1. Introduction

In today's world, consumers' lives are digitized to an extent we have never witnessed before (Yoo 2010). Ongoing progress in the information technology (IT) industry has led to an ever-growing number of products that are equipped with IT components and a continuous improvement of products' capabilities (Bharadwaj et al. 2013; Lyytinen and Yoo 2002; Yoo 2010). By making effective use of artificial intelligence and the constant connection to local or wireless networks, a new category of "autonomous products" has emerged (Endsley 2017; Hancock 2017; Krogmann 1999). Several autonomous products, such as the iRobot Roomba (an autonomous vacuum cleaner), the Husqvarna Automower (an autonomous lawn mower), and the Nest Learning Thermostat (an autonomous thermostat) are already available on the market. These products operate in a relatively low-complexity environment. This thesis focuses on an autonomous product that, due to its highly complex environment, is still under development and has the potential to radically change our lives: the autonomous vehicle.

In the following, I explain the background and the need to empirically examine the autonomous vehicle from a consumer perspective, which has frequently been neglected thus far. The related research gaps are applied to formulate research questions, which are answered in the course of this thesis. The chapter ends by outlining the thesis organization for the reader.

1.1. Background

Hundreds of millions of people all around the world have driven cars for over a century. Soon, technological progress will allow us to substitute the manually driven car with the autonomous vehicle (Hein et al. 2018). Automotive manufacturers such as Tesla, Audi, Volkswagen, Daimler, Volvo, and Ford; ride hailing companies such as Uber and Lyft; and IT companies such as Google and Nvidia have been conducting field tests of autonomous vehicle prototypes for many years to make this highly complex autonomous product ready for market launch (Bunghez 2015; Fagnant and Kockelman 2015; Jo et al. 2015). As the autonomous vehicle is considered to have the potential to disrupt the mobility industry (König and Neumayr 2017), it is of high relevance for researchers and practitioners. Current discussions are centered on the technical development, legal aspects,

and the economic potential of autonomous vehicles (see Bunghez 2015; Burns, Jordan, and Scarborough 2013; Chen et al. 2016; Fagnant and Kockelman 2015; Jo et al. 2015; Krueger, Rashidi, and Rose 2016; Litman 2014, Mersky and Samaras 2016; NHTSA 2016; SAE 2014, 2016; Underwood 2014).

So far, little attention has been paid to the consumer, which is surprising given that the success of this radical innovation depends on whether consumers will be ready to use it (Meuter et al. 2005). It is particularly relevant for practitioners to gain an understanding of the consumer perspective because adoption rates for radical innovations are low, which eventually leads many of them to fail (Kim, Hahn, and Yoon 2015; Luo, Wong, and Chou 2016). A comprehensive understanding of the consumer view of the autonomous vehicle would be helpful for several stakeholders, such as automotive manufacturers, suppliers of hardware and software, mobility service providers, insurance companies, traffic law advisers, and politicians. Manufacturers could use these consumer insights to improve new product development processes and offer autonomous vehicles that better match consumer demands or create effective communication strategies to promote the technology. Firms that operate in the mobility industry today or may enter it as a result of the expected disruption to it (König and Neumayr 2017) could take the currently missing consumer perspective for autonomous vehicles into account and make market-oriented decisions (see Kohli and Jaworski 1990; Narver and Slater 1990). The consumer perspective would not only allow firms, legal advisers, politicians, and other stakeholders to anticipate the change to come, but would also offer an opportunity to directly influence the future by taking action to make this radical technology succeed in the market.

As a result of the ongoing focus on technical capabilities, legal issues, and the economic potential of autonomous vehicles, research with a consumer perspective is in its early stages. Furthermore, several of the few consumer-oriented studies that have been conducted about the autonomous vehicle show deficiencies in their theoretical underpinning (e.g., Bansal, Kockelman, and Singh 2016; Bazilinskyy, Kyriakidis, and de Winter 2015; Haboucha, Ishaq, and Shiftan 2017; König and Neumayr 2017; Kyriakidis, Happee, and de Winter 2015; Payre, Cestac, and Delhomme 2014). This is not ideal because theories provide clear directions for empirical research that are most needed when the research domain is less known,

help explain what causes a phenomenon, and also result in practical outcomes (Lawrence 1997; MacInnis 2011; Van de Ven 1989). The deficiencies in theory development have led to a multitude of attitudinal beliefs about the autonomous vehicle that researchers defined a priori and tested for consumers' agreement, which has let to inconsistencies. So far, no study exists that profoundly explores the perception of consumers towards the autonomous vehicle. Given that a comprehensive understanding of psychological drivers and barriers about the autonomous vehicle is lacking, we do not know which beliefs are decisive in shaping the adoption intention. Such an understanding would be of high value for researchers and practitioners alike.

Academic consumer studies are missing not only for the autonomous vehicle but for other autonomous products as well (Leung, Paolacci, and Puntoni 2018). Still, some studies about autonomous products other than the autonomous vehicle show the relevance of consumer traits, which may also be of importance for the adoption of an autonomous vehicle. In the context of autonomous apps for music and home heating, Schweitzer and van den Hende (2016) have shown that implementing an intervention design that allows individuals to interfere with the operation can reduce the feeling that the innovation reduces the freedom to choose or act. The authors have further found that such an intervention design is only preferred among less innovative consumers, which indicates the relevance of consumer innovativeness for the adoption decision. Leung, Paolacci, and Puntoni (2018) have shown that identity-based consumption leads to resistance towards automated products. The authors have demonstrated that autonomous products can hinder consumers from attributing the outcomes of an activity to the self, and thus the expression of an identity cannot be acquired. This shows the role of consumer identities, which can negatively influence consumers' adoption. These examples illustrate the relevance of understanding the effect of consumer traits on the adoption decision of an autonomous vehicle. In particular, practitioners who work in the mobility industry could benefit from such an understanding, as market segmentation and consumer targeting could be improved if traits show relevant differences for consumers' decision-making.

To conclude, the following research gaps have been identified. First, there is no adequate empirical study that investigates the market potential of the autonomous

vehicle from a consumer perspective. It remains unclear which psychological drivers and barriers consumers perceive and how they influence the future adoption decision. Moreover, several of the existing academic articles do not rely on a theory (e.g., Bansal, Kockelman, and Singh 2016; Bazilinskyy, Kyriakidis, and de Winter 2015; Haboucha, Ishaq, and Shiftan 2017; König and Neumayr 2017; Kyriakidis, Happee, and de Winter 2015; Payre, Cestac, and Delhomme 2014), which indicates the need to develop a theoretical framework for the adoption decision of autonomous products. In addition, consumer differences in innovativeness and identification with a product category have been shown to be relevant for the decision to use autonomous products other than the autonomous vehicle (Leung, Paolacci, and Puntoni 2018; Schweitzer and van den Hende 2016). Further research needs to examine the effect of these traits in the context of an autonomous vehicle to generate a comprehensive view of the consumer perspective. Finally, the scarcity of consumer studies about the entire category of autonomous products emphasizes the need to examine similarities and differences between different categories of autonomous products. This can be accomplished by classifying autonomous products in two categories: those that operate in a highly-complex environment such as the autonomous vehicle, and autonomous products that operate in a low-complexity environment, such as an autonomous vacuum cleaner or an autonomous lawn mower. Given that all autonomous products share the product attribute of autonomy, it is of interest to see which psychological drivers and barriers about the autonomous vehicle can be generalized and which attitudinal beliefs are product-specific.

1.2. Thesis Objectives and Focus

The identified research gaps emphasize the demand for empirical research that provides a comprehensive view of the consumer perspective towards the autonomous vehicle. Based on these gaps, the following research questions have been derived:

- Which psychological drivers and barriers do consumers perceive towards using autonomous vehicles in the future?
- What importance does each of these drivers and barriers have for the future adoption decision of autonomous vehicles?

- How do consumer traits affect the perception of psychological drivers and barriers and the importance of these beliefs for the future adoption decision of autonomous vehicles?
- Which psychological drivers and barriers towards using autonomous vehicles exist for autonomous products in general?

With a combination of qualitative and quantitative studies, this thesis delivers comprehensive findings to answer each research question and sheds light on the consumer-oriented market potential of the autonomous vehicle. Grounded in a coherent theoretical framework, a qualitative study is applied to explore the psychological drivers and barriers consumers perceive about the autonomous vehicle. The results answer the first research question. These findings are transferred into a quantitative research design to measure the relative importance of drivers and barriers for the adoption decision to address the second research question. In addition, the role of consumer traits for the adoption decision is investigated to answer the third question. Another qualitative study is also conducted to discover the drivers and barriers consumers perceive towards using other, less complex autonomous products. The drivers and barriers that are related to the autonomous vehicle can thus be compared with other autonomous products, and their generalizability can be examined. This comparison provides answers to the fourth research question.

Given the need for empirical consumer research about the autonomous vehicle and the potential of the technology to disrupt the mobility industry, the focus of this thesis is examining the consumers' view of this radically new technology. By providing comprehensive answers to the first three research questions, researchers and practitioners should be able to extend their understanding of the consumer perspective on the autonomous vehicle. In addition, the qualitative findings about the autonomous vehicle provide an opportunity for expansion and comparison with qualitative results about autonomous products that operate in a less complex environment. Thus, the scarce academic research in the entire domain of autonomous products can be extended.

This thesis concentrates on the consumers' view of the product attribute of autonomy and neglects other attributes of autonomous products, such as design. The

approach is justified by the overall goal of examining consumers' psychological drivers and barriers that stem from the attribute of autonomy, which represents the main differentiator between autonomous and manual products. In addition, only autonomous driving is investigated, while different levels of automated driving are not addressed. As I explain in a technical perspective on autonomy in the second chapter, autonomous driving is considered the evolution of automated systems (Hancock 2017) and brings the most radical changes to the way consumers use their cars today. Furthermore, as the autonomous vehicle is not yet available, this thesis investigates consumers' current perceptions of the autonomous vehicle and consumers' expected behavior in the future.

As this thesis is grounded in a theoretical framework that incorporates the knowledge transfer paradigm, i.e., the transfer of knowledge from an existing solution to an innovation (Gentner 1989; Gregan-Paxton and Roedder John 1997), the findings are limited to the target group of car drivers. These consumers have knowledge about and experience with the manual or semi-automated car and are expected to show differences in their perception of psychological drivers and barriers and the impact of these beliefs on the adoption decision of an autonomous vehicle compared to consumers who have never driven a car. The consumer-oriented market potential of the autonomous vehicle is examined for German car drivers. The long-established German car market is of high interest because many Germans are highly involved in cars (Algesheimer, Dholakia, and Herrmann 2005). With over 3.4 million newly registered passenger cars in 2017, the German car market reached its highest level in this decade, and it remains the largest market in Western Europe (VDA 2018). As German car drivers represent a high proportion of German consumers, understanding their perception of the autonomous vehicle and their market potential is of high relevance for practitioners.

1.3. Thesis Structure

In order to answer each research question in a comprehensive and compelling manner, the next chapter of this thesis discusses different perspectives on autonomy. I explain autonomy from a technical point of view by clarifying the technical characteristics of autonomous systems that differentiate them from automated systems. This technical understanding is then enhanced with a societal perspective. I shed light on what citizens of Europe know about autonomous systems and

how they feel about them. The societal view on autonomy is then addressed in more depth from a marketing perspective. Here, psychological processes that occur during consumers' evaluation of a radical innovation, such as the autonomous vehicle, are explained. The discussion is centered on the transfer of knowledge from an existing product, in this case, the manual or semi-automated car, to the autonomous vehicle, which contributes to the development of the theoretical framework. The second chapter ends with a detailed discussion of consumer-oriented research findings for the autonomous vehicle and other autonomous products.

In the third chapter, the theoretical framework of this thesis is developed. The theory of reasoned action (see Ajzen and Fishbein 1980; Fishbein and Ajzen 1975), which explains the determinants of human decision-making and their formation, as well as a decomposed modification of the theory (see Taylor and Todd 1995a, 1995b), are explained. Afterwards, the means-end theory (see Gutman 1982, 1984) is addressed and compared to the decomposed theory of reasoned action. Both theories are then integrated and enhanced by a sacrifice perspective that is grounded in the knowledge transfer paradigm. These conceptual considerations are finally applied to the context of autonomous products to develop a theoretical framework that guides the subsequent empirical research.

The fourth chapter transfers the theoretical framework to an empirical research design. The first qualitative means-end study is used to investigate which psychological drivers and barriers consumers perceive about the autonomous vehicle. A second qualitative means-end study examines less complex autonomous products to investigate the generalizability of findings about the autonomous vehicle. The results of both studies are therefore integrated and discussed in consideration of other academic research findings on autonomous products. The third study transfers qualitative findings about the autonomous vehicle to a quantitative design. The quantitative study examines the relative influence of psychological drivers and barriers on the adoption decision of the autonomous vehicle. Furthermore, this study investigates how consumer characteristics that have been identified as relevant affect the perception of psychological drivers and barriers and the impact of these beliefs on the adoption decision of the autonomous vehicle. To investigate further potential differences among consumers, a latent class approach is ap-

plied. The differences and similarities between identified groups of consumers are described and explained to further understand the consumer perspective towards the autonomous vehicle. The results of the third study explain what will drive and hinder the decision to use an autonomous vehicle in the future and how these drivers and barriers differ among consumers.

The final chapter summarizes the main findings of this thesis and addresses theoretical implications. To provide a managerial perspective, the results are then considered in light of practical implications, followed by a discussion of how practitioners, such as new product development managers, can improve the product proposition of the autonomous vehicle and how marketing communication can benefit from these findings. In the end, the limitations of the thesis are addressed, and implications for future research are derived accordingly.

2. Different Perspectives on Autonomy

The following chapter examines autonomy from technical, societal, and marketing perspectives. First, the technical characteristics of autonomous systems are outlined and compared to automated systems. Both systems are then discussed in the context of smart products, which share certain similarities. Second, based on the understanding of autonomous systems, light is shed on how members of societies perceive these systems. Finally, a marketing perspective provides more depth for this view. Here, consumers' psychological processes in the context of evaluating autonomous products are explained, and an overview of the latest research findings about consumers' adoption of autonomous products is given.

2.1. A Technical Perspective on Autonomy

The concept of autonomy has long been applied to a variety of fields, such as politics and psychology. More recently, autonomy has also been mentioned in the context of technical systems (Endsley 2017). The resulting term "autonomous system" is, however, frequently used interchangeably with the long-predominating term "automated system", which leads to confusion among researchers and practitioners. By returning to the origin of the concept of autonomy and explaining the developments in the IT industry that let to its application to technical systems, I explain the differences between autonomous and automated systems. In addition, autonomy is discussed in the context of smart products because autonomy is frequently conceptualized as one aspect of product smartness (see Hoffman and Novak 2018; Rijsdijk and Hultink 2009; Rijsdijk, Hultink, and Diamantopoulos 2007).

The term "autonomous" originates from the Greek word "autonomos," which means "having its own laws" (Oxford 2019). An entity that acts autonomously is therefore in a condition of self-governance. In a political sense, a state can be considered autonomous if it acts as sovereign (Pauly 1995), i.e., independently from other states. From a psychological view, autonomous behavior is present when an individual can choose a certain action without any regulation (Deci and Ryan 1987; Ryan and Deci 2000). Hence, autonomous systems need to be capable of performing actions independently, without human interference. Such capabilities

are the result of several developments in the IT industry and differentiate autonomous from automated systems.

The ongoing progress in the IT industry has led to continuously decreasing costs for IT components, such as computers and sensors that make the integration of IT hardware into previously analog products economically feasible (Yoo 2010; Yoo, Henfridsson, and Lyytinen 2010). However, not only have we witnessed an increasing number of objects with embedded IT components, but the IT capabilities also continue to improve. Computers possess increasing processing power, larger storage capacities, and more efficient power management (Bharadwaj et al. 2013; Lyytinen and Yoo 2002; Sørensen et al. 2005; Yoo 2010). Investments in artificial intelligence sub-fields such as machine learning have grown exponentially over the last decade (Lewis and Denning 2018), leading to more accurate system decision-making. In addition, the rising bandwidths offered via local and wireless (including mobile) networks (Lyytinen and Yoo 2002) allow systems to collect and process data in real time. These developments have led to the emergence of autonomous systems, which possess more advanced capabilities than automated systems.

Automated systems rely on deterministic, logic-based programming that can perform a limited number of predefined outcomes (Endsley 2017; Hancock 2017; Krogmann 1999). These systems are not capable of adapting to changes in the environment in which they operate and require a certain level of human interference. We find such systems in many areas of today's world, such as in home appliances (e.g., phones, washing machines), retail (e.g., scanning cash registers, logistic systems), and assembly lines, to mention only a few. In contrast, autonomous systems make use of artificial intelligence as they contain adaptive, context-specific algorithms that allow them to learn over time and achieve their goals independently (Endsley 2017; Hancock 2017; Krogmann 1999). Autonomous systems can, for example, be found in the mobility industry (e.g., autonomous vehicle prototypes), in home appliances (e.g., autonomous vacuum cleaners, autonomous lawn mowers), in finance (e.g., autonomous credit granting via personal finance score), and in employee recruiting (e.g., autonomous applicant selection via video analysis). Due to their higher computational capacities in comparison to automated systems, they can use information they receive via their connection to