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Applied artificial intelligence and trust—The case of autonomous vehicles and medical assistance devices

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ABSTRACT

Automation with inherent artificial intelligence (AI) is increasingly emerging in diverse applications, for instance, autonomous vehicles and medical assistance devices. However, despite their growing use, there is still noticeable skepticism in society regarding these applications. Drawing an analogy from human social interaction, the concept of trust provides a valid foundation for describing the relationship between humans and automation. Accordingly, this paper explores how firms systematically foster trust regarding applied AI. Based on empirical analysis using nine case studies in the transportation and medical technology industries, our study illustrates the dichotomous constitution of trust in applied AI. Concretely, we emphasize the symbiosis of trust in the technology as well as in the innovating firm and its communication about the technology. In doing so, we provide tangible approaches to increase trust in the technology and illustrate the necessity of a democratic development process for applied AI.

1. Introduction

Autonomous driving and autonomous vehicles are currently among the most intensively researched and publicly followed technologies in the transportation domain (Beiker, 2012). Before realizing the vision of fully autonomous vehicles, many technical and legal challenges remain to be solved (ibid.). In addition to these technical and legal challenges, questions regarding user and societal acceptance come into play. For example, a survey of 1003 car buyers in Germany conducted by Puls (plus, 2015) in 2015 revealed that almost half of respondents were skeptical regarding the topic of autonomous driving. With respect to the actual use of such vehicles, approximately 49% of respondents preferred traditional driving and 43% preferred semi-autonomous driving. Only 5% of respondents preferred fully autonomous driving.

Autonomous vehicles involve the application of intelligent automation. In general, automation is defined as technology that actively selects data, transforms information, and makes decisions or controls processes (Lee and See, 2004). The decision-making process employed in the technology is based on inherent artificial intelligence (AI), hence the term "intelligent automation". The transportation industry is only one among many industries that are increasingly influenced by automation involving inherent AI. For instance, intelligent, personal robots have begun to noticeably appear in diverse application fields ranging from home automation to medical assistance devices.

In order to approach the topic of AI, the distinction between strong and weak notion of AI is essential. Strong AI implies a system with human or superhuman intelligence in all facets and is pure fiction today. Currently, only the weak notion of AI is of interest for commercial applications. This notion describes AI in terms of specific tasks that require single human capabilities, e.g., visual perception, understanding context, probabilistic reasoning and dealing with complexity (Russell and Norvig, 2010). In these domains, machines exceed human capabilities by far. However, intelligent technologies are not able to execute intelligent tasks such as ethical judgments, symbolic reasoning, managing social situations or ideation (Brynjolfsson and McAfee, 2014). This study will focus on applied AI in its weak notion, which is defined in terms of the tasks humans do rather than how humans think.

In human social interaction, trust is intuitively important (Slovic, 1993). Similarly, trust provides a valid foundation for describing the relationship between humans and automation (Lee and See, 2004). In academic literature, two different research streams on trust in the context of automation and innovation have emerged: First, there is prior work on trust in the technology (Ghazizadeh et al., 2012; Lee and Moray, 1992; Lee and See, 2004; Zuboff, 1988). Second, there is recent research on trust in the innovating firm and its communication (Brock, 1965; Chiesa and Frattini, 2011; Nienaber and Schewe, 2014; Ram, 1989; Ram and Sheth, 1989; Sternthal et al., 1978). In our study, we draw from both research areas to examine the mechanisms for building trust in applied AI.

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Thus, motivated by evidence of unusually high skepticism towards the concept, our aim is to develop an understanding of how firms have enhanced trust in applied AI. Hence, we examine the following research question: How is trust in applied AI fostered?

Our study makes five contributions to theory. First, we examine trust in applied AI via a discipline spanning approach and accordingly contribute to the cognitive engineering, innovation management, and sociology literature. Second, we consider technology acceptance based on the single construct of trust. Consequently, we diverge from earlier technology acceptance literature based on the technology acceptance model (TAM) (Davis, 1989). Third, our results illustrate the dichotomous constitution of trust in applied AI, which is formed by a symbiosis of trust in the technology as well as trust in the innovating firm and its communication. Fourth, our results provide tangible approaches that can be applied alongside the three bases of trust in automation identified by Lee and Moray (Lee and Moray, 1992). Accordingly, trust in the technology evolves alongside performance, process, and purpose information. The performance basis is primarily reliant on both operational and data security aspects; the process basis is determined by cognitive compatibility and usability of the application; and the purpose basis is founded on application context and design. Fifth, we illustrate the necessity of a democratic development process for applied AI (e.g., via stakeholder alignment, transparency in development, and early, proactive communication).

2. Theory

2.1. The essence of trust

In interpersonal relationships, the essence of trust is the willingness to be vulnerable to the actions of another person (Mayer et al., 1995). This behavior is founded in the expectation that the trustee performs a particular action that is important to the trustor, irrespective of the ability of the trustor to monitor or control the trustee. Trust is an evolving and fragile phenomenon and can be destroyed much more quickly and easily than it can be created. This asymmetry is due to the fact that negative, trust-destroying events are more visible and draw more attention than positive, trust-building events (Slovic, 1993).

2.2. Trust and perceived risk

Trust is essential to reducing perceived risk (Rousseau et al., 1998). Perceived risk has been formally defined as a combination of uncertainty plus the seriousness of the outcome involved (Bauer, 1967). In the innovation literature, perceived risk is mainly defined in terms of uncertainty about the possibility of the failure of a new product or the likelihood that the product will not work properly (Nienaber and Schewe, 2014). In the context of AI, perceived risk further stems from the delegation of control to a machine and its respective control mechanisms (Castelfranchi and Falcone, 2000). Accordingly, control is constitutive of trust. Interestingly, the original TAM (Davis, 1989) and its successors (Venkatesh and Davis, 2000; Venkatesh et al., 2003) do not mention the constructs of risk or trust. Trust has only recently been added to TAM, mainly in the context of high-tech innovations such as mobile banking or e-commerce (Luarn and Lin, 2005; Pavlou, 2003).

In the context of innovation, consideration of perceived risk is given high significance since it is a central determinant for adoption. Similarly, resistance to adoption is likely to arise due to the fact that any new product entails change, uncertainty, or risk (Nienaber and Schewe, 2014; Ram and Sheth, 1989). The perception of risk is influenced by the novelty of an innovation (Kleijnen et al., 2009). The more familiar users become with an innovation, for instance, through media coverage or experience, the more likely adoption is to occur (Wejnert, 2002). This is especially true for radical innovations where pre-purchase uncertainty regarding the benefits and consequences is higher (Chiesa and Frattini, 2011).

However, the adoption decision for a specific technology takes place not just at the individual level (Rogers, 2003). Whereas theory on new product development and marketing assumes that utility is a main determinant for adoption, sociological theory explains adoption and resistance in terms of interaction between the technology and its social context (MacVaugh and Schiavone, 2010). Since the perception of risk is a social process (Douglas and Wildavsky, 1983), technologies cannot be viewed as isolated from their social context and cultural values (Selwyn, 2003; Slovic, 1993). Whether a risk is accepted is a political choice that depends on values, beliefs, and alternatives (Fischhoff et al., 1978). Especially for radical innovations and automated technologies with partially unknown risks and consequences, social principles affect judgment regarding which types of risk are feared (Douglas and Wildavsky, 1983). Ultimately, there is a discrepancy between scientifically proven risks and their intuitive perception. “The risks that kill you are not necessarily the risks that anger and frighten you” (Sandman, 1987, p. 21). This gap between statistical safety and public perception can be attributed to a lack of trust (Slovic, 1993).

2.3. Trust in the technology

Drawing an analogy from interpersonal relationships, the interaction between humans and automation is mediated by trust (Ghazizadeh et al., 2012). Over time, trust in automation evolves alongside the three dimensions of predictability, dependability, and faith (Rempel et al., 1985). Accordingly, in early phases, trust is mainly driven by the predictability of the technology, which can be defined as the degree to which future behavior can be anticipated. McKnight et al. (McKnight et al., 2002) emphasized the importance of initial trust, especially in the case of radically new technologies where perceptions of risk must be overcome in order to create willingness to use the technologies. Over time, the driver of trust becomes dependability, which can be described as the degree to which an automation technology's behavior is consistent. Ultimately, the relationship shifts to faith, which is the condition in which the user relies on the technology.

Zuboff (1988) found that trust in a new technology depends on trial-and-error experience, followed by understanding of the technology's operation, and finally, faith, which are similar to Rogers' (2003) dimensions of experience, understandability, and observability. Understanding the motives of a machine creates trust that is more stable than trust based only on the reliability of performance (Lee and See, 2004). Lee and Moray (1992) identified three factors that are crucial for trust in automation: performance, process, and purpose. Although performance is a strong indicator of preference, it does not guarantee adoption, which is further influenced by factors such as resistance to change (Ghazizadeh et al., 2012). The process dimension refers to the understandability of the technology. When algorithms and functional logic are transparent, trust is likely to be reinforced (Lee and See, 2004). Purpose reflects faith in intentions. In the case of humans, this might represent motivations and responsibilities; with machines, purpose reflects the designer's intention in creating the system (Lee and Moray, 1992).

2.4. Trust in the innovating firm and its communication

High-tech companies often mistakenly believe that the quality of their technological innovations is sufficient to convince users and accordingly neglect marketing and commercialization of these products (Slater and Mohr, 2006). Several studies have revealed high failure rates, especially for radical innovations, indicating that the reasons for innovation resistance go beyond the technical characteristics of the products (Chiesa and Frattini, 2011; Heidenreich and Spieth, 2013; Ram, 1989; Ram and Sheth, 1989). Particularly, trust in the innovating firm and its communication influence the adoption decision (Sternthal et al., 1978).

It is widely agreed that communication has positive effects or is even the main driver of the diffusion of innovations (Cooper, 1994; Crawford, 1991; Rogers, 2003) and levels of perceived risk (Slovic, 1993). Ram (1989) found communication to be a main strategy for enhancing the acceptability of an innovation. Particularly in the early stage of commercialization, when customer knowledge is low and an extensive public discourse has not yet emerged, the innovating firm is the main source of communication about an innovation (Ram, 1989). Extensive communication, especially in the market introduction of unknown and new products can reduce fears (Nienaber and Schewe, 2014), particularly when it signals openness and promotes two-way-communication instead of indicating a purely public relations approach (Slovic, 1993). Communication is most effective when it provides concrete and tangible information about the specific applications of a technology (Frewer et al., 1997). Perception is more differentiated when they are based on specific applications rather than on the general technology (ibid.). Ultimately, communication should emphasize how an innovation is compatible with the current lifestyle of users (Kleijnen et al., 2009).

Furthermore, the credibility of the communicator has a significant effect on consumer behavior (Brock, 1965) as people judge the messenger before they judge the message (Slovic, 1987). Source effects literature states that the credibility of a communication source derives from the target audience's judgment that its statements are truthful, valid, and thus worthy of being considered (Wilson and Sherrell, 1993). Source credibility is mainly influenced by expertise, reliability, and goodwill. In this context, perceived expertise has been found to have a strong effect on attitudes and behavior (ibid.).

To a considerable degree, discourse about the trustworthiness of a communication source takes place on the societal level, especially in the case of innovations with effects in both public and private spheres (Wejnert, 2002). Societal acceptance is not merely a question of adoption or resistance but instead refers to how an innovation is introduced into a societal context (MacVaugh and Schiavone, 2010). Socialization in terms of social context and specific codified and tacit knowledge is a critical factor in how potential adopters acquire knowledge about an innovation (ibid.). The way innovations are introduced influences social learning and perception. Incremental market introduction allows for gradual learning and a certain familiarization effect, resulting in a low risk of scandal and resistance. In contrast, the revolutionary introduction of an innovation brings higher risk of rejection or scandal but also holds the potential for reputation gains and a considerable competitive advantage (Debruyne et al., 2002).

3. Material and methods

3.1. Research context

Due to limited theory about how firms foster trust in applied AI, we conducted inductive, multiple case study research (Eisenhardt, 1989). Inductive case studies are particularly valuable when contemporary theory has not sufficiently approached the research question. Additionally, multiple case studies offer the possibility to compare and contrast data, thus enabling richer and more valid theory development (Strauss and Corbin, 2008; Yin, 2013).

3.2. Selection of case studies

For the selection of case studies, we relied on the concept of theoretical sampling (Eisenhardt and Graebner, 2007). First, we identified industries in which applications of AI have provoked skepticism. In general, skepticism is more likely to emerge towards applications where human decision making is replaced or supplemented by an autonomously acting machine (Lee and See, 2004). This criterion led to the selection of two industries that the literature has indicated as dealing with this type of intelligent machine and where the take-over of control by machines is to some extent visible to the user: the transportation industry (Jamson et al., 2013) and the medical technology industry (Najarian et al., 2011).

Second, we selected cases that satisfied four conditions determined by our research setup and definition: (1) the application contains a component of AI; (2) the application compensates for human flaws or supplements human decision making; (3) the application is on the market or close to market introduction; and (4) the application requires user involvement. To select relevant case studies from the two industries, we conducted unstructured interviews with industry experts who were scientists from engineering and traffic research institutes. By viewing the industries and players through the lens of these external experts, an initial list of eleven potential case study firms was created (Rouse and Daellenbach, 1999). All of the firms were approached at the beginning of 2015. Three declined participation mainly based on reasons such as confidentiality, company policies, and time pressures within daily business operations (Mezger, 2014). Nine firms declared their intention to contribute to our research. Five cases were from the transportation industry, and four cases originated in the medical technology industry.

The five cases from the transportation industry include car, truck, train, and underground train technologies.

- The case of **BMW** studies semi-autonomous and fully autonomous cars. Whereas semi-autonomous cars are already on the market, fully autonomous cars are still in the development phase. In semi-autonomous cars, the vehicle takes over both longitudinal and lateral control, but the driver is responsible for mental monitoring. In fully autonomous cars, this monitoring is performed by the car.
- The case of **Daimler** describes the Future Trucks 2025 project, which is aimed at developing autonomously driven trucks where the driver is present and can perform defined side activities. Market introduction is planned for 2025.
- The case of **ZF Friedrichshafen AG** examines driving assistance systems and systems for fully autonomous driving.
- The case of **Deutsche Bahn** considers semi-autonomous and fully autonomous trains. While semi-autonomous trains are currently in operation, fully autonomous trains will be tested for technical feasibility in a pilot scheduled to begin within one to two years. In semi-autonomous trains, the driver is present and intervenes in the case of an emergency. In contrast, train drivers will no longer be present in fully autonomous trains.
- The case of **VAG Nürnberg** describes a fully automated underground train introduced in 2008. The fully automated train operates in the city of Nürnberg, Germany.

The four cases from the medical technology industry include IBM, HP, AiCure, and Fraunhofer IPA.

- The **IBM** case deals with Watson, a cognitive system that can understand natural language and build hypotheses based on evidence. In February 2011, the world was introduced to the cognitive computing system that defeated Ken Jennings and Brad Rutter at Jeopardy! (Markoff, 2011). Since Jeopardy!, Watson has tackled increasingly complex data sets and developed understanding, reasoning and learning that go far beyond deciphering. Indeed, the goal of cognitive computing is to illuminate aspects of the world that were previously invisible, reveal patterns and insights in unstructured data, in particular allowing humans to make more informed decisions about consequential matters.
- The case of **HP** considers a data analytic system for automated fraud detection in the healthcare sector. The system compares social media data with sick leave of employees and indicates potential cases of fraud. This is an assistant system, and the cases require further investigations by humans. Several pilot projects based on this technology have been initiated, primarily in Eastern Europe.

- The case of **AiCure** describes a medical adherence app for mobile devices. The app reminds patients of upcoming medication doses and asks the patient to use the imaging power of their smartphone to confirm ingestion. The data is transmitted to the treating doctor, who intervenes only when medication adherence is incorrect. The assistance system is currently on the market.
- The case of **Fraunhofer IPA**[1] describes Care-O-bot 3, which is a research platform for upcoming commercial service robot solutions to offer support to people in their houses (Graf et al. 2009; Parlitz et al., 2008). Currently, the robot can navigate autonomously and perform bring-and-fetch services. Development of the Care-O-bot series began in 1998.

Tables 1 and 2 provide detailed information about the nine case studies from the transportation and medical technology industries.

3.3. Data collection

To address our research question, we used different sources. First, we conducted semi-structured interviews; second, we made informal follow-ups via e-mails and short phone calls; and third, we worked with archival data. To reduce risk from informal bias and control for the subjective judgment of individuals, we triangulated the different data sources to increase construct validity (Gibbert and Ruigrok, 2008; Jick, 1979).

Semi-structured interviews were the major data source, and at least one round of interviews was conducted with each firm. The interviews were scheduled between March and April 2015 and each took between 30 and 65 min. All interviews were recorded and were later literally transcribed. For accuracy improvement, the interview transcripts were reviewed and, if applicable, corrected by interviewees (Huber and Power, 1985).

Based on the theoretical framework of this study, the initial guidelines for the semi-structured interviews were divided into three main sections. The first section dealt with interviewees' understanding of the AI aspect underlying the technology application. The second section focused on strategies for promoting trust in the technology. The final part examined the firm's activities and strategies for enhancing trust in the firm and its communication.

Several pilot interviews were conducted with managers and engineers from the target industries and executives from outside the target industries to evaluate the initial interview guidelines. After these interviews, the guidelines were accordingly refined. In later interviews, the questions were sharpened to ask more specifically about processing and connecting the big data underlying the AI applications.

3.4. Data analysis

For data analysis, the first step was coding the interview and archival data (Huberman, 1994; Strauss and Corbin, 2008), which was completed by two independent researchers. The aim of this initial step was to identify basic concepts underlying the firms' approaches to increasing trust in applied AI. The results of the two coding sessions were combined and any cases of deviation specified. Simultaneously, the results were aligned with the literature on trust and radical technological innovation, specifically the literature on automation and AI, which allowed for inductive adjustment of the coding. After several iterations between the literature and the data, the analysis clearly revealed security aspects of technology and transparency in communication as crucial to the discussion on trust.

In the second step, individual case reports for each firm were written with the aim of facilitating within-case analysis (Eisenhardt, 1989; Yin, 2013). By closely considering the theoretical background, within-case analysis revealed details on how trust is fostered (Eisenhardt, 1989; Huberman, 1994). This step resulted in an overview of the specific trust-building strategies for applied AI at each case firm. For missing data, we collected additional data to complete the case.

Finally, we performed cross-case analysis of the case studies (Eisenhardt and Graebner, 2007). For this purpose, we inserted the data from each case study into tables to consider the emergent trust-building strategies. By iterating between theory and data, we refined the strategies and underlying theoretical argumentation (Eisenhardt, 1989). The resulting tables provide evidence of the relevant constructs of this research (Eisenhardt and Graebner, 2007). By utilizing these tables for comparison (Huberman, 1994), we were able to examine common patterns and differences across cases. Tables 3 to 5 describe comparative data for each case and all the constructs developed in this study, see also appendix Tables to A.3.

4. Results

This study provides insights about how firms systematically increase trust in applied AI. In the following section, we concentrate on the insights gained from cross-case analysis.

4.1. Trust in the technology

Following Lee and Moray (1992), performance, process, and purpose form the general basis of trust in automation, see Table 3. Performance information describes what the automation does. In the observed cases, two factors emerged as determinants of performance trust (Lee and See, 2004). First, operational safety is necessary to initiate performance trust. In this context, prior to use, a technology must be certificated and approved, and policies established to govern it. These standards should be not only technical but also deal with ethical questions. Thus, analysis revealed evidence that technologies operate according to defined standards and developing firms have a legally certain arena in which they act.

> *We do not want to drive politics ahead of us, but we need politicians as partners who advocate creating a legal basement. […] It is necessary to have a clear societal standpoint or a view that the decision the car makes will be accepted (Head of Driver Assistance and Perception at BMW Group Research and Technology, BMW).*

Second, across all cases, regardless of industry sector, data security was determined as an eminent factor influencing trust in the technology. In the transportation sector, data security directly refers to operational safety. In this context, data security bears two key challenges: First, how ensure that the underlying algorithms are not flawed? Second, how does the vehicle know that it can trust the data it receives? Therefore, it is essential to develop security standards that protect the safety paths and sensor systems of vehicles. In the automotive sector, the topic of data security becomes even more important for connected vehicles.

In the healthcare industry, privacy protection is a major issue since all applications deal with sensitive personal data. Both HP and IBM emphasized their role as being primarily service providers:

> *Primarily, the most important thing is the security and how we treat data. We bring the means to work with the data through a secure cloud service (Executive Consultant, IBM).*

When dealing with personal data, it is essential to provide information about how the data is used and who has access to what kind of data. For instance, AiCure provides video tutorials with introductory information discussing the privacy aspect of their application. Similarly, in the case of Car-O-bot 3, users must actively agree to camera activation to use the telepresence function.

[1] Fraunhofer IPA is a non-profit research institute. However, for reasons of simplicity we refer to it as a firm.

Table 1
Overview of transportation industry case studies.

Case study	Industry	Target country	Description of application	Market introduction	Interviews and e-mail correspondence
Semi-autonomous and fully autonomous cars (BMW)	Transportation	Global	- In semi-autonomous cars, the vehicle takes over both longitudinal and lateral control. - The driver is responsible for mental monitoring. - In fully autonomous cars, the vehicle takes over both longitudinal and lateral control as well as mental monitoring.	Semi-autonomous cars are already on the market. Introduction of fully autonomous cars is not terminable at the moment.	Head of Driver Assistance and Perception at BMW Group Research and Technology
Future Trucks 2025 (Daimler)	Transportation	Global	- The truck drives autonomously. - The driver is present and can participate in defined side activities unrelated to driving.	2025	Director of Advanced Engineering Trucks
Driver assistance systems and autonomous driving (ZF Friedrichshafen AG)	Transportation	Global	- Driving assistance systems. - Systems for autonomous driving.	Not explicitly mentioned.	Engineer Research and Development
Semi-autonomous and fully autonomous trains (Deutsche Bahn)	Transportation	Germany	- The train operates fully autonomously. - The train driver is present on the train and intervenes in case of emergency. - The train operates fully autonomously. - No train driver is present on the train.	Semi-autonomous trains are currently in operation. The first pilot study of autonomous trains is planned on a closed rail system in 2016 or 2017.	Senior Manager of Strategy and Innovation with CTO
Fully autonomous underground train (VAG Nürnberg)	Transportation	Nürnberg city, Germany	- The underground train operates fully autonomously. - No staff is present on the train.	2008	Operating Manager of Subway and Underground Transport

Process information describes how the automation operates and refers to its understandability (Lee and See, 2004). In terms of process, three categories emerged in the included cases. First, cognitive compatibility was found to be a major determinant of the process dimension of trust. If the algorithms are understandable and guide users towards achieving their goals, they tend to trust automation.

Table 2
Overview of medical technology industry case studies.

Case study	Industry	Target country	Description of application	Market introduction	Interviews and e-mail correspondence
Watson (IBM)	Medical technology	United States	- Cognitive system that can understand natural language and build hypotheses and evidence. It requires a certain body of data for evidence, which it can then use to build a hypothesis. - It can assess the level of confidence in evidence used to support a hypothesis by a percentage score. - It has machine learning technology capability, which means that it can learn and adapt based on information it receives. - After ingesting a corpus of knowledge, curated by experts on any given subject, cognitive systems are trained by being fed a series of question-and-answer pairs. This machine "knowledge" is then enhanced as humans interact with the system, providing feedback on the accuracy of the system's responses.	- In 2011, the first public appearance was on the TV quiz show Jeopardy!. - Since Jeopardy!, Watson has tackled increasingly complex data sets and developed understanding, reasoning and learning that go far beyond deciphering.	Executive Consultant
Automated fraud detection in the healthcare sector (HP)	Medical technology	Primarily Eastern Europe	- The system compares social media activity to sick leave of employees. - The system identifies presumably sick employees who are posting on social media, which indicates that they are actually skipping work. - The data analytic tool works autonomously and automatically. - The system is able to learn on its own.	Several pilot projects.	Director of Solutions and Sales Support, Mobility and Workplace Solutions Practice
Medical adherence app for mobile devices (AiCure)	Medical technology	United States	- App that reminds patients of upcoming medication doses and asks them to use the imaging power of the smartphone to confirm ingestion. - Data is submitted to the treating doctor, who is informed of incorrect patient behavior.	End of 2014	CEO
Care-O-bot 3 (Fraunhofer IPA)	Medical technology	Germany	- A robot that supports people (primarily the elderly) in their houses. - The robot can navigate autonomously by drawing a map of its surroundings, orienting itself on the map, approaching a target, and circumventing obstacles. - The robot can also perform bring-and-fetch services, which involves learning objects, grasping them, and bringing them to the user via face recognition.	- Development of predecessors began in 1998. - Caro-O-bot 3 is a research platform for upcoming commercial service robot solutions to offer support to people in their households.	Group Manager of Service Robotics

Table 3
Comparative data from case studies—trust in the technology.

Case study	Performance	Process	Purpose
Semi-autonomous and fully autonomous cars (BMW)	Operational security Data security	Cognitive compatibility Trialability Usability	Concrete context Design is not explicitly mentioned.
Future Trucks 2025 (Daimler)	Operational security Data security	Cognitive compatibility Trialability Usability	Concrete context Design is not explicitly mentioned.
Driver assistance systems and autonomous driving (ZF Friedrichshafen AG)	Operational security Data security	Cognitive compatibility Trialability is not explicitly mentioned. Usability	Concrete context is not explicitly mentioned. Design
Semi-autonomous and fully autonomous trains (Deutsche Bahn)	Operational security Data security	Not explicitly mentioned due to very early status of the project and role as operator and not developer of the system	Concrete context Design is not explicitly mentioned.
Fully autonomous underground train (VAG Nürnberg)	Operational security Data security	Cognitive compatibility Trialability Usability	Concrete context Design is not explicitly mentioned.
Watson (IBM)	Operational security Data security	Cognitive compatibility Trialability Usability	Concrete context Design
Automated fraud detection in the health care sector (HP)	Operational security Data security Privacy	Cognitive compatibility is not explicitly mentioned. Trialability Usability	Concrete context Design is not explicitly mentioned.
Medical adherence app for mobile devices (AiCure)	Operational security Data security Privacy	Cognitive compatibility Trialability Usability	Concrete context Design: Technology is available as an app for smartphones
Care-O-bot 3 (Fraunhofer IPA)	Operational security Data security Privacy	Cognitive compatibility Trialability Usability	Concrete context Design

The robot can support the interaction through speech output and gestures, and this is one possibility to make its behavior understandable for the user. It has to be transparent to the user why the robot has made a decision. […] Otherwise, this could lead to acceptance problems. It needs to always be clear that the robot is under the control of a human and does not really make decisions in a complex environment (Group Manager of Service Robotics, Fraunhofer IPA).

Second, trialability is an additional strategy to enhance understanding. Trialability of an innovation was found to reduce concerns of both potential users and the media. Trials can be conducted by inviting users to test the technology (BMW) and presenting it at public exhibitions (Daimler) and user fairs (Fraunhofer IPA).

If you have personal driving experience and you see it works this way, fear will disappear and thus trust and acceptance will increase (Head of Driver Assistance and Perception at BMW Group Research and Technology, BMW).

When you survey the perception of new technologies across generations, you typically see resistance appear from people who are not users of technology. […] Perceptions of the technology change quite a lot, once you attract users to the technology (CEO, AiCure).

Third, usability is another determinant for the process dimension of trust in the technology. In both industries, usability studies are conducted and potential users are integrated in the development process to provide feedback. On one hand, human–machine interfaces need to be designed in a way that the technology can be easily and intuitively handled and creates no obstacles for the user.

For example, we perform relevant tests to objectively measure reactions and sensitivities and to record the influence of highly automated driving on the well-being and condition of drivers by measured data (Director of Advanced Engineering Trucks, Daimler).

On the other hand, the interface design must mediate between control and autonomy. The design must first consider the characteristics of the target user group such as age and context of use. Second, the amount of control the target user group is willing to delegate to the machine in the specific use situation must be tested.

It is very important for us as a company to […] make sure that the technology is interactive so that many different types of patients with different capabilities are able to utilize the technology (CEO, AiCure).

Purpose, as the third determinant of trust in the technology, describes why the automation was developed. Therefore, the technology needs to first be placed into a defined context. Explaining the purpose of a technology is crucial for avoiding generalizations and providing an easily understood message. This strategy emerged in both industries.

It is really important to explain what the purpose of the technology is. So, for example: "Our company is called AiCure and is leveraging AI to help people get better." That message is very clear. It aligns people's interest to say: "If I use this technology, I can make patients healthier, I can make hospitals more efficient, I can get much higher quality data." And that message is very simple and easy to understand. So when you explain the context of where the technology will be applied, people understand the problem that it is solving. Thus, society tends to accept the approach (CEO, AiCure).

For instance, at the beginning of the eight-year development period for the fully autonomous underground train in Nürnberg, Germany, the project was called RUBIN (realization of an underground train in Nürnberg) to make it more concrete and stress the value of the project for the city. During the development period, intense PR work and communication explaining the purpose of the project were undertaken to create interest in and desire for the technology.

Finally, design is an additional factor that promotes the purpose dimension of trust in the technology. Especially in the healthcare industry cases, the design of applications was consciously chosen:

For our Care-O-bots, we focused on giving them certain human features, but on an abstract level, so that it is always clear that it is a machine that

Table 4
Comparative data from case study—trust in the innovating firm.

Case study	Stakeholder alignment	Transparency of the development project	Gradual introduction of the technology
Semi-autonomous and fully autonomous cars (BMW)	Internal stakeholders, e.g., involved employees External stakeholders, e.g., politicians	Democratic process, e.g., via media involvement, public events	Sequential introduction of innovations that build on each other
Future Trucks 2025 (Daimler)	Internal stakeholders, e.g., top management External stakeholders, e.g., politicians	Democratic process, e.g., via media involvement, public events	Sequential introduction of innovations that build on each other
Driver assistance systems and autonomous driving (ZF Friedrichshafen AG)	Internal stakeholders not explicitly mentioned External stakeholders, e.g., politicians	Not explicitly mentioned	Sequential introduction of innovations that build on each other
Semi-autonomous and fully autonomous trains (Deutsche Bahn)	Internal stakeholders, e.g., involved employees External stakeholders, e.g., politicians	Democratic process, e.g., via surveys	Sequential introduction of innovations that build on each other
Fully autonomous underground train (VAG Nürnberg)	Internal stakeholders, e.g., involved employees and top management External stakeholders, e.g., politicians, regulatory institutions, users	Democratic process, e.g., via surveys, media involvement, public events	Comparatively large step from conventional automated operation to fully automated operation
Watson (IBM)	Internal stakeholders not explicitly mentioned External stakeholders, e.g., politicians, regulatory institutions, users	Democratic process, e.g., via media involvement	First introduction in 2011 was a comparatively large step; since then, sequential extension of application fields
Automated fraud detection in the health care sector (HP)	Internal stakeholders not explicitly mentioned. External stakeholders, e.g., society, politicians	Democratic process, e.g., user involvement	Sequential introduction of innovations that build on each other
Medical adherence app for mobile devices (AiCure)	Internal stakeholders not explicitly mentioned External stakeholders, e.g., users, society, politicians	Democratic process, e.g., via media involvement	Not relevant due to status as a young company
Care-O-bot 3 (Fraunhofer IPA)	Internal stakeholders not explicitly mentioned. External stakeholders, e.g., users, politicians	Democratic process, e.g., public events, feedback loops	Sequential introduction of innovations that build on each other

does not really make its own decisions. For a system with a very robotic look, it is even more important to give users the feedback that they are always in control (Group Manager of Service Robotics, Fraunhofer IPA).

Ultimately, cross-case analysis revealed an important difference in the distance between the applied technology and society, which particularly influences trust in the technology. This difference refers to observability, which is defined as the visibility of an innovation's outcome (Rogers, 2003).

Generally, we found the four cases from the medical technology industry to be less visible than the five cases from the transportation industry. HP's service for automated fraud detection is a quite abstract technology and since there are no direct points of contact, individuals may not even be aware of the intelligent technology. In the case of IBM's cognitive system Watson, humans interact with the system and provide feedback on the accuracy of the system's responses. Similarly, patients directly interact with the medical adherence app for mobile devices by AiCure and Care-O-bot by Fraunhofer IPA and may delegate some degree of control.

On the contrary, in the cases from the transportation industry, visibility of the intelligent technology is higher. Autonomous cars (BMW, ZF) imply the most drastic change for individuals since the actual task of driving is replaced and the entire driving experience changes. Autonomous trucks (Daimler) may provoke rather psychological effects (e.g., fear) due to the mixed character of the traffic system with both conventional and highly automated vehicles. In contrast, autonomous trains (Deutsche Bahn) and underground trains (VAG Nürnberg) imply only a psychological difference for passengers since the passive riding experience itself does not change.

We found the differences in the visibility of a technology influence all three bases of trust in the technology. Accordingly, the more visible a technology is to society, the more intensively firms follow the above mentioned strategies to foster performance, process, and purpose trust in the technology.

4.2. Trust in the innovating firm and its communication

Regarding trust in the innovating firm, three major strategies emerged across the cases, see Table 4. First, stakeholder alignment was found to be crucial across all cases, irrespective of industry. Both external and internal stakeholders need to be aligned. Major external stakeholders include users of the application, groups that may be affected by the technology, regulatory authorities, insurance companies, the media, and political institutions. Important internal stakeholders are the employees involved in the development process as well as top management.

Without participation of the media and the public, the citizens of Nürnberg would say such a project can't be done. Of course, we also informed the political committees and involved them via a stakeholder meeting. Finally, the approving authorities for the underground train had to sanction the project so that we were authorized to operate such an automation system. We involved another very important group—all employees within VAG who deal with the automation system. […] The project had high priority. For instance, this was visible in the fact that top management was involved in each decision-making process concerning marketing activities (Operating Manager of Subway and Underground Transport, VAG Nürnberg).

Second, transparency of the development process is an additional factor that promotes trust in the innovating firm. The development process can be seen as a democratic process that requires transparency and involvement of stakeholders from the onset. Open and credible communication about both risks and opportunities enhances the credibility of the innovating firm. For instance, during the development of the fully autonomous underground train in Nürnberg, Germany, every project milestone was announced during a press conference and exhaustive information about the technological details was provided. This approach also provided a means to actively communicate success stories, which reflects on both the technology and the innovating firm. Furthermore, a transparent development process also provided the opportunity to gain feedback from users in order to improve the application, if necessary, via several iterative feedback loops.

> *We speak to various users and actively involve them in our projects. We do several feedback loops to make sure that the things we develop are really relevant for practical life (Group Manager of Service Robotics, Fraunhofer IPA).*

Finally, introducing a technology gradually is a constructive strategy for enhancing trust in the innovating firm. Gradual introduction of a technology promotes trust in a stepwise manner. By sequentially introducing innovations that build on each other, the innovating firm increases its credibility. Furthermore, gradual introduction builds trust in the technology. This strategy often occurs naturally given the speed of technological development and legal processes but can also be consciously chosen to familiarize users via increasing levels of automation:

> *Via a stepwise introduction, we want to slowly bring the technology closer to society. Thus, we want to slowly reduce fears regarding the technology among people. Simultaneously, we can extend the operating conditions step by step (Head of Driver Assistance and Perception at BMW Group Research and Technology, BMW).*

Likewise, three factors related to trust in communication appeared across the nine cases, see Table 5. First, communication needs to be proactive from the early stages of diffusion. This strategy emerged in the cases where firms are in direct contact with users of an application (BMW, Daimler, VAG Nürnberg, IBM, Fraunhofer IPA).

Second, communication needs to provide concrete and tangible information. It is important to explain the technology based on its single application. The application and its purpose need to be explained with a message that is easy to understand:

> *What we found is perception of technology changes dramatically if society experiences the purpose of the technology. I think the idea that you can use a technology for good in a specific application is accepted by most of society. Explaining the technology based on the application is very important. If you have applications with meaningful uses, then the good should be highlighted. The negatives or risks should also be highlighted but it is easy to fear monger when new technologies come into play or where there is a general lack of understanding around the impact to society (CEO, AiCure).*

In this context, framing the technology in terms of terminology is an additional communication approach for trust promotion. In the transportation industry, the phase "artificial intelligence" is avoided in external communication. Instead, all projects are described as autonomous or automated. Similarly, in the medical technology industry, technology applications are clearly framed as autonomous or assistant. Only AiCure obviously uses the terminology AI.

> *The problem with the term AI is that it can mean many things to many people. And it sounds scary because there is a lack of understanding, pretty much like any new technology that is introduced into society. When a technology is not well understood, it is open to*

Table 5
Comparative data from case studies—trust in the firm's communication.

Case study	Early, proactive communication	Concrete and tangible information/ framing terminology	Benefit related information
Semi-autonomous and fully autonomous cars (BMW)	During the development period, organization of public events and constant public communication	Application-based communication, not technology based In external communication, framed as "autonomous"	Individual benefits Societal benefits
Future Trucks 2025 (Daimler)	During the development period, organization of public events and constant public communication	Application-based communication, not technology based In external communication, framed as "highly automated"	Individual benefits Societal benefits
Driver assistance systems and autonomous driving (ZF Friedrichshafen AG)	Not explicitly mentioned	Application-based communication, not technology based Framing of the technology not explicitly mentioned	Individual benefits Societal benefits
Semi-autonomous and fully autonomous trains (Deutsche Bahn)	Not relevant due to very early status of the project	Application-based communication, not only technologically based In external communication, framed as "partly autonomous or autonomous"	Societal benefits
Fully autonomous underground train (VAG Nürnberg)	During the development period, organization of public events and constant public communication	Application-based communication, not technology based In external communication, framed as "automated"	Societal benefits
Watson (IBM)	First public presentation on the TV quiz show Jeopardy! in 2011; since then, application in the medical industry and constant public communication	Application-based communication, not technology based In external communication, framed as "collaborative and assistant"	Societal benefits
Automated fraud detection in the health care sector (HP)	Not relevant due to the role as service provider	Application-based communication, not technology based In external communication, framed as "automated and assistant"	Societal benefits
Medical adherence app for mobile devices (AiCure)	Not explicitly mentioned since customers are pharmaceutical companies and health systems, not patients, who are the end users	Application-based communication, not technology based In external communication, framed as "assistant"	Individual benefits Societal benefits
Care-O-bot 3 (Fraunhofer IPA)	During the development period, organization of public events and constant public communication	Application-based communication, not technology based In external communication, framed as "assistant"	Individual benefits Societal benefits

misunderstanding and misinterpretation (CEO, AiCure).

Finally, communication is needed to inform different groups of the benefits of an application. All interviewees agreed on the importance of esmphasizing the concrete benefits of a technology and translating them specifically for different target groups.

I am convinced that many people would reconsider their resistance if the benefit of this application can be successfully proven to them (Director of Solutions and Sales Support, Mobility and Workplace Solutions Practice, HP).

Furthermore, it was observed that the more abstract and indirect the benefits, the higher the need to contextualize the benefits in terms of their societal implications, for instance, better traffic management, reduced healthcare spending, or the macro-economic potential for the technological development of industries and societies.

5. Discussion

The examined cases constitute radical innovations that are either still in the development process or in an early phase of diffusion. Hence, these technologies are characterized by high levels of initial resistance and perceived risk (Heidenreich and Spieth, 2013; McKnight et al., 2002). For these cases, the literature has emphasized the importance of initial trust in creating the willingness to use a technology (McKnight et al., 2002). In phases when knowledge is still low, trust is mainly driven by the perceived predictability of a technology (Muir, 1987). This kind of trust is theorized to be more stable than trust based solely on the reliability of performance (Rempel et al., 1985).

Our study focuses on how firms promote trust in applied AI. Trust in applied AI evolves along two dimensions: first, via trust in the technology (Ghazizadeh et al., 2012) and second, via trust in the innovating firm and its communication (Sternthal et al., 1978).

Concerning trust in the technology, we draw on the work of Lee and Moray (1992), who identified performance, process, and purpose as the general bases of trust in automation. Our findings revealed that operational security and data security are decisive factors promoting the performance dimension of trust in a technology. Operational safety is a fundamental determinant of trust in the technology. A technology based on the delegation of control will not be trusted if it is flawed (Lee and See, 2004). Since negative events are more visible than positive events (Slovic, 1993), small incidents can provoke disproportionate resistance (Kasperson et al., 1988). Consequently, operational safety is necessary but not sufficient for acceptance.

Our findings also revealed cognitive compatibility, trialability, and usability as the main factors related to the process dimension of trust in a technology. Cognitive compatibility refers to compatibility between what people feel or think about an innovation (Tornatzky and Klein, 1982) and their values (Karahanna et al., 2006). It has been suggested that trustors tend to trust automation if the algorithms are understandable and guide them towards achieving their goals. This agrees with Rogers' (2003) adoption criterion of understandability of the technology. In the context of AI, the understandability of algorithms and motives directly affect the perceived predictability of the system, which, in turn, is one of the determined foundations of trust (Rempel et al., 1985).

Trialability is a strategy to enhance understanding (Ghazizadeh et al., 2012; Martínez-Torres et al., 2015). Technology trials can demonstrate technological progress and provide a visualization of the concrete benefits, thereby reducing perceived risk and resistance (Heidenreich and Spieth, 2013). This is especially effective at reducing passive innovation resistance, which is formed prior to experience (ibid.).

Our results show that in the context of applied AI technologies, usability is influenced by both the intuitiveness and mediation effect of the human–machine interface. The requirement of an intuitive human–machine interface corresponds to usability in terms of perceived ease of use in TAM (Davis, 1989). Particularly for people with less affinity for technology, an intuitive interface can reduce initial resistance and make the technology accessible. This can be achieved by usability tests with the target user group. However, for autonomous technologies, it is even more important that the interface design mediates between control and autonomy and considers that autonomy is based on trust (Castelfranchi and Falcone, 2000). AI technology is only truly effective when it takes over some degree of control from the user (Jamson et al., 2013). For efficient collaboration between humans and machines, the appropriate level of automation must be carefully defined. The mediation effect of the human–machine interface is of special importance in intelligent applications with the objective of changing human behavior by means of incentives and communication with users. Some interactive intelligent systems such as the medical adherence app for mobile devices by AiCure are more intensive than others. In this case, it is important that the interaction does not make people feel they are being monitored. People are much more willing to accept an application they can use as an assistant than a system that can exert control over their life. Therefore, it is important to establish appropriate incentives to keep people engaged with an application and to design interaction in a way that motivates users.

Ultimately, we determined contextualization of an application and its design as decisive factors regarding the purpose dimension of trust in a technology. Placing the application of a technology in a concrete context avoids generalization of the technology. In the medical technology cases in particular, a design with balanced human and robotic characteristics helped users understand the purpose of the application.

Our cases show that visibility of a technology has an effect on trust in the technology. Accordingly, high visibility of a technology (e.g., in the transportation industry through autonomous cars or in the medical technology industry through the medical adherence app by AiCure and Care-O-bot by Fraunhofer IPA) requires more intensive efforts to foster trust in the technology in the three dimensions.

Regarding trust in the innovating firm, our findings suggest that stakeholder alignment, transparency of the development process, and gradual introduction of the technology are crucial strategies. Stakeholder alignment and transparency of the development process are means to increase the credibility of the innovating firm (Brock, 1965; Slovic, 1987; Wilson and Sherrell, 1993).

The market launch strategy has a strong impact on the commercial success of an innovation (Chiesa and Frattini, 2011) by reducing risk perception and emphasizing benefits (Lee and O'Connor, 2003). The stepwise introduction of innovations allows for gradual social learning (Debruyne et al., 2002; MacVaugh and Schiavone, 2010). Accordingly, established firms in our sample tend to pursue the gradual introduction of their AI applications. On the contrary, younger companies (in our sample, AiCure) tend to choose a more revolutionary introduction approach. This type of approach can provide an opportunity for a company to position itself as a technology leader. However, while the approach contains potential for creating competitive advantage and reputation gains, it also holds the risk of rejection and the generation of scandal when, for instance, the underlying algorithms are flawed (Debruyne et al., 2002).

Regarding trust in communication, we ultimately found that communication should be proactive beginning at the early stages of diffusion. When public opinion is uncrystallized and knowledge levels are low, communication influences societal acceptance (Frewer et al., 1998). Furthermore, open and proactive communication has considerable effects on the perceived credibility and trustworthiness of the communicator (Slovic, 1993) and thus can positively influence attitude formation (Sternthal et al., 1978).

Additionally, communication should be application based. Research has supported the assertion that the strategy of providing concrete and tangible information about the specific application of a technology results in more differentiated perceptions (Frewer et al., 1997; Frewer et al., 1998).

Ultimately, by communicating the benefits of an application, users can build compatibility between the application and their lifestyle (Kleijnen et al., 2009). Likewise, the logic of the inverse relationship between risk and benefits (Slovic, 1993) implies that a focus on benefits in the communication strategy reduces perceived risk.

As previously discussed, our study contributes in five major ways to the literature on trust in automation. Our first major contribution is the examination of trust in applied AI via an approach that spans three different disciplines, namely, cognitive engineering, innovation management, and sociology. With the increasing proliferation of AI applications in daily life, consideration of trust has become inevitable in discussions on acceptance (Lee and See, 2004). Furthermore, the broad connectivity of the topic emphasizes the relevance of our study for both theory and practice.

Our second major contribution is consideration of technology acceptance based on the single construct of trust. Originally, TAM, developed by Davis (1989) in the information system domain, served as the core model of technology acceptance (Pai and Huang, 2011). The model constitutes perceived usefulness and perceived ease of use as the primary and secondary determinants of use of a technology. Trust has been examined previously in relation to technology acceptance using the TAM framework, and both the cognitive engineering and information systems fields have identified trust in technology as an important factor which influences acceptance (Ghazizadeh et al., 2012). However, there is little prior work that examines acceptance of technology based on the single concept of trust [e.g., Lee and See, 2004]. Thus, by examining technology acceptance through the single lens of trust, our study contributes details to this discussion. Whereas Lee and See, (2004) solely examined trust in the technology, we extend this discussion by providing a more comprehensive, two-dimensional view on the topic. Concretely, this is manifested in our third major contribution.

Our third major contribution is the dichotomous consideration of trust in applied AI, specifically via trust in the technology on one hand and via trust in the innovating firm and its communication on the other hand. Both domains have been discussed per se in literature, but a comprehensive framework involving trust in both domains has not yet emerged. Thus, our study reveals insights into the symbiosis of the domains. Concerning trust in the technology, we contribute to the work of Lee and See (2004), who theoretically elaborated on trust in automation and concluded that trust is likely a critical factor in the acceptance of consumer products such as home automation, personal robots, and automotive automation. Concerning trust in the innovating firm and its communication, we contribute to previous work claiming that, in the case of radical innovations, technical features may not be sufficient to overcome innovation resistance (Chiesa and Frattini, 2011; Heidenreich and Spieth, 2013; Ram, 1989; Ram and Sheth, 1989; Slater and Mohr, 2006). Hence, trust in the innovating firm and its communication can help overcome this resistance (Sternthal et al., 1978). Ultimately, we agree with Ram (Ram, 1989), who stressed the importance of communication in enhancing the acceptability of an innovation.

Our fourth major contribution is the presentation of tangible approaches alongside the three bases of trust in automation identified by Lee and Moray (1992). While Lee and Moray (1992) identified performance, process, and purpose as the bases of trust in automation in general, we examined trust in the specific, concrete context of automation in autonomous vehicles and medical assistance devices. Our results prove that these three bases are also suitable for trust in applied AI. Furthermore, we provide concrete approaches to foster each of the three bases of trust in applied AI.

Our fifth major contribution is illustration of the necessity of a transparent, democratic development process for applied AI. Democratic participation of users and other stakeholders (e.g., early, proactive communication and feedback loops) are a powerful means to not only convince users of the technical features but also increase trust in the communication and the credibility of a firm. Thus, we expand on prior work (Slovic, 1993) that has indicated this approach.

In addition to theoretical contributions, this study has several important implications for managers. The mechanisms for trust development do not differ tremendously between the transportation and medical technology industries. Trust in applied AI requires not only trust in the technology but also trust in the innovating firm and its communication. Like trust in interpersonal relationships, trust in applied AI is an evolving phenomenon. Consequently, firms in the two domains must begin to build trust during the development process of a technology. Trust in the technology evolves alongside performance, process, and purpose information about the technology. The performance basis is primarily reliant on both operational and data security aspects; the process basis is determined by cognitive compatibility, trialability, and usability; and the purpose basis is founded on application context and design. Trust in the innovating firm increases with stakeholder alignment, high public transparency of the development project, and gradual introduction of the technology. Ultimately, trust in communication grows primarily by early, proactive, and application-based communication as well as the transmission of benefit-related information.

6. Conclusions

Automation with inherent AI is a growing field with diverse applications in various industries. Our study contributes to a richer understanding of how firms can systematically foster trust in applied artificial intelligence. By capturing trust as a single construct for acceptance, we shed light on the driving mechanisms for building trust in the technology as well as trust in the innovating firm and its communication.

Appendix A. Appendix

Table A.1
Data—trust in the technology.

Case study	Performance	Process	Purpose
Semi-autonomous and fully autonomous cars (BMW)	*Operational and data security* "The three topics that we consider the big challenges at the moment are data security, operational security, and robot ethics."	*Cognitive compatibility* "Robot ethics is a major concern that we have detected: How ethical are decisions that robots make and how can they integrate intuition and emotions in their decisions like humans do? But of course it is not always good to decide based on emotions instead facts." *Trialability* "If you have personal driving experience and you see it works this way, fear will disappear and thus trust and acceptance will increase."	*Concrete context* "Already, autonomous driving is realized as a new technology, as a field that can really introduce disruptive change, which redefines mobility." *Design* Not explicitly mentioned.

Table A.1 (*continued*)

Case study	Performance	Process	Purpose
		Usability "Of course we do market research with customers and non-customers by inviting them to relevant tests… This is important information for us on how people react to these technologies."	
Future Trucks 2025 (Daimler)	*Operational security* "Due to the dynamic performance of trucks, longitudinal dynamics, i.e., braking, is prioritized for lateral dynamics, i.e., steering, because it might come to critical situation by automated steering." *Data security* "Of course we need to develop appropriate security standards to make sure that specifically on the safety paths and relevant sensors of the vehicles nothing happens. That is self-evident. […] Concretely, the topics of data security and intrinsically safe vehicles raises the question of how the vehicle can trust the data it receives. This is certainly a key question in the whole topic of connected driving."	*Cognitive compatibility and trialability* "We showed certain use cases to illustrate how the vehicle reacts to objects in traffic around and in front of us." *Usability* "For example, we perform relevant tests to objectively measure reactions and sensitivities and to record the influence of highly automated driving on the well-being and condition of drivers by measured data."	*Concrete context* "We call the technology of Future Trucks 2025 highway pilot. This shows that we focus on highway traffic, long-distance traffic." *Design* Not explicitly mentioned
Driver assistance systems and autonomous driving (ZF Friedrichshafen AG)	*Operational and data security* "Data is a big topic. How is the data processed, where does the data come from, and where is the data saved?"	*Cognitive compatibility* "Or when the vehicle tells the driver to visit a garage, the question is does the driver want to be reminded or is he negatively surprised." *Usability* "We aim to develop a solution that is optimal for the customer, which means the function is perfect. This is the most noticeable when the driver gets in touch with the human–machine interface in the interior. We definitely deal with this."	*Concrete context* Not explicitly mentioned *Design* "When the vehicle is trimmed to drive comfortably, how can different manufacturer differentiate themselves? Certainly, factors apart from actual driving like customer taste and offerings in the interior become crucial."
Semi-autonomous and fully autonomous trains (Deutsche Bahn)	*Operational security* "Fundamentally, if the technique is established, certificated, and approved, it will speak for itself, which means the technique can act autonomously. […] I think when it is proven that the technology works seamlessly, the chances will surmount the risks." *Data Security* "The underground train in Nürnberg works in a closed area. On the contrary, our rail network is in an open area. There is the possibility that something might happen due to external influences. But that might also happen when a person is sitting in the cockpit. […]"	Not explicitly mentioned due to very early status of the project and role as the operator and not developer of the system	*Context* "The technique also has the advantage that it makes train driving even safer than human drivers could do." *Design* Not explicitly mentioned
Fully autonomous underground train (VAG Nürnberg)	*Operational security* "Safety approvals are done to guarantee that the system always strictly does what it is supposed to do. Also, in the case of an error, the system turns off before any kind of false command is edited or, in the worst case, the train starts even though it is not supposed to." *Data security* "That is a stand-alone network that is not connected to the office communication network or the Internet."	"We invested a lot of energy to build the automation system in a way that the controller in the coordination center can comfortably use it via computer graphics. [...] We specifically considered the human–machine interface. […] Additionally, when the train is in trouble, the service employee quickly needs to realize what kind of trouble it is and what needs to be done to drive the train manually. […] We did special tests and collected feedback that we considered later on."	*Context* "We gave the project a name to make it more tangible. That is the reason for the term RUBIN, which stands for realization of an automated underground train in Nürnberg." *Design* Not explicitly mentioned
Watson (IBM)	*Operational and data security* "Primarily, the most important thing is the security and how we treat data. We bring the means to work with the data through a secure cloud service. After ingesting a corpus of knowledge, curated by experts on any given subject, cognitive systems are trained by being fed a series of question-and-answer pairs. This machine "knowledge" is then enhanced as humans interact with the system, providing feedback on the accuracy of the system's responses."	*Cognitive compatibility* "Watson builds hypotheses in the same way as an oncologist starts to think about a diagnosis during a consultation." *Trialability* "The WatsonPaths project explores a complex scenario and draws conclusions much like people do in real life. When presented with a medical case, it extracts statements based on the knowledge it has learned from being trained by medical doctors and from medical literature. Using Watson's question-answering abilities, WatsonPaths can examine the scenario from many angles, working its way through chains of evidence – pulling from reference materials, clinical guidelines and medical journals in real-time – and drawing inferences to support or refute a set of hypotheses. This ability to map medical evidence allows medical professionals to consider new factors that may help them to create additional differential diagnosis and treatment options."	*Concrete context* "We see this as being a perfect collaboration between men and machine. I underline that Watson does not make decisions on what a doctor should do. It makes recommendations based on hypothesis and evidence based." *Design* For the game show Jeopardy!, the system was named after the founder of IBM Thomas J. Watson Sr. and was visualized on a screen via an image of a connected globe.

(continued on next page)

Table A.1 (*continued*)

Case study	Performance	Process	Purpose
		Usability Constant collaboration with doctors to improve the system. Pilot projects are developed in close collaboration with customers.	
Automated fraud detection in the healthcare sector (HP)	"Personal data and personal-related data are involved, which is, of course, a critical topic. Here, you need to be careful. In our system, data is processed anonymously, which means we as a service provider can under no circumstances determine data for individual people. Only the social insurance agency, the one who is affected by the fraud, can do that. The reverse is also true—the social insurance agency cannot examine personal data that is not relevant for the comparison. […] A very important topic is privacy protection."		*Context* "You need to create an understanding that these criminal actions behind social insurance fraud are costly for the whole society. I am convinced that by stressing this, a very comprehensible system could be created." *Design* Not explicitly mentioned
Medical adherence app for mobile devices (AiCure)	"We provide introductory information in video tutorials on the technology. It is very important to discuss the privacy aspect of the technology with patients to ensure that they understand that their information is always protected and maintained in a highly secure and confidential manner and is never open to any kind of exploitation. That is absolutely critical. Therefore, explaining this directly to the patient as a user is really important."	*Cognitive compatibility* "So what we are doing is providing an easy way for the patient to use a device they already have to monitor whether they have taken their medication. In the event that they are doing something incorrectly, the human provider will intervene, only in the event of a critical deviation or due to nonadherence." *Trialability* "When you survey the perception of new technologies across generations, you typically see resistance from people who are not users of the technology. […] So perception of the technology, once you attract users, changes quite a lot." *Usability* "However, when we do interact with patients it is critical for us to explain how the technology works. […] We do extensive usability studies to determine what the perception is in all age groups, from 18 to 85 years old."	*Context* "So when you explain the context of where the technology will be applied, that is very important. […] You need to explain what the purpose of the technology is. So, for example, 'our company is called AiCure and is leveraging AI to help people get better' and that message is very clear. It aligns people's interest to say 'if I use this technology, I can make patients healthier, I can make hospitals more efficient, I can get much better quality data' and that message is very simple and easy to understand." *Design* Technology is available as an app for smartphones.
Care-O-bot 3 (Fraunhofer IPA)	"Fundamentally, our robots are autonomous and capable of processing data on board. […] Telepresence and remote-control is also possible, for example to use the robot as a communication platform. You need to think about the fact that camera connection is only possible after user acceptance in order to avoid misuse."	*Cognitive compatibility* "The robot can support interaction via voice output and gestures, which is one possibility to make its behavior even clearer to the user." "It needs to be comprehensible as to why the robot decides in a certain way. I think it is essential that the robot gives relevant feedback to users so that they understand what the robot does. If the robot does things that are not comprehensible to users, this might provoke acceptance problems. It needs to be clear that the robot is always under human control and does not really make decisions on its own in a complex environment." *Trialability and usability* "It is really important that the technology is extremely easy to handle and that the handling does not create additional obstacles." "We typically involve usability partners in our projects who deal with the development and evaluation of user interfaces."	*Context* "Finally, our primary aim, our vision is support for people in the domestic environment." *Design* "We really tried to realize a certain human appearance for the Care-O-bots, but in an abstract way. That way it is always clear that it is a machine that is now deciding on its own […] which means in a system that looks more robotic, it is even more important that the user receives feedback that shows he still has control."

Table A.2
Data—trust in the innovating firm.

Case study	Stakeholder alignment	Transparency of the development project	Gradual introduction of the technology
Semi-autonomous and fully autonomous cars (BMW)	"We discuss acceptance questions in the research department where we fundamentally deal with the effects of these new technologies. We deal with the concrete effects on different societies and stakeholders regarding this topic." *Politics* "We do not want to drive politics ahead of us, but we need politicians as partners who advocate for creating a legal basement."	*Democratic process* "We also let reporters drive our highly automated vehicles on the highway to make the experience more concise and intense."	"Via stepwise introduction, we want to slowly bring the technology closer to society. Thus, we want to slowly reduce fears among people against the technology to persuade them and extend the conditions for operating step by step."
Future Trucks 2025 (Daimler)	*Politics* "However, at the moment, we do not have the appropriate approach for trust building actions for the public. Our target groups are political institutions and authorities to bring such systems towards approval. You are right, however, that it is an important aspect."	"During the last IAA (International Motor Show), we presented the vehicle to the public for the first time. By July 2014, we held a technical event on a closed highway area. We had a relevant press event there to exhibit the technology."	"I am convinced that we are not making a revolutionary step in the case that, for example, for 10 years nothing happens and then an autonomous level 3 truck is launched. Instead, we introduce a sequence of small innovations that lead in the same direction. […] We will see that the

Table A.2 (*continued*)

Case study	Stakeholder alignment	Transparency of the development project	Gradual introduction of the technology
	Top management "At the IAA (International Motor Show), our boss, who is responsible in top management for trucks and buses, drove such an autonomous truck to speak to the press and explain it."		technique will be approved for extended conditions. So I think it is evolutionary steps rather than a revolutionary step towards autonomous driving are required. Perhaps society will follow step by step with growing levels of automation and autonomy."
Driver assistance systems and autonomous driving (ZF Friedrichshafen AG)	*Politics* "You should not neglect politics and the question of how to put the topic on the market."	Not explicitly mentioned	"It works via an adoption of local laws, which allows a certain amount of automation in the steps."
Semi-autonomous and fully autonomous trains (Deutsche Bahn)	*Politics* "We also have to consider the legal conditions. In the status quo, we are not allowed to operate fully automated trains on the road network. The relevant work rules need to be changed." *Employees* "Dealing with current topics that affect our business is a daily activity for each employee. Everybody has their own task, but that constantly changes a bit and […] thus we do a lot of workshops where we meet different business units."	*Stakeholder involvement* "We do constant surveys in the sense of market research and ask customers and employees how they evaluate the topic."	"There are four grades auf automation. Grade 1 is driving on sight or when the train is driven via signals. That is the old style and what happens on regional railways. Grade 2 is ICE (Inter-City--Express) operation, which means partially automated operation where the train brakes and accelerates in a mainly self-acting manner, but the train driver gives the signal to leave the rail station and is responsible for closing the doors. While driving, he can intervene manually, but the train is mainly operated via transmission lines. Grade 3 means that the train is fully autonomous, including starting and braking. The train driver only intervenes in critical situations. Grade 4 would mean that the train driver is no longer on board."
Fully autonomous underground train (VAG Nürnberg)	*Users* "Without participation of the media and the public, that is to say the citizens of Nürnberg, such a project can't be done. Various projects in Germany have shown that without the involvement of citizens, numerous difficulties arise. In the worst case, such projects can't be realized." *Politics*, *regulatory institutions*, *employees* "Of course, we have also informed the political committees. Finally, the approving authorities of an underground train had to sanction the project so that we were authorized to operate such an automation system. We involved another very important group—all employees within VAG who deal with the automation system." *Top management* "The project had a high priority. This was, for instance, visible in the fact, that top management was involved in the decision making processes concerning marketing activities."	"We countered the concerns with conscious PR work. For example, we created a special website to provide information about the project […] For each milestone, we held a press conference. We invited the press and explained the current status, what has been done, and discussed the next steps. We addressed all citizen associations, associations for handicapped people, and nursing homes and offered lectures on the automated underground train […] We held 50 to 100 lectures in the Nürnberg area to explain the project […] We also installed a notice board in the company to inform our employees about new milestones."	"We realized fully automated operation in Nürnberg on the lines U2 and U3, which means we took a huge step from conventional to fully automated operation."
Watson (IBM)	*Users* Constant collaboration with doctors to extend discoveries in new application fields.	"In 2011, it was ready. To show the clients, the industry, and the world that we had built a cognitive system, we decided that the best challenge would be to play Jeopardy!. Playing the game was the ultimate challenge."	"Several projects are underway in several industries (healthcare, pharmaceutical, retail, consumer products, banking, insurance, travel and transport."
Automated fraud detection in the healthcare sector (HP)	*Society* "Doing something against users' or citizens' will is not a clever approach." *Politics* "Of course, we also collaborate with governments, especially if country-wide projects are on the agenda. It should also be considered that not everything that is technically feasible is politically desired. In this context, many norms and regulations need to be established and specified. […] Unfortunately, many regulations and approval mechanisms lag behind reality and technical feasibility. That is natural. […] I think politics demands two perspectives—building legal conditions and the right communication."	"That simply means that better communication is needed and that in the future people need to be involved in democratic processes regarding such topics and every participant in traffic or healthcare needs to be respected."	"First, the healthcare financial system was implemented and established. Fraud detection and prevention is only an extension."
Medical adherence app for mobile devices (AiCure)	"It is really important to have stakeholder alignment."	"The media's most important role is education, and to avoid fear mongering. AI can be of significant benefit for society today and will continue to grow."	Not relevant due to status as a young company
Care-O-bot 3 (Fraunhofer IPA)	*Politics* "It is, of course, also important that politicians have an appropriate understanding about what we are doing that corresponds with how the topic is presented in the media. Finally, in the context of	*Feedback from users* "We speak to various users and actively involve them in our projects. We do several feedback loops to make sure that the things we develop are really relevant for practical life."	"Over the years, the autonomy of the systems increases. It happens automatically and is not completely autonomous root from the beginning. At the beginning, user instructed systems

(continued on next page)

Table A.2 (*continued*)

Case study	Stakeholder alignment	Transparency of the development project	Gradual introduction of the technology
	healthcare, funding of technical solutions also plays a key role. Politicians need to consider new possibilities to make life easier for the elderly and nursing staff and determine how this helping tool can be supported financially."	"Of course, we also attend user fairs to really show the aim of our work and where the technique is standing at the moment. This applies to both the public and the media as well as users. For user fairs especially, nursing staff members are present, who – in addition to the elderly themselves – might be important beneficiaries of our developments."	are launched, which slowly increase in autonomy."

Table A.3
Data—trust in the firm's communication.

Case study	Early, proactive communication	Concrete and tangible information/ framing terminology	Benefit-related information
Semi-autonomous and fully autonomous cars (BMW)	"Of course we do market research with customers and non-customers by inviting them to relevant tests. We start in the simulator and let them drive autonomously on a road with display manipulation. This allows them drive as a passenger in a real car would. In addition, they can turn around by themselves on our test route." "We also give reporter the chance to drive in highly autonomous cars so they can have an even more intense experience. They get out and conclude, 'That is fantastic. Now I can appreciate what the car is able to do.' We say that the development is not finished, that is not yet perfect, but it is a way to increase trust."	*Application-based communication* "Autonomously driving cars and new mobility concepts involving autonomous cars consider sustainability: decreasing traffic, increasing comfort and safety for people, and offering new possibilities for individual local traffic." *Framing terminology* "In external communication, we use the terminology 'autonomous driving' to make it understandable for people. In internal communication, we differentiate among various levels of automation according to accepted definitions." "The term AI is used in internal communication in the context of understanding the processor."	"First, automation compensates for human flaws, which means where humans are not skilled, automation with relevant functions can compensate for these flaws. A robot will not become tired or inattentive and will behave according to its rules in a perfect way. […] Second, we need to consider the social effects of a robotic car towards improved comfort, better traffic management, perhaps less traffic jams, and the benefit of individuals doing another activity during a traffic jam. Third, economic aspects are involved. This new technology is, of course, a possibility for industries and societies to advance technologically and create modern work places and other things."
Future Trucks 2025 (Daimler)	During the development period, public events are organized where use cases are presented.	*Application-based communication* "I think we showed at the IAA (International Motor Show) how it works through the use cases, how the longitudinal and lateral intervention works, how the truck acts." *Framing terminology* "We do not use the term AI. We call it highly automated driving according to levels defined by the authorities."	"We had the experience that attitudes can change in only a few years when there is a relevant user benefit. […] I think when we have relevant performance values, the technology can initiate a triumphal procession."
Driver assistance systems and autonomous driving (ZF Friedrichshafen AG)	Not explicitly mentioned	*Application-based communication* "Regarding acceptance, we need to differentiate between the acceptance of a function and the topic of autonomous driving in general. You need to deal with that independent of the status as supplier or manufacturer." *Framing terminology* Not explicitly mentioned	*Benefits* "Certainly, acceptance is not only influenced by the interface, for example, what benefits it has."
Semi-autonomous and fully autonomous trains (Deutsche Bahn)	Not relevant due to very early status of the project	*Application-based communication* "We assume that driving without a driver makes train operation even safer. However, we know that at the moment the combination of man and machine is optimal but with an increased share of technology." *Framing terminology* "If you use the terms partly autonomous and autonomous you can't make any mistake. […] We also have another term when we speak about automation in the context of processes. Then, we use the term 'asset intelligence' and attempt to establish condition-based maintenance via sensor technologies and data analysis."	*Benefit* "All the human flaws, for example, braking too strongly or accelerating too quickly, can be eliminated. Thus, the vehicle operates in a more energy-efficient manner."
Fully autonomous underground train (VAG Nürnberg)	"The project was announced in 2000. When it became public, there was bad press, for example, talk about ghost trains. Fears and uncertainties were clearly visible. We confronted this with conscious PR work. […] We also did a survey in Nürnberg on automation and asked what kind of fears there are in order to address them with purposeful PR work. […] All these actions over the years helped to increase acceptance for the project. Finally, in 2008, when the U3 was opened, people did not show resistance. Press reports were positive and it was even an advertisement for Nürnberg." During the development period, various public events were organized.	*Application-based communication* "Compared to conventional operation, automatic operation more operator-controlled actions are performed by the system instead of by humans, which makes the automatic system safer." *Framing terminology* "There is a norm for automation grades. This norm uses Grades of Automation (GOA) 0 to 4. Verbally, we use conventional train operation, semi-automated train operation, driverless train operation, and unattended train operation."	"The main beneficiaries are the operating company and passengers. The benefits to the passenger are a higher frequency and improved personal service compared to conventional train operation."

Table A.3 (*continued*)

Case study	Early, proactive communication	Concrete and tangible information/ framing terminology	Benefit-related information
Watson (IBM)	The first public presentation was on the TV quiz show Jeopardy! in 2011.	*Application-based communication* "I think the important thing is to understand how the system works and, more importantly, how we use and apply the technology. I think when the transparency is there it is clear, there is a sort of comfort." *Framing terminology* "Cognitive systems are probabilistic, meaning they are designed to adapt and make sense of the complexity and unpredictability of unstructured information. They can "read" text, "see" images and "hear" natural speech. And they interpret that information, organize it and offer explanations of what it means, along with the rationale for their conclusions. They do not offer definitive answers. In fact, they do not "know" the answer. Rather, they are designed to weigh information and ideas from multiple sources, to reason, and then offer hypotheses for consideration. A cognitive system assigns a confidence level to each potential insight or answer."	"If providing data is going to help me have better chances of not getting a disease, most likely they will share the data. Thus, this is not a fear or a concern."
Automated fraud detection in the healthcare sector (Hewlett Packard)	Not relevant due to the role as service provider	*Application-based communication* "If you show people that the system promotes fraud detection and prevention instead of observing people, I think this will reduce resistance. I am really sure that convincing people means education and information. […] If you don't communicate the technology in a clear way, this will lead to uncertainty, and this is negative for all people involved." *Framing terminology* Automated fraud detection in the healthcare sector	"Political institutions need to establish the understanding in society that criminal actions have costs for everybody. I think if you show this to citizens along with the benefits, we will all pay less in the future and there will be greater understanding in society. Furthermore, people could see that individual data is not being used in a criminal way."
Medical adherence app for mobile devices (AiCure)	Not explicitly mentioned since customers are pharmaceutical companies and health systems, not patients, who are the end users	*Application-based communication* "I think the idea is that you can use a technology for good in a specific application that will be accepted by most of society. I think when you focus on broad statements that paint a future of robots that take over the world, it is obviously scary." *Framing terminology* "It is an assistive technology. […] The problem with the term AI is that it can mean many things to many people. And it sounds scary because there is a lack of understanding, pretty much like any new technology that is introduced into society. When a technology is not well understood, it is open to misunderstanding and misinterpretation."	"For all of these technologies, if you want to exploit them and be open to exploitation, it is just a question of the societal return on investment." "The benefits and the manner in which the technology works need to be thoroughly investigated and carefully explained. They need to be translated not just for patients but also for care providers, health systems, hospitals, and pharmaceutical companies."
Care-O-bot 3 (Fraunhofer IPA)	"Of course, we regularly attend user fairs with our robots to really show […] how the technology works."	*Application-based communication* "Ultimately, we try to bring the technique into practical life to show what robots can already do today, how can they do it, and how are they used." *Framing terminology* "We deal with assistant robots. […] When I speak to people from care practice I prefer to say 'autonomous function'. Intelligence is always associated with human intelligence, and that is not the topic. Instead, the topic is programmed behavior, which the robots exhibit. Learning aptitude is limited to recognizing objects—not like a baby learning complex action sequences by themselves."	"We learn that presenting the benefits and verbalize them helps to increase acceptance. Nursing staff are also thankful for things that ease their daily routines at work, because this is an exhausting job."

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