers buying a nice German car some years ago and during the two years she owned it, she didn't know how to turn on the dome light and gave up after making various attempts. Then she went to a friend's house who lived in Paris. They found out that his car was the same as hers. He turned on the dome light to check the map on his way to drive her to the airport (GPS was not common at that time), which excited her and she asked him how he did it. He proudly told her that he put his hand on the lower left side near the front door shaft, there was a key that was used to control the various lights, pull out this rotary lever and the dome light was on! He told that a lot of people didn't know this trick. Then, to prove that she wasn't the stupidest person, she did some research and found that almost no one, professor or Ph.D., who drove the car had managed to find out how to turn on the dome light, and the funny thing was that everyone's manuals were in the front bucket of the car and no one bothered to look them up, because no one would spend half an hour looking up the manual for the small matter of controlling the dome light. To a designer, it may seem like a good idea to have all the light controls in one place, but for a user, there's no way to imagine that the dome light switch would be there, let alone that the swivel can be pulled outwards.

Don't think this is a story from the past. Nowadays, in-car systems are becoming more and more complex and many older drivers are at a loss for what to do with many of them. Erik Hollnagel, who is a renowned expert in the field of automotive HMI, once told the following story from his own personal experience. He was once driving home on a French motorway when his newly purchased car suddenly popped up with a warning message "There is a problem with your car's engine!" He looked at it and, thinking it was a serious problem, pulled into the nearest petrol station at a motorway rest area. He went to ask the staff at the station how to deal with the problem and the staff, who looked like an experienced man, said, "If it was a mechanical car, I could help you find the problem and fix the fault, but now it's electronic and I can't figure it out". At the professor's request, he followed him to the car. Then he said "Start the car and see what happens". When the professor started the car again, the warning had disappeared. He drove the rest of the way with a lot of trepidation.

The two stories here are both related to in-car interaction design. To design a product that interacts with people, you need to consider the following questions: (1) Who will use the product? (2) How will these users use it? (3) In what environment or context will they use it? The design of the user interface, the way information is entered and presented, needs to match the users' behaviours. For interaction designers, we often need to ask ourselves an important question: How can my design optimise the user's interaction with the product in its particular environment, so that the product or system supports the user's activities in a useful, effective, usable and enjoyable way (Sharp et al. 2019, p. 9)? Because users often operate systems in their instinctive, taken-for-granted ways, the process of using a system is likely to be very different from what the designer imagined, or hoped for, so every designer needs to consider the characteristics of the user. What are they good at? What are their weaknesses? How can we make them better at what they want through our design?

2.2 Definition of Interaction Design

What is interaction design? Sharp et al. (2019, p. 9) give the following definition.

> Interaction design is about designing interactive products to support the way people communicate and interact in their everyday and working lives
>
> Interaction design is about creating spaces for users to communicate and dialogue with the system, enhancing their experience of using the product in their work and everyday lives, while increasing productivity, pleasure and satisfaction.

In the automotive domain, Interaction Design is often carried out in the department of Human–machine Interaction, and concerned with the design of the Human–Machine Interface (HMI). Interaction design is a very comprehensive discipline encompassing many fields, three of which are often confused with the concept of interaction design: ergonomics, human factors (HF), and human–computer interaction (HCI). It should be noted that interaction design encompasses all these disciplines, which have a longer history than interaction design and are the basis of interaction design. But interaction design is not the same as any of these disciplines. It also encompasses general psychology, cognitive psychology, engineering, computer science, software engineering, sociology, anthropology, ubiquitous computing, human physiology, acoustics, aesthetics, biomechanics and many more. In design, it includes graphic design, product design, art design, industrial design, information engineering, even film and television design, media, marketing and more. No single person is capable of understanding so many areas, so interaction design is usually done by a team, especially in the case of cars. The interaction design team also needs to be made up of people from a variety of backgrounds rather than a single one (Fig. 2.1).

There is no single interaction design team in the world that encompasses all of these disciplines, which means that the composition of team members' knowledge backgrounds will vary from product to product. In many cases, ad hoc teams are formed to complete a particular project. The advantage of this is that people from different backgrounds working together can often produce more creative design ideas for innovative products. Of course, when people from different backgrounds work together, there is also a period of adjustment. Automated driving systems are complex systems that involve many different technologies, such as mechanics and electronics. The design of these systems brings together many different disciplines and specialisms, each with its own design approach. Within the engineering domain, we can distinguish between the disciplines of mechanical engineering and software engineering (computer science and electrical engineering). Both disciplines have developed their own methods to guide developers in delivering technically sound products. However, the fundamental principle of interaction design is that the process

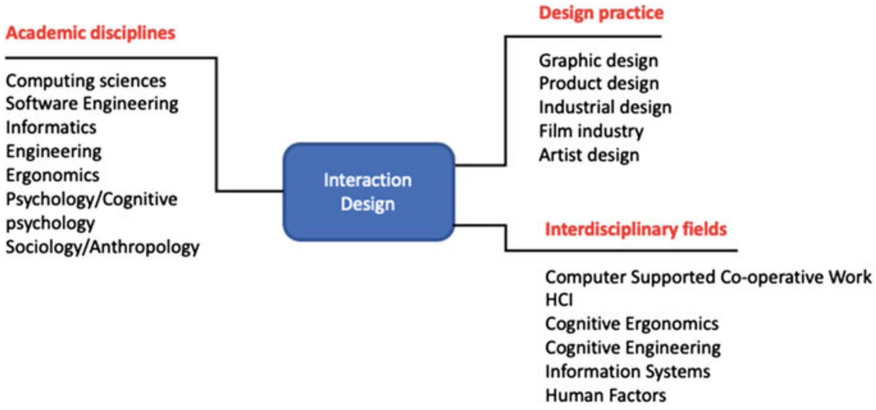


Fig. 2.1 Interaction design requires an integrated team

of developing technically sound products needs to take into account the consumers' point of view and their needs or, more generally, the human point of view, in order to achieve a result that is satisfactory to both the individual user and society. In Part IV of the book, we examine the methodologies of the technical disciplines, summarise the motivations and characteristics of human-centred design, and consider how human-centred design approaches can be combined or harmonised with technical design approaches.

2.3 Human-Centred Design

There is a fundamental difference between human-centred design and technology-centred design. Until the 1980s, for consumer products, there was a relatively direct relationship between the form of the product and its function. Most products contained a number of buttons or similar controls and it was a relatively simple matter to figure out how to use the available functions by manipulating the controls. More complex systems were usually intended for professionals or for very specialist amateurs (as in the case of photo cameras), and their use usually required more or less explicit training and practice. In the case of complex systems aimed at the general public (e.g., vehicles), the law required people to obtain a licence to use the system, which involved also explicit training. However, in the late 1980s, personal computers became available to non-professionals and personal computers began to enter the homes of the general public. At the same time, developments in electrical engineering made it possible to extend the functionality of devices such as car radios. For these new devices, the relationship between form and function was no longer simple and clear. Often there were few controls, and a single control would provide control over many functions. On the other hand, often people were not willing to spend much time learning and training in operation. This has led developers to understand that they must strive to design user interfaces that are easy to use, otherwise these products and features will be abandoned. This led to the development of a conceptual framework for usability and a user-centred design approach.

When it comes to human-centred design, it is good to understand what makes it different from other design approaches. Human-centred design, as the name suggests, puts people at the centre of design. In this context, the term 'people' refers primarily to users. This concept can be compared to the technology-centred design of the past. Technology-centred design is more about the functions that technology can perform and the form in which these functions need to be expressed in such a way that the user understands the state in which the technology is being used. Human-centred design considers the needs of people first, and then looks for technologies that can meet those needs, and the interaction between people and systems takes into account their perceptions, habits, abilities and limitations and real needs.

The advantages of adopting human-centred design are manifold: (1) increased productivity; (2) increased usability and user experience; (3) reduced training and after-sales service costs; (4) reduced work stress and discomfort; (5) increased market competitiveness; and (6) benefits for the sustainability of the product. The theory and methodology of human-centred design is at the heart of our book and will be the subject of Chaps. 8–13.

Before we go any further, we need to distinguish a few basic concepts.

UX: User experience
UI: User interface
IxD: Interaction design

These concepts are often mixed or confused. In fact, there is a clear distinction between them. Interaction Design refers to the design work of a designer who uses different theories and techniques to design a product according to the needs of the user, and who presents the product to the user as a User Interface. The user interacts with the system through this interface in order to complete the tasks that s/he wants or needs to complete. The User Experience is the feeling that the user gets from operating the interface and completing the task. Figure 2.2 illustrates these relationships.

2.4 Usability

There are several levels of interaction design for the car, as shown in Fig. 2.3. Firstly, there is functionality. This concerns the different functions that the in-car interaction system offers to help the user perform the tasks s/he needs to do, such as driving the car, listening to music, communicating with the outside world, helping to check road conditions and so on. Each design therefore serves one or more functional objectives. The second level is safety. Safety is always at the forefront of car design. When cars become more automated, safety will be entirely taken care of by automated systems, and safety may no longer be a primary concern in the interaction design process of the user interface. But other aspects of safety, such as information security, will still be present. The third layer is usability. The fourth layer is user experience.

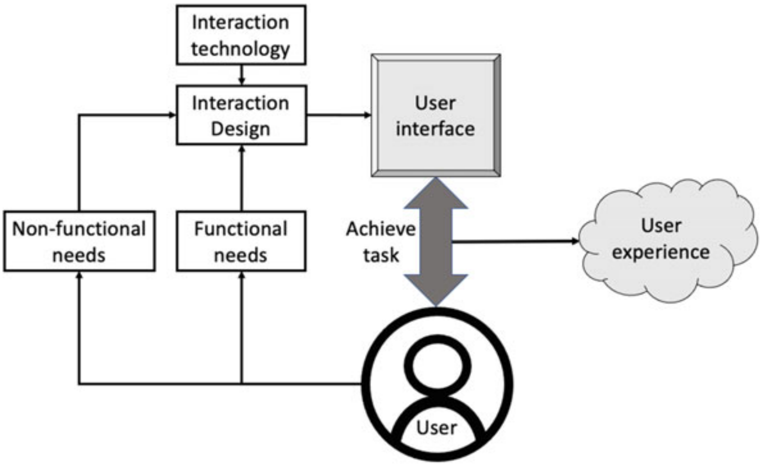
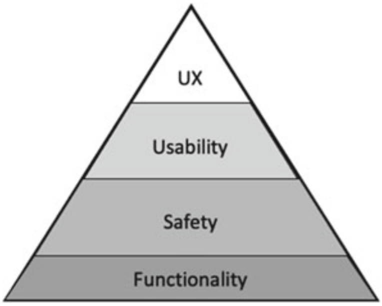


Fig. 2.2 Interaction design, the relationship between user interface and user experience

Fig. 2.3 Hierarchy of car interaction design



ISO standard 9241–11 defines usability as.

> The extent to which a specific user can use a product to achieve a specific goal with effectiveness, efficiency and satisfaction in a specific usage environment.

Figure 2.4 expresses the concept of usability. Several things need to be noted about this definition. Firstly, it was devised as part of an attempt to make usability measurable, i.e., to replace the need for experts or professionals to make global judgements about whether a given product is easy to use, by a method to measure a product's usability in terms of actual use. Secondly, it involves a specified user, a specified target and a specified context of use. In other words, a product's usability is only valid for people with certain characteristics, for whom a product is or is not easy to use when they use it under certain conditions and for certain purposes. If these conditions do not apply, then complaints about poor usability are irrelevant. The relevant characteristics of the population are usually related to issues such as background knowledge and communication skills (language proficiency). For instance, if a system is designed for a professional audience, and a layperson finds it difficult

Fig. 2.4 Usability goals

to use, the complaint has no bearing on the system's usability. Similarly, if a system is intended for normal people and a blind person says s/he cannot get it to work, this comment has no bearing on the system's usability. Thirdly, the definition contains the terms of effectiveness, efficiency and satisfaction. These concepts need further elaboration.

Effectiveness is a question of whether a user is able to complete the task that the product supports and achieve his/her goals. For example, in the case of a navigation system, can the user complete the task of entering the intended destination/itinerary? If the user does not know how to proceed during the process of entering the destination/itinerary, or if the wrong destination is specified, the navigation system is ineffective. Effectiveness can be measured for instance by asking a number of target users to complete a set of tasks and count the number of tasks that are solved successfully. Efficiency concerns the effort required to complete the task. Efficiency can be measured in terms of time ("how long it takes the user to enter a destination/itinerary") or, in other cases, in terms of the amount of mental effort it takes to perform a particular task (for example, how long the user needs to concentrate to perform the task), or, in yet other contexts, the number of people required to complete a particular task. Both effectiveness and efficiency can be measured objectively, without having to rely on subjective judgement. For example, to improve effectiveness, a test might be arranged with 50 participants who perform a set of tasks, and we can calculate the percentage of tasks successfully completed. For efficiency, an improved version of the user interface could be tested again with the same participants and the time taken to complete the tasks could be calculated and compared with the time it took with the previous version of the interface. In addition, during such tests, errors that occur are usually analysed to identify usability bottlenecks that need to be addressed. The distinction between effectiveness and efficiency also implies a distinction between fatal errors, i.e., errors that prevent the user from completing the task successfully, and non-fatal errors, i.e., errors that do not prevent the user to complete the task successfully but slow down the interaction. For effectiveness, only the fatal errors are relevant, while efficiency is affected by non-fatal errors. Furthermore, it should be noted that effectiveness is usually the primary concern for novice users and infrequent use, while efficiency is the primary concern for experienced and frequent users, for whom effectiveness is no longer an issue because they already know how to complete the tasks successfully. For companies, efficiency may be also a concern in the case of novice and infrequent users. For instance, an inefficient user interface at a toll booth at the highway may result in unnecessary queues and a request to install more toll booths.

The definition of usability does not only rely on objective metrics, but also includes a subjective component, namely satisfaction with use. Satisfaction is usually measured by asking test participants to fill in a questionnaire or by conducting interviews. In addition, questionnaires for measuring satisfaction are often combined with questionnaires for usefulness and usability, such as the SUS questionnaire (Sect. 13.5). This allows developers or testers to compare objective data about usability with the subjective opinions of users.

Other definitions of usability include additional elements. For example, Nielsen (1994) suggests including aspects such as learnability and memorability. Learnability relates to ease of use at first contact, and memorability relates to the knowledge of interactions with the system that people recall after a period of non-use. In other words, while the ISO definition does not explicitly mention that people's knowledge of their interactions with the system may change over time, Nielsen's definition explicitly recognises the relevance of changes in people's knowledge to repeated use. However, as the ISO definition has become the accepted standard, we will use the standard definition of ISO 9241-11.

2.5 User Experience

In the latter half of the 1990s, product and system developers began to recognise that interacting with products and systems is not only about understanding how to use the system, but also about the full range of human emotions. The emotional aspects of interaction with the product/system, previous experiences, and expectations became the focus of the user experience component. ISO standard 9241-210 defines user experience as "the personal perceptions and responses that result from the use or intended use of a product, system or service".

Hassenzahl's (Hassenzahl and Tractinsky 2006) framework of user experience includes usefulness, usability and enjoyment. Firstly, a product or system should be useful to people, where 'usefulness' can be understood as 'allowing people to engage in activities that are meaningful to them'. Meaningful activities are considered to be those that relate to basic human needs, such as the famous Maslow's Hierarchy of Needs (Maslow 2013). Maslow's theory divides human needs into five categories: Physiological needs, Safety needs, Social needs, Esteem needs and Self-actualisation needs, in ascending order. At the self-actualisation level, there is a process of learning and growth, aesthetics and self-transcendence. Secondly, the product should be easy to use. Thirdly, the interaction with the product or system should also be emotionally satisfying or pleasurable, or at least not emotionally intrusive (frustrating, annoying, etc.). A product or system can provide a good user experience if it provides meaningful functionality, is easy to use and provides an emotionally satisfying experience.

It is clear from the ISO definition that user experience not only depends on what happens during actual use, but that the user's expectations also play an important role. A product or system with the same target characteristics may produce a completely different experience depending on the level of expectations of the user. Expectations may be generated by advertisements, experience with previous products from the same company, comments from the public opinion community, personal communication between friends/relatives, etc. Therefore, it is important that advertisements do not overstate the benefits that the product or system offers; otherwise, users may be disappointed with the actual experience.

So far, the definition of user experience is rather vague, and it seems that many factors are involved in user experience, for example, memory also contributes to user experience. If a person's interaction with a product or system changes over time, we might ask how an instantaneous interaction can determine the overall user experience. Is the overall experience the average of all momentary experiences, or is there a more complex relationship? The peak-end rule, proposed by Kahnemann (Kahneman et al. 1993) goes some way to answering this question. The peak-end rule states that the memory of an experience is largely determined by the peak experience (positive or negative) and the experience of the final moments of the actual interaction. For example, your experience of using your in-car system for a whole year is no match for the mental imprint left by a traffic accident. Therefore, excessive negative experiences should be avoided as much as possible, as they can seriously affect the overall user experience, and one bad experience can replace 100 good ones. In addition, designers should pay particular attention to the final part of the interaction, as this can also be an important factor in determining the overall user experience.

The desired goal of the user experience varies somewhat from product to product, but in general terms, it consists of the following descriptors.

1. Goals to be achieved

Comfortable	Helpful	Interesting	Delightful	Driven
Exciting	Superior	Challenging	Surprising	Cognitively stimulating
Motivating	Engaging	Supportive of creativity	Emotionally fulfilling	Entertaining

2. Outcomes to be avoided

Boring	Disappointing	Discouraging	Overly pampering	Sinful
Making you feel stupid	Fed up with	Annoying	Childish	Fancy

From these terms, we can see that a good user experience refers to the positive feeling that a user has after using a product. This feeling varies from person to person. As different people have different cultural backgrounds, different levels of education,

Fig. 2.5 Factors to consider in interaction design

different past experiences and needs, different expectations and so on, all of them will have different user experiences when using the same product. It is clear from this that the user experience will change with the knowledge, understanding and continuous use of the product. Therefore, we would say that there is no way to design the user experience, but rather that design should aim to establish a good experience through the product. We will discuss more about user experience in Chap. 6.

This being the case, let us turn back to what interaction design is. As can be seen in Fig. 2.2, interaction design is the process of designing the user interface with the user's needs in mind, that is, the user interface is created through interaction design, and the user experience is shaped by the user's interaction with the user interface. In other words, interaction design is the process of helping a technical product talk to its users, or as Norman says in his book "Design Psychology": "Design is really an act of communication, and designers need to have a deep understanding of the people they are communicating with." (Norman 2013).

So, what are the design considerations? Figure 2.5 provides an illustration. If we take the middle triangle to represent a product, then the immediate factors to consider in interaction design are: Who is the user? Where does the user interact with the product? What actions will the user use to interact with the product?

The German industrial designer and academic Dieter Ramsay has identified ten principles of design that are equally important for interaction design.[1] Any good design will have the following characteristics.

1. It is innovative. It does not only give us a deeper understanding of the product, but also allows for a different experience than before.
2. It is useful and long-lasting. Any product needs to have a practical value for its users. Good design stands up to changing trends, because it covers universal topics that are always relevant to you. Well-designed products play an important role in how we perceive things and how we perceive ourselves.
3. It is aesthetic, comprehensible, simple, honest and thorough down to the last detail. A product needs to be pure, leaving only the necessary functionality, understated but sophisticated and attractive. Even if only 10% of the details are

[1] https://www.interaction-design.org/literature/article/dieter-rams-10-timeless-commandments-for-good-design.

not perfect, it will detract from the overall feeling. At the same time, the user can see straight away how to use it without having to learn further.

4. It is unobtrusive, as little design as possible, and environmentally friendly. A product should not be "over-designed", with too many things that we don't use, it should not foster social motivators such as status, wealth and power, and not contribute to wasting natural resources.

2.6 Improving Usability

Human cognitive abilities and limitations are discussed in detail in Chap. 3. Since it is often difficult to translate these scientific insights into convenient design tools, theorists such as Nielsen, Norman and Schneidermann have provided usability principles or rules to guide design. In The Design of Everyday Things (Norman 1988) Norman identifies three principles that must be met in order to achieve good usability: mapping, affordance and constraints.

- Mapping is about the relationship between the form of an element in an interface and its function. In order to achieve a particular goal, it should be clear for the user how to operate the elements in the interface. For example, if three light switches are adjacent to each other, there should be a clear mapping from the physical arrangement of switches to that of the lights, so that it is clear which switch controls which light.
- Affordance is about the physical characteristics of a control. The physical shape of the control suggests how to operate it. For example, a button is shaped so that people, when they see it, know that it is for pressing, while a knob elicits a rotating movement. The handle of a car door is a cue for where to put one's hand when opening the door.
- Constraints refer to limitations on how people can or are expected to interact with a system. Physical constraints limit the physical interaction between people and objects. For example, a typical light switch can only be placed in two different states, 'on' or 'off'. Because it is always in one of the two states, it can only perform one action. Cultural constraints are learned practices that influence people's perceptions of how they interact with the system. For example, "green" usually means "pass/go on", while "red" usually means "stop". Using such constraints in the interaction automatically elicits the proper behaviour. It should be noted that cultural constraints may acquire characteristics similar to affordance, and hence prompt for action. For example, because icons on touchscreens are not physical elements, there is no inherent affordance for pressing, but even so, because people have learned this association, the icons are felt to be pressable elements.

It may be argued that these principles, at the outset of use, help the user to generate assumptions about how to interact with the system based on the information provided by the interface. If the principles are violated, the user will find that s/he has to learn and remember the way to interact with the system. This additional learning requires effort and reduces the ease of use of the system. Furthermore, the ability to generate correct assumptions also depends on the user's background knowledge. Someone who has no experience with touchscreens may not think that the corresponding function on the touchscreen can be activated by touching an icon. For someone with experience with touchscreens, it is simple enough for that person to figure out which icon needs to be clicked to activate a particular application. Ease of use is therefore very much dependent on the background knowledge of the user. Usability and ease of use will therefore vary from person to person.

In addition to these general principles, theorists have proposed various rules or guidelines for interaction design (for example, Schneiderman's eight golden rules[2] and Nielsen's ten design heuristics[3]). These aspects are explained in more detail later. Some of the most salient points are.

- Visibility: The system should always make the user aware of what is happening through appropriate feedback within a reasonable time. For example, it should be clear which mode the system is in to avoid mode confusion. Similarly, it should be clear that if a response cannot be displayed immediately, the system needs to show that it is performing a particular action and how long it will take to complete that action.
- User control and freedom: the user should feel in control of the interaction and be able to predict the changes that will occur in the system after each action, rather than being passively asked to perform various actions.
- Consistency and standards: the use of different terms to describe the same thing, the same situation or action should be avoided. The operation of the system also requires adherence to a number of recognised conventions, various design guidelines and standards.
- Flexibility and efficiency of use: shortcuts ("accelerators") should be provided so that skilled users can speed up interactions and thus interact more efficiently, without complicating the interface for novice users. In other words, skilled users should have the possibility to set up shortcuts. As mentioned before, novice users are interested in effectiveness, whereas for experienced users, the principle of effectiveness is usually satisfied and efficiency becomes more important.

It is worth mentioning here that these heuristics or rules were proposed in the 1990s, when the development of electronics had greatly increased the functionality of systems and the design needed to enable the user to handle the large number of functions available. With the advent of intelligent systems, systems do not only react to the user's actions, but also perform certain actions automatically according to the user's behaviour and context. Nevertheless, the heuristics and rules mentioned above are equally valid for ensuring good usability and no research has yet been conducted to explicitly oppose these regulations.

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[2] https://www.interaction-design.org/literature/article/shneiderman-s-eight-golden-rules-will-help-you-design-better-interfaces.

[3] https://www.nngroup.com/articles/ten-usability-heuristics/.

Usability can be achieved by applying the design principles and heuristics described above and by conducting continuous testing throughout the design process. As the design principles and heuristics are still abstract, designers need more specific guidelines and criteria, including interface design and methods for evaluating how the interface design is judged in terms of achieving the goals of the system. Guidelines and criteria will be discussed in later chapters.

It should be mentioned that pleasantness may be influenced by cultural differences. In particular, aesthetic preferences may differ between cultures. What is considered beautiful in Europe (e.g., minimalist design) may not be considered attractive in China. However, as Chinese people become more accepting of Western culture and as globalisation progresses, they are becoming more appreciative of the simple, beautiful design style of Scandinavia.

Finally, it should be noted that, while the usefulness, ease of use and pleasantness of a product all affect the user experience, the contribution of ease of use is asymmetrical: while a badly used product may negatively affect the user experience, good usability does not necessarily have an equally positive impact. Instead, good usability is often taken for granted. Nonetheless, usability should still be valued so that poor usability is avoided, but design for a good user experience undoubtedly also requires attention to the aesthetics, resulting in a pleasing experience.

2.7 Know Your Users

Understanding your user is an important part of interaction design. Understanding the user includes understanding his life, his work, his education, his environment, his relationships and so on, so that you can design a product that meets his needs. Understanding the end user, understanding a group of users, is not the same as understanding the individual user. Each individual user is very different, and from a deeper understanding of the individual it follows that, if a product is suitable for one person, it may not necessarily be suitable for a group of people. In addition to individuality, age, gender, education, individual differences also arise from work, culture, life experience, social status, family status etc. For special systems, such as voice interaction systems, individual language skills and accents can also have an impact on interaction. We want to design products that are accessible to as many people as possible and that meet the needs of as many people as possible. In this case, it is important to understand individual differences. In other cases, the product may be used by more than one person, so it is important to understand this common group.

Age and gender differences are two of the most fundamental differences. Some abilities differ between ages, and products designed and developed for children cannot be based on the physiological, psychological and cognitive abilities of adults. Similarly, products designed for younger people may not be suitable for older people, and the other way around. This is because reaction time, eyesight, hearing and muscle strength are all deteriorating with age. Furthermore, many studies have shown that teenagers, between the ages of 18 and 25, are not mentally mature enough to cope with the road environment when driving and are therefore more likely to be involved in car accidents than other age groups. They also have different interests than adults and may be more interested in novelty and excitement. Similarly, with the advent of an ageing society, researchers in many Western countries are studying the characteristics of older drivers, hoping to extend their driving experience and improve their safety through interaction design.

In many ways, gender differences are also evident. In driving tasks, this difference may not be immediately obvious. However, in the use of infotainment, or some peripheral products, differences may arise. When someone studied why a European car sold so well in Europe in the 1970s but not so well in the US, it was thought to be because there was no small mirror on the back of the sun visor above the driver's seat. Because women in America, when preparing for work in the morning, may not have time to put on their make-up and need to do this in the car. The absence of a mirror can be a deciding factor in whether they buy the car or not!

The educational background and nature of the user's work can have a significant impact on interaction design. For instance, while users with an engineering background may expect the system to provide more logical explanations of the interaction, users without such a background may not want to know every technical detail. Good design boils down to a deep understanding of people. An understanding of the user starts with the following.

1. Understanding the user's strengths and weaknesses, the main emphasis here being on their cognitive abilities and limitations. What are they used to, what are they good at. What are they not good at, what don't they understand how to do, etc. This is described in more detail in Chap. 3.
2. Designing to help people do things the way they are used doing them: this is important if a design is trying to change the way people are currently used to do things, emphasising them to learn a completely new way of doing things, which can evoke resistance from users. Many years ago much research was done into the arrangement of keys on the keyboards of typewriters and it was concluded that the current arrangement was not the best design, but this research did not result in redesign of the keyboard, because people were already used to the current alphabetical arrangement of keyboards and did not accept the new arrangement.
3. Any design mediates a user experience. The design is not just a list of various functions that the user needs, stacked there. Through an in-depth understanding of the user, mastering the user's operational characteristics, the design can better guide the user to operate the relevant functions, so that the user feels that the product is designed for him.
4. Meet the needs of the user and, if possible, even involve them in the design. There are theories that the person who knows best is the person themselves. So, there are theories that involving users in the design will make the product more

responsive to their needs. This idea is difficult to implement in practice, especially for companies. However, it can be a very effective way to give designers a deeper understanding of user needs through user involvement in early design.
5. Use a tried and tested user-centred approach.

2.8 A Short History

When it comes to interaction design for cars, there are a few terms that often come up: ergonomics, human factors and interaction design. What is the difference?

Wojciech Jastrzebowski coined the term 'Ergonomics' in a philosophical narrative in 1857, from the Greek words ergon (work) and nomoi (natural law), to refer to the technique of optimising the design of a product to make it more user-friendly. In the early 1900s, industrial production still relied heavily on human/motor power and ergonomic ideas were being developed to improve worker productivity. Scientific management (as developed by Frederic Taylor) to increase worker efficiency through improved workflow was popular. However, in a strict sense, design in this period was still a design that 'made people fit the job', which is not the modern concept of 'ergonomics'. The modern concept is that we design work to meet the characteristics and needs of people. The prototype of this concept was born in the Second World War. There was a huge amount of modern weaponry being used in the war. It soon became apparent that many soldiers were not killed by the enemy but injured by their own weapons. This was because the weapons were not designed in accordance with human mechanics, anthropometry, human physiology and so on. This led to a great deal of research into the human being. To date, ergonomics still focuses on the effects of human mechanics and anthropometry, human physiology, environmental physiology, etc. on human performance. This is an important part of the design of automobiles, which includes the study of the comfort of car seats, seat belts, steering wheels, air conditioning, interior sound, lighting, the layout of physical buttons and so on.

Human Factors Engineering, on the other hand, is a discipline that has developed more on the basis of human cognitive psychology. The rise of this discipline was due to the development of large-scale industries and the emergence of many complex systems that brought complexities that, at that time, were beyond the scope of human cognitive psychology, such as the emergence of large industrial control rooms. The study of human factors has led to a broad understanding of the characteristics and limitations of human behaviour and cognition. Interaction design, on the other hand, emerged from the rapid development of electronic systems as computers became widespread. Interaction design is, in a way, a part of ergonomics and human factors engineering.

References

Hassenzahl M, Tractinsky N (2006) User experience—a research agenda. Behav Inf Technol 25(2):91–97

Kahneman D, Fredrickson BL, Schreiber CA, Redelmeier DA (1993) When more pain is preferred to less: adding a better end. Psychol Sci 4(6):401–405

Maslow AH (2013) A theory of human motivation. Simon and Schuster

Nielsen J (1994) Heuristic evaluation. In: Nielsen J, Mack RL (eds) Usability inspection. Wiley, New York

Norman DA (1988) The design of everyday things. Basic Books, New York

Norman DA (2013) Design of everyday things, Revised. Basic Books, New York

Sharp H, Rogers Y, Preece J (2019) Interaction design—beyond human-computer interaction, 5th edn. Wiley