Societal and Individual Acceptance of Autonomous Driving

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A good science fiction story should be able to predict not the automobile but the traffic jam Frederik Pohl *([1]: 287).*

29.1 Introduction

What attitudes and expectations do (potential) future users, and the public at large, bring to the new technology of autonomous driving? Alongside the technical and legal areas of research, this question is moving into ever-greater focus. The emerging debates assume that a switch from conventional to autonomous driving might bring about clear changes for all road users. From these perspectives—individual users and society—the question of acceptance arises. To what extent are individuals ready to use fully-automated vehicles, and to what extent are we as a society prepared to accept a transport system with fully automated vehicles on the road?

Public interest in autonomous driving has grown appreciably of late—in surveys, a majority now speak of already having "heard of" autonomous driving (see [2]). In mass media news coverage, driving's automation is often portrayed as the solution to many of our automobile-related transport problems. It is further expected that it will bring about a revolution in car usage and ownership. The term "autonomous driving," however, is even

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less clearly defined in the public discourse: sometimes the talk is of automated driving and self-driving or driverless cars, sometimes partly- or fully-automated driving. Frequently, it is not clear which of the potential transport options is being discussed, what concrete options, potential, and risks are involved, or what challenges still need to be overcome on the path to autonomous driving.

The perspectives of road users and potential future users are paid little attention in this, even if it is constantly stressed that a user- and usage-oriented view can make an essential contribution to acceptance, and thus also to autonomous vehicles' success (see [3, 4]). Acceptance must be brought into the discourse surrounding autonomous driving at an early stage, even if the realization of road traffic with fully automated vehicles is not currently conceivable at all. Introducing the technology will potentially bring changes across the entire sphere of mobility, impacting many levels of society. At the same time, it could trigger a fundamental transformation in the way we get around. In order to know in good time what the essential issues are, and to control the transformation where necessary, it is important to identify the significant influencing factors and understand their dynamics. One of these factors is the acceptance of technology.

This paper begins with a determination of what is to be understood by (technological) acceptance, and then discusses which main research areas are relevant in connection with autonomous driving. The empirical section begins with the results of current studies on autonomous driving's acceptance. It then introduces the outcome of our own investigation looking into the views of today's road users. This provides findings for future, more closely use-oriented empirical analysis on the acceptance of autonomous driving.

29.2 Acceptance

When acceptance is talked of, what is meant in general terms is "*agreeing, accepting, approving, acknowledging; to agree with someone or something*" ([5]: 136, translation by the authors). This formulation encompasses a sense of "willingness for something," which bestows an active component on acceptance. This differentiates it from simple acquiescence and the absence of resistance, but also from tolerance. Acceptance takes place in the context of social and technological construction processes—that is, it is dependent on people, their attitudes, expectations, actions, environment, value- and norm-framing etc., but also on changes over time (see [6]). The processual and changeable character of acceptance makes it overall an "*unstable construct*" ([7]: 25, translation by the authors)—one that depends on various specificities, types, and the subject, object and context of acceptance. Moreover, it can vary greatly in the course of time [8].

For the acceptance of a specific technology such as autonomous driving, this means that various usage options and fears of risk are woven together alongside the technical options, on both individual and societal levels. In this way, a technology can alter its "original purpose" over time before finally stabilizing, or even becoming institutionalized. The field of transport is especially ripe with such examples, starting with the railway originally being

invented exclusively for goods transportation, right up to using cable cars as public transportation in densely populated inner cities. This progression from the genesis of a technology to its adoption poses great challenges for research into acceptance. At each stage of technology development, implementation and adoption, different stakeholders and stakeholder groups are variously relevant to acceptance. When viewing acceptance in the context of such a sociotechnical process of transformation (see [9]), the several stages of the process must be distinguished between, as their relevance to acceptance always differs.

29.2.1 (Technology) Acceptance: Concepts, Research and Characteristics

The subject of technology acceptance is a decidedly inhomogeneous field; various scientific disciplines (e.g. psychology, sociology, economics, etc.) are related to and have mutual bonds with it. Overall, acceptance research is still a relatively young field. The topic first came to prominence in the 1970s with broad public opposition to nuclear energy. This was postulated—rather unjustly, as things have turned out—to indicate general hostility to technology among Germans (for more on this, see Chap. 30, on risk analysis and assessment) ([10, 11]: 45 ff).

The aims of acceptance research are, firstly, a better understanding of particular acceptance phenomena (social-science/empirical analysis). Secondly, it is to enable specific objects of acceptance, e.g. a specified technology, to be developed and designed in such a way that acceptance occurs (normative-ethical approaches). At research and policy levels in Germany, several institutions accompany the development of (new) technologies and debate surrounding them. They have emerged in parallel with the various research approaches to meet these requirements ([11]: 47 ff). All institutions share the basic assumption that technology cannot be viewed removed from its embedding in social, economic, and also usage-related contexts. In short, technology's embedment in its sociotechnical system must also be taken into consideration (see e.g. [11, 12]).

29.2.1.1 Acceptance Subject, Object and Context

Acceptance always takes place within an interplay of subject, object and context (see [13]: 88 ff): "*To be stated is not only what is accepted (or refused), but rather what, by whom, within which society, in what situation, at what time, and for what reason*" ([13]: 90, translation by the authors). Figure 29.1 shows the relationship between the subject, object, and context of acceptance.

Acceptance subject

An acceptance subject has attitudes, or develops attitudes, in relation to the object of acceptance, and also links them, where appropriate, with corresponding actions (see [12, 13]). The term "subject" refers here not only to individuals, however, but also groups, institutions or society as a whole.

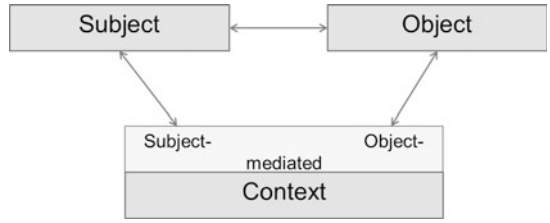

Fig. 29.1 Acceptance as relational between subject, object, and context (based on [13]: 89)

The acceptance subject of autonomous driving can currently be approximated, for example, by taking transport system users who will either passively or actively come up against autonomous driving in future. This covers all of those using the current road system, be it as car drivers, cyclists or pedestrians. Further relevant acceptance subjects include developers and engineers, politicians and businesspeople, or even public research institutes.

Acceptance object

Acceptance object does not necessarily imply a physical object as such, but rather refers to the adoption of something "*on offer, available, or proposed*" ([13]: 89, translation by the authors). This may be engineering or technology, but it could also be artifacts of any type, or people, attitudes, opinions, arguments, actions, or even the values and norms behind such things. In turn, such an object acquires its significance only from what individuals or society ascribe to it—there is therefore no such thing as autonomous driving per se. Rather, the question is what specific functions autonomous driving can fulfill, and what significance individual people and society at large place in the technology. Behind this is the assumption that engineering and technology have no significance in and of themselves; instead, this is only attained by the fulfilling of social functions, human actions, and their embedding into social structures (see [9]).

Acceptance context

The acceptance context refers to the environment in which an acceptance subject relates to an acceptance object—and thus can only be viewed in relation to both. For example, the context of autonomous driving is determined by the current individual and social significance of car usage: Why do people use cars? What attitudes, values, expectations, etc. inform (auto)mobile praxis? Does autonomous driving fit in here seamlessly—or will it change the meaning of (auto)mobility and its system of norms?

In the copious literature on acceptance and acceptance research, various dimensions and levels are identified where acceptance is visible and, above all, comprehensible. In the following, we shall take a closer look at the dimensions of attitudes, actions, and values.

29.2.1.2 Dimensions of Acceptance

Attitudes dimension

Attitudes regarding acceptance that can be surveyed include mindsets, values, and judgments. These can be polled and interpreted on both individual and societal levels. Attitudes are significant for acceptance research, as it is assumed that they can be read as willingness and intent for concrete actions ([13]: 82 f). Nevertheless, questions on the genesis of technology, its specific usage, the associated challenges, and frameworks—all in their specific contexts—cannot be captured with such measuring of attitudes ([11]: 46).

A typical measuring instrument of the attitudes dimension of acceptance is the opinion poll—even though such surveys quickly lead "*to a simplified picture of an opinion-forming process based on the perceived properties of technology*" ([14]: 35, translation by the authors). This is because they imply that technology sends out signals that spark off set reactions in the population or individuals. One-dimensional surveying of attitudes has been replaced in recent years, however, with greater insights into technology acceptance, and expanded into an analysis that incorporates attitudes' contexts in particular. In this way, the focus of acceptance research shifted from the "*descriptive inventory of attitudes and actions*" ([14]: 36, translation by the authors) to a more analytically aligned perspective. This takes greater account of the complexity in individuals' perceptions and evaluations, experts' subjectivity, and the significance of contextuality ([14]).

Actions dimension

The actions dimension of acceptance describes observable behavior, although acting in this sense may relate either to doing something or to refraining from it. Actions can manifest themselves in many ways, for instance in purchasing, using, and spreading (or the opposite, e.g. initiating protests), or in supporting other (decision-making and planning) activities.

The dimension of actions is often equated with that of acceptance, as found in Lucke, for example (see [13]: 82). On the other hand, other authors do not view action, or a concrete intention to act, as imperative for acceptance ([15]: 19, [16]: 11). Schweizer-Ries et al. ([16]: 11) have depicted this reciprocity between the dimensions of actions and attitudes in a two-dimensional model (Fig. 29.2).

Values dimension

In many approaches, the values dimension is not viewed as a separate level of acceptance, but combined with the attitudes dimension. Values and norms, according to this argument, are also the basis of attitudes and therefore can only be separated from them with difficulty. The dimension of values comes into its own, however, when acceptance is visible on the level of actions, for instance in the use of a specific product. These actions may only accord with subjective individual values slightly or not at all—a person can own and use a car while being strongly ecologically-minded. This, in turn, may show itself more

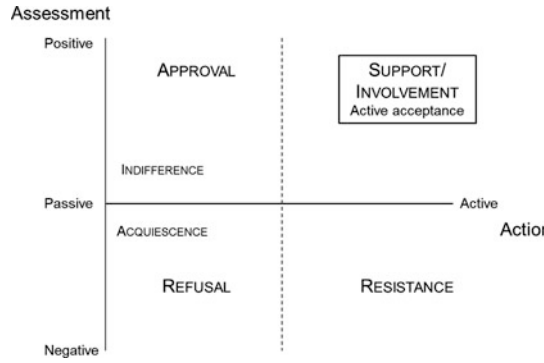

Fig. 29.2 Two dimensions of the concept of acceptance (based on [16]: 11)

clearly in other areas of activity—for example, by mainly or only shopping in organic grocery stores. In the context of autonomous driving, ethical criteria and social standards, which (must) determine how it is viewed, are especially challenging—see Chaps. 4 and 5 in this volume. In general, an acceptance object is also always evaluated in relation to an existing system of norms and values (see [14]).

29.2.1.3 Research on Acceptance

Acceptance takes place not only on various levels as described above, but is also the result of a complex individual and collective process of evaluation and negotiation, sometimes even of relatively unspecific "*sensitivities*" ([8]: 55, translation by the authors). This raises the question of how such a process can be made measurable and thus empirically accessible. For a relatively new technology such as autonomous driving, this means to examine in what way individual stakeholders (e.g. users), social groups, organizations, and institutions meet the challenges of technological and scientific progress as well as "*to identify the potential for design to meet social challenges and to test technological options in view of their problem-solving capacity*" ([12]: C, translation by the authors).

In summary, we may say that, for acceptance research, acceptance "*is a complex, multilayered construct that is not directly measurable, and for which there are no* "*calibrated*" *measuring instruments*" ([12]: 21, translation by the authors). Depending on the acceptance object in question, but also on the relevant dimensions, only indicators specific to each case may be operationalized and rendered measurable—which in turn excludes the use of others. This should also be reflected in the research process.

29.3 Acceptance of Autonomous Driving: The Current State and Focus of Research

Autonomous driving can be placed alongside products of everyday technology. In contrast to working technologies and so-called external technologies, such as nuclear power or satellite technology, everyday technologies mainly involve products for individual

consumers, and are controlled by the market. Nonetheless, they can have consequences for third parties ([14]: 31). Car usage and ownership are typical examples from this area. Acceptance of technology in this context primarily means purchase, but as a rule also includes use. Particularly at the beginning of autonomous driving's potential implementation, however, it may be assumed that not only the level of private or individual consumption plays a role, but also that the effects on various social spheres are publicly discussed and weighed up. This could include questions of whether we can permit vehicles in our transport system that will probably be involved in accidents just like conventional vehicles—but with the possible difference that the machine or driving robot causes the accident, not only endangering its own occupants but all road users. Recently there has also been the question of the common good (for more on this, see Chap. 30 on risk analysis and assessment Chap. 4 on the ethics of autonomous driving).

It is possible that autonomous driving may bring with it other social or economic risks and consequences that could be the subject of public debate. It will thus also be important, in empirical terms, to demarcate the border between these two spheres—the individual and the societal aspects of acceptance—as clearly as possible, and to establish "*how technological attributions come about as internally or externally controlled*" ([14]: 32, translation by the authors). In general, no hostility to technology is visible in Germany, and in the sphere of its individual use, the reverse is even true. To a great degree, many German households have, and constantly use, everyday technological products (see [10, 17]).

In summary, it is often said of autonomous driving that such vehicles will only be accepted if, on the one hand, they drive "better" than humans, and on the other, if the vehicle user can override the autonomous functions as a last line of control (see [4]: 2 ff). However, Grunwald reports elsewhere in this volume that risk perception is many times more complex than such statements would have us believe (see Chap. 30).

Analogies to other technologies from these areas, and thus their experience of acceptance, tend to be difficult to make. Although we already have many examples of automated transport systems today (for instance airplanes, ships, (metro) trains, and military vehicles), they all still have humans with authority to supervise or control them. We do not yet have a vehicle or mobility system without this human authority ([4]: 6). For this reason, autonomous driving could place unique demands on acceptance.

The question of which factors, characteristics, demands, expectations, value systems, of whom and to whom, and what, etc. is connected with autonomous driving's acceptance —all this has not yet been sufficiently empirically recorded. Some studies dealing with the topic from market and opinion research have found a general and also increasing openness to autonomous driving (see [2, 18, 19]). But these do not make clear what the respondents actually understand as "autonomous driving," in which context their perceptions and evaluations are embedded, and what challenges and obstacles, and also benefits, may be identified in relation to it.

On the user side, surveys directly testing judgments of autonomous driving are currently also subject to the problem that, to date, neither broad levels of knowledge, nor concrete experience may be assumed. Attitudes and assessments recorded as such are

therefore possibly of only limited validity, for the object of the survey is not yet clearly defined, as people have hardly encountered it. In their study on acceptance and electric mobility, Peters and Dütschke suggest the following: "*Surveys of potential users, for instance questionnaires as to whether or under which circumstances they would be prepared to buy an electric car, have the problem that judgments on the new, still little-known system of electric mobility are difficult for consumers to make. As a rule, they rest on a comparison to conventional vehicles on the basis of previous mobility patterns*" ([20]: 6, translation by the authors). A comparable assessment can be carried over to autonomous driving.

The few studies that have considered aspects of autonomous driving's acceptance give, in part, quite a heterogenous picture. In their study of active and passive safety systems, Frost and Sullivan show that the majority of car users to date resist the idea of giving up control of their vehicle to a machine or robot [21]. Other surveys, on the other hand, have demonstrated that young drivers between 19 and 31 in particular often find driving to be burdensome—specifically, driving can stop them addressing other, more important, meaningful or interesting activities: "*Regulation keeps trying to say texting is distracting to driving but for the consumer it is really the driving that is distracting to texting*" ([22]: 2). A poll of Europeans' desires for the car of the future also revealed that some two thirds of respondents are open-minded concerning autonomous driving [18]. Although an international survey of car drivers in Germany, China, the USA, and Japan found openness in principle, it also showed that a large number of those questioned in all countries currently (still) harbor doubts about the technology's safe operation [19] or are even rather scared of it [2].

29.4 The Road-User Perspective

Despite the haziness in the empirical methods outlined above, the main questions when looking at autonomous driving's acceptance have to be: How is the acceptance object actually perceived? What acceptance-relevant issues, on either individual or social levels, are associated with the technology? The aim must be to obtain initial indications as to the dimensions of attitudes and values regarding acceptance, and to identify the concrete expectations, hopes, desires, even fears, linked with the development, use, and design of the technology (see [12]). Within the "Villa Ladenburg" project, the first work on individual and societal acceptance was therefore an exploratory study that took a broad look at the point of view of today's road users—who are also tomorrow's potential users of autonomous driving. In the process, essential issues of perceived use from a subjective perspective were considered. The survey also addressed discernible differences in different socio-cultural environments—in this case Germany and the USA. These are among the leading automobile nations, where wide-ranging debates on autonomous driving have already begun with media coverage of the topic having increased noticeably in the last two years. This indicates that autonomous driving is gradually gaining the public's attention.

29.4.1 Methods

The study analyzed statements from comments on autonomous driving. The methodological approach took the form of an analysis of how online articles in widely distributed print media were received. This reception can be traced in the online comments by the users. In particular, this approach assumes that media discourse has a critical influence on individual and societal opinion forming (see [23]). One criterium in selecting articles was that the online news portals they were published in should give a representative picture of the German and US print media landscapes. This permits the assumption that the articles both reflect and help to form the current public discourse on autonomous driving. For Germany, the comments analyzed were on articles from Bild [24], Die Welt [25], Frankfurter Allgemeine Zeitung [26], Heise online [27], Spiegel Online [28–30], Süddeutsche.de [31] und Zeit Online [32]; for the USA, from the Los Angeles Times [33], NY Daily News [34], The New York Times [35], San Francisco Chronicle [36], The Wall Street Journal [37] und The Washington Post [38]. In total, 827 comments on 16 articles were evaluated. To ensure as great a combarability as possible, most articles concerned California's decision at the end of September 2012 to allow Google's driverless cars onto its roads. In terms of "*conceptual representativeness*;" a theoretical sampling was undertaken ([39]: 154 ff), i.e. in the course of the analysis, comments were analyzed in stages, which in the end led to three comparison groups: (1) comments from German mass media portals, (2) comments from US mass media portals and (3) comments from one technology-centred German portal (Heise online). The evaluation used a qualitative content analysis following Mayring [40] whose aim is to identify texts' meanings, particularly those not immediately apparent. This is done using a systematic and intersubjectively verifiable analysis that meets the linguistic material's interpretational requirements and wealth of meaning. The result of the (summary) contents analysis is an inductively developed category system ([40]: 67 ff). This reflects how the topic of autonomous driving is discussed and negotiated from the online commenters' point of view; which issues and features are perceived; and how these are assessed. To this end, all comments were coded—the smallest coding unit within a comment was one word. A total of 1,421 codings were made in this way, and in successive steps of reduction and abstraction, were condensed into the category system.

29.4.2 Results

The category system, consisting of almost 60 categories and subcategories, is divided into two levels. First there is an object-related level, which is also the more objective of the two. This encompasses statements that contained (positively and negatively) perceived features of the technology, as well as connected topics concerning its general and specific potential for development, and also those on the legal framework, liability questions, etc. Such statements are above all oriented around the object of acceptance, and

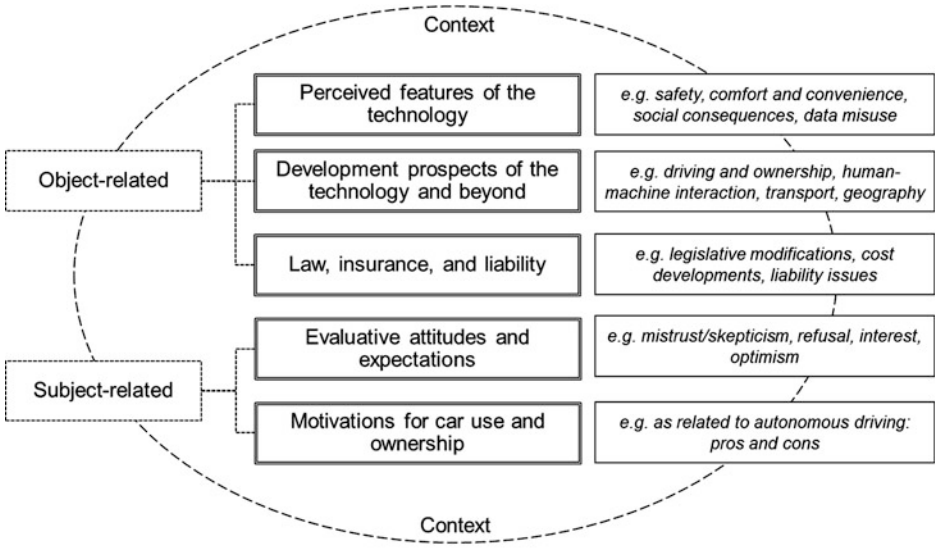

Fig. 29.3 Two-level category system

simultaneously closely linked to the acceptance context. On the more emotional level, on the other hand, the question at hand is the subject of acceptance—statements mostly directly refer to the commenters themselves and contain attitudes, judgments and subjective motivations regarding autonomous driving. These are also essentially strongly linked to the context of acceptance, for example with the context of car usage and ownership. Around 15 % of all statements were not applicable to the research object and therefore were deemed to have no relevance. Figure 29.3 shows the category system and a reduced graphic overview and Table 29.1 has the percentages of statements on the two levels as well as the survey's general figures.

Table 29.1 Distribution of statements, general figures

	Ger	USA	Hei		Ger	USA	Hei
Level	Mentionsin %			Level	Mentionsin %		
Objective/object-related	43	47	48	Affective/subjective	43	32	33

	Ger	USA	Heise Online
Political-ideological connotation	*0%*	*8%*	*0%*
Statements without relevance	*14%*	*13%*	*19%*
Total comments	314	322	191
Total cases	214	221	82
Total codings	536	527	358

29.4.2.1 Object-Related Level

Perceived features and consequences of autonomous driving

Distributed among the three comparison groups (German and US mass media; tech-savvy Heise online), between 43 and 47 % of all statements were attributable to the object-related level. Table 29.2 shows a selection of the categories and their percentage distribution. The comments give concrete expectations in relation to the features of autonomous driving, but also to the potential changes and consequences for transport and social systems, and in legal terms. At least two thirds of the anticipated features and consequences have clearly positive connotations, as many as 70 % in the German-media comments. These may, for example, refer to expected safety benefits of autonomous driving, which are expected to greatly reduce, if not completely prevent, road traffic accidents in future. One user puts it thus:

Table 29.2 Statement distribution of N = 647 on an objective/object-related level

	Ger	USA	Hei
Category	Mentions in %		
Features, consequences of autonomous driving	60	66	27
Positive	*71*	*61*	*70*
Safety, reliability	39	39	37
Flexibility, comfort	28	18	30
Contribution to traffic optimization	11	11	9
Integrative transport use	8	10	0
Progress	5	17	6
Sustainability	5	3	9
Cost savings	4	2	9
Negative	*29*	*39*	*30*
Social consequences	47	63	22
Data misuse	18	11	14
Deficiencies in technical infrastructure	15	11	0
Cost increases	10	5	57
Uncerrtainties	10	10	7

	Ger	USA	Hei
Category	Mentions in %		
Liability, insurance and law	21	16	19
Liability issues	75	34	51
Legislative modifications	19	8	28
Cost developments	6	24	18
Civil law questions	0	34	3
Development perspetives	19	18	54
Social and general	11	11	9
Technology & vehicle design	23	29	35
Human-machine interaction	2	7	25
Transport & geography	25	11	7
Driving and ownership	39	29	24
Questions	0	13	0

"*A car, though, should actually be much safer on the road than with a driver, as it will have a lot more sensors to see what's coming, be able to look in all directions at once, and have a reaction time close to zero*." On the negative side, the main fears revolve around the social consequences, for instance job losses: "*What they are working towards is the abolition of the German car industry. Nobody is going to buy a Porsche or a nice fat Benz if they will only get schlepped around like every other Tom, Dick or Harry.* […] *Losing the German car industry means ca. 25 % fewer of the most highly qualified jobs*." Other issues associated with autonomous vehicles in the statements included—on the positive side—flexibility and comfort, transport optimization and efficiency, integrated transport use ("travel-strengthening" currently restricted transport users), general progress accompanying technology, and cost savings. On the negative side, a series of issues were mentioned beyond fears of social consequences: data misuse; deficiencies in the technical infrastructure, i.e. the assumption that such vehicles will not be safe (enough); increased costs; and relatively unspecific uncertainties surrounding the way these vehicles will function. Thus several of the positively perceived features find their negative counterparts here: safety vs deficiency thereof, cost savings vs increased costs, progress vs social consequences.

Liability, insurance, and law

According to our evaluation, liability, insurance, and law are topics of particular concern in Germany—expected modifications to the legal framework will also be accompanied by changes to the insurance set-up. This signals uncertainty for almost half the statements on this topic on German mass media portals. One user framed it this way: "*This car is not a technological problem, but a legal one. Whose fault is it, then, if the car causes an accident*? *The driver's or Google's*?" A country-specific problem also materialized in the US comments, however, albeit often in ironic fashion—the auto insurance and liability-centered legal profession, seen as being addicted to disputes and litigation, might stand in the way of a successful roll-out of autonomous vehicles: "*Leave it to the trial lawyers to spoil the party!*" was how one commenter summed up this view. Further discussion on this topic revolved around the necessary future legal changes and development of costs.

Development perspectives for autonomous driving

Particularly on the Heise website, many commenters address development perspectives in the context of autonomous driving which go far beyond features exclusively associated with technology (54 % of all object-related comments). Such statements may be about social development in a rather general sense, but also the future development of car usage and ownership, design and vehicle equipment, the interaction between humans and machines, and considerations on the future form of transport and urban space. One user, for instance, touches on the consequences of a changed legal framework: "*The question is no longer* '*who is liable when there are car accidents*?' *but rather* '*who will still be allowed to drive manually*?'"

29.4.2.2 Subject-Related Level

Evaluative attitudes and expectations

As a rule, comments in online forums consist of several statements that can be categorized to several levels or (sub)-categories—statements on a more "objective" level are often linked with the more subjective/emotional one. When, for example, negative features are associated with autonomous driving, commenters likewise tend to take a dismissive stance to using the new technology, and vice versa: "*I don't want to let the controls out of my hands! Certainly not to a computer that can be manipulated and hacked, just like PCs and cellphones!*" This statement combines security fears (an autonomous vehicle, similarly to a computer, will not be entirely secure, data may be misused) with a subjective refusal. On the other hand, the expectation that autonomous vehicles are especially comfortable and flexible may accompany positive personal assessments of the technology: "*Fully automated driving with no annoying passengers, no train cancellations and delays—that'd be really great.*" Statements are not always linked on the different levels, however. Judgments can also be made with no further justifications given, such as this one from US online portals: "*Yes. Easiest question I've been asked all day!*" or "*Jerry, I support you, but not on this*" ("Jerry" refers here to the Governor of California, Jerry Brown, who accorded Google driverless cars their street-legal status to media fanfare in the Google headquarters in 2012).

In general, although the technology is clearly positively perceived (see above—"Perceived features and consequences"), it is rather ambivalently-to-negatively assessed (more than two thirds of all statements in this category do not have positive connotations, see Table 29.3). Mistrust and skepticism is either related to the technical development, its whole rationale, or whether it will be possible to bring in the technology at all. The category of ambivalent statements largely concerns the prerequisites and consequences (on the technical, social or infrastructural side) deemed essential before assessing autonomous driving positively.

Car usage and ownership

The perception of autonomous driving is strongly bound up with subjective and personal motives of individual car use. Our analysis was able to identify two opposite poles in the assessment of autonomous driving. On one side, there are statements which stressed motivations for using cars due to their comfort and flexibility, and their "general" benefits. Such statements also generally contain a rather positive appraisal and assessment of autonomous driving: "*Cars do have, above all, this almost ubiquitous character, because it is so practical. I would find it more practical if I could order such an auto-auto to my front door online and have it drop me off at any destination without me having to bother with parking. If this vision of the future becomes possible, then goodbye Porsche!*" On the

Table 29.3 Statement distribution for N = 516 on an affective-subjective level

	Ger	USA	Hei		Ger	USA	Hei
Codes/Levels	Mentions in %			Codes/Levels	Mentions in %		
Judgments, attitudes, expectations	86	84	78	Motivation for car use and ownership	14	16	22
Negative	*48*	*53*	*37*	General	34	27	20
Mistrust, Skepticism	76	67	91	Related to autonomous driving	66	73	80
Refusal	24	33	9	– Pro auton. driving	48	21	25
Positive	*35*	*35*	*30*	– Contra auton. driving	43	79	25
Optimism, trust	55	43	44	– Ownership, carsharing	9	0	50
Imaginable, desirable	35	47	41				
Basic interest	10	10	15				
Ambivalent	*17*	*12*	*33*				

other side, there are statements highlighting issues of freedom, control and the fun of car driving; most of these are skeptical-to-dismissive of the new technology: "*Without driving by myself, where's the fun in that*? *Technology or no technology: I want to give orders to my car myself, not any computer.*" Furthermore, some users discuss in very general terms which motives and attitudes underlie their car use, or raise the question of why anyone would (or would not) actually buy a car in a future with autonomous vehicles.

29.4.2.3 Comparing the Groups: Germany, USA and Heise Online

Many perceptions, assessments, perspectives, and value systems showed up in similar measure in all three groups. However, there are some clear differences in some areas, which were either specific to the country or level of knowledge (for Heise online comments, it was safe to assume a far higher level of knowledge on autonomous driving, as well as understanding of technology and engineering in general). Alongside the group-specific topics of development perspectives and liability, insurance and law mentioned above, we also saw that US commenters look at autonomous driving in far more socio-political terms in comparison to their German counterparts (see Table 29.1). Furthermore, evaluating the topic of car use and ownership revealed that fun in driving, individual freedom, and control of the vehicle are the predominant motivations for car use among US comments. This is mostly accompanied by an attitude of refusal regarding autonomous driving (79 % in the USA compared to 43 % of German mass media comments and only 25 % of the tech-savvy posts).

The questions on liability were overall most controversially discussed on Heise online, while the few statements on this topic on US sites see liability as lying with manufacturers in future. In contrast, a majority of people (58 %) commenting on Spiegel and co.—that is, the German mass media—think that liability will also lie with the vehicle owner in future.

The general tone of German comments is overall somewhat more positive. On both the Heise website and those of the German mass media, positive features of autonomous driving were discussed more often than on US ones (70 and 71 % as opposed to 61 %). At the same time, less negative judgments were made (37 and 48 % as against 53 %).

29.4.2.4 Summary

In both the US and German reader comments made on the mass media portals, statements predominate that are still currently focused on the expected features of autonomous driving. That is to say, the acceptance object is in fact the physical object—the car—and its individual use. This takes a different form on Heise online, where discussions already range far beyond familiarization with purely "technical" issues. Instead, they debate concrete user scenarios and see autonomous driving more strongly in the context of the overall socio-technological system of (auto)mobility. Most of those posting on the Heise portal clearly possess greater knowledge of the technology than "normal" media consumers. Public debate on autonomous driving has only just begun to pick up speed in the last two to three years. We may therefore assume that, as it progresses, topics covering not only the technology, but also its embedding in the system, will become of greater relevance.

Overall, our study spans the "scope of acceptance" for autonomous driving as it currently stands. This scope results from the topics setting the public agenda via the media at present; these topics are also linked to specific judgments. When considering the range of topics, it is apparent that some negative features accompany the mostly positive ones attributed to autonomous vehicles. Furthermore, a series of questions have been thrown up which still need clarifying from commenters' point of view. Depending on how they are answered, this will, in turn, have an impact on acceptance. The ambivalence that finds expression here is amplified when objective/object-related statements are supplemented by affective/subjective ones. Although autonomous vehicles as such are mainly adjudged positively, there are also responses to autonomous driving and the roll-out of autonomous vehicles in the transport system that range from distinct mistrust and clear skepticism to downright refusal. This attitude is especially often associated with fear of negative social consequences, and also loss of freedom.

Such an ambivalent stance vis-à-vis autonomous driving is, however, typical for attitudes to technology—and is mirrored in the findings of other technology-acceptance studies (in Germany) [14]. On the one hand, many benefits are associated with autonomous driving that may make life more comfortable and open up new possibilities. On the other, the expected changes are accompanied by fears of negative social consequences. These manifest themselves in "*loss of control of one's own environment and one's own*

life" ([14]: 33, translation by the authors). At the bottom of this ambivalent response lies the desire "*to bring one's personal environment and technology together in harmony and to preserve the social, economic and natural environment for future generations*" ([14]: 33, translation by the authors). As our analysis has shown, the debate on autonomous driving not only revolves around making motorized personal transport safer, more comfortable, more flexible, more efficient, etc., but also highlights and reflects on the societal, social and economic effects that it will usher in.

29.5 Outlook

Acceptance research, we have argued, must go beyond solely researching opinions and attitudes. It should rather, in terms of an anticipatory societal market research (cf. [12]: 3), identify requirements, ideas, desires, hopes, fears and anxieties, and classify these in the context of a socio-technical system—in this case the transport system as part of the overall social system—and its development. In this way, potential can be brought in line with concrete options (see [41]). A complex topic like autonomous driving touches on various aspects of our society, which is why interdisciplinary cooperation—such as the "Villa Ladenburg" project of the Daimler and Benz Foundation, which initiated and brought together the articles in the present volume—is indispensable.

Future studies on the acceptance of autonomous driving should place greater focus on both cultural-, type-, and milieu-specific differences in acceptance, and interdependencies between different aspects of the topic. The assessment of online comments has provided important initial insights here, and shows the way for future surveys. The ambivalent results concerning motivations for car usage must be given greater consideration. This will make it possible to categorize the individual and social significance of the way cars are used and owned; the symbolic, emotional, and instrumental features ascribed to autonomous vehicles; and the influence current car use and ownership patterns can be expected to have on the autonomous vehicles' acceptance. Chap. 31 focuses on these questions.

In public discourse at least, it is currently not at all clear what is actually meant when autonomous driving is under discussion—this is true of how the media both perceives and presents the technology. Are autonomous (private) vehicles being discussed where the driver can take the controls now and then? Or is it about driverless taxis that, "on command" as it were, can transport both people and goods anywhere, anytime? It can currently be assumed, as our analysis has also demonstrated, that many questions accompanying a potential future roll-out of autonomous vehicles in our transport system still need answering. This in turn means, however, that there is no clear answer to the question of the use of autonomous driving, on both individual and societal levels. At present, it can only be imagined which assigned values will assume the most important roles in autonomous driving. We have, though, been able to at least give an insight into the relevant topics associated with the technology: safety, comfort, cost savings, environmental impacts, time savings, equal opportunities etc.

Furthermore, the context of acceptance and autonomous driving described above is of central significance for future studies. This conclusion can also be taken from the results, among others, of US comments, with their marked socio-politically connoted statements. These show that, to the commenters, autonomous driving looks like it may collide with the prevailing system of norms and values of car usage. Future studies should therefore investigate the individual and societal significance of how cars are used today, and then enquire precisely into how this is embedded in the context of daily praxis and cultural- and milieu-specific frameworks (on this, see also Chap. 31). This will help to define which specific issues can be expected to have an effect on the acceptance of autonomous driving.

In terms of defining uses and assigning values more precisely, in future it will also be a question of allowing potential users and other persons affected to experience the technology. This will give them an idea about what to expect from it, but also let them know what it cannot do. To this effect, policy and public bodies especially could help in promoting acceptance, or at least access ([4]: 3), by shaping public debate more vigorously or initiating specific autonomous driving test and pilot projects: For the current efforts and endeavours being made on the policy side, see Chap. 8. In other areas of the project, it is already clear that specific use cases, as outlined in Chap. 2, each bring with them specific judgments, expectations, and assessments (see Chap. 31 on car usage and ownership in the context of autonomous driving and Chapters by 6, 12 and 32).

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