# Fakultät für Wirtschaftswissenschaften (TUM School of Management)

## Personal autonomous future: The role of emotions, cognitions, and individual values in the adoption process of autonomous cars

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## Abstract

This thesis enhances the understanding of society's perception and behavioral tendencies towards autonomous cars by examining psychological factors that shape individual adoption processes. A first qualitative study provides first ndicators with regard to risk and benefit perceptions associated with autonomous cars. The results show that predominantly performance-related and psychological risks as well as societal and personal benefits are prevalently associated with autonomous cars. The second study examines, whether societal groups differ in their willingness to use automated cars due to affective reactions towards them. The results of the second study show that, indeed, men and women differ in their willingness to use autonomous cars due to different positive and negative affective reactions. More precisely, women (in comparison to men) showed higher levels of anxiety towards autonomous cars, which reduce the intention to use them and lower levels of pleasure, which enhance the intention to use them. Moreover, the study shows that these perceptions vary as a function of respondents' age in such a way that the differential effect of sex on anxiety (but not on pleasure) was more pronounced among relatively young respondents and decreased as age increases. The third study examines how benefit evaluations, anxiety-related affects, and the interplay between these two factors influence the willingness to use autonomous cars for people with different levels of self-enhancement. The results show that higher levels of benefit evaluations positively and anxiety perceptions negatively influence the willingness to use autonomous cars. Moreover, higher levels of anxiety diminished the positive effect of benefit evaluations on the willingness to use autonomous cars. Interestingly, the diminishing effect of anxiety on the positive relationship between benefit evaluations and willingness to use decreased with increasing levels of self-enhancement. Based on the empirical results, the thesis provides novel theoretical insights for the innovation and technology adoption literature as well as practical recommendations for decision makers.

## Kurzfassung (German abstract)

Die vorliegende Dissertation verbessert das Verständnis über den Einfluss von psychologischen Faktoren innerhalb der Gesellschaft, die zur Akzeptanz von neuartigen Technologien beitragen. Konkret untersucht die Thesis das Erleben und potentielle Verhalten von verschiedenen gesellschaftlichen Gruppen gegenüber autonomen Automobilen. Eine erste qualitative Studie gibt Aufschluss über die Risiko und Nutzen Wahrnehmung von autonomen Autos. Dabei stellt sich heraus, dass überwiegend leistungsbezogene oder psychologische Risiken sowie soziale oder persönliche Nutzungserwartungen mit autonomen Autos assoziiert werden. In einer zweiten Studie wird untersucht, ob emotionale Reaktionen gegenüber autonomen Autos Geschlechtsunterschiede in der Bereitschaft diese zu nutzen, erklären. Die Ergebnisse der Studie zeigen, dass unterschiedlich stark assoziierte positive und negative Emotionen Geschlechtsunterschiede in der Bereitschaft autonome Autos zu nutzen verursachen. Dabei zeigt sich, dass Frauen mehr negative und weniger positive Emotionen mit autonomen Autos verbinden, was die Bereitschaft diese zu nutzen, verringert, wohingegen der gegenteilige Effekt bei Männern zu beobachten ist. Darüber hinaus zeigt die Studie, dass der Wahrnehmungsunterschied zwischen den Geschlechtern hinsichtlich der assoziierten Emotionen abhängig vom chronologischen Alter ist. Es ist zu beobachten, dass der Geschlechtsunterschied in der Tendenz autonome Automobile zu nutzen, verursacht durch das unterschiedliche Erleben von Angst, besonders ausgeprägt zwischen jungen Männern und Frauen ist, aber mit zunehmenden Alter abnimmt. In einer dritten Studie wird der Einfluss der antizipierten Nutzen- und Angstwahrnehmung sowie deren gegenseitigen Wirkungsweise in Abhängigkeit der individuellen Motivation der Selbstaufwertung *[Engl. self-enhancement]* untersucht. Die Ergebnisse zeigen, dass eine stärkere Nutzenwahrnehmung sich positiv und eine stärkere Angstwahrnehmung negativ auf die Bereitschaft autonome Automobile zu nutzen auswirkt. Zusätzlich zeigt sich, dass mit zunehmender Angstwahrnehmung die

positiven Effekte der Nutzenwahrnehmung auf die Bereitschaft autonome Automobile zu nutzen abnimmt. Interessanterweise nimmt der abschwächende Effekt der Angstwahrnehmung auf den positiven Effekt der Nutzenwahrnehmung und die Bereitschaft autonome Automobile zu nutzen, mit zunehmenden Anstieg der Selbstaufwertung ab. Basierend auf den empirischen Befunden liefert die vorliegende Dissertation neuartige theoretische Hinweise im Bereich der Technologieakzeptanz sowie praktische Empfehlungen für Entscheidungsträger.

# 1    Introduction[1]

*"It's supposed to be automatic, but actually you have to push this button"*

— John Brunner

## 1.1    Motivation and research questions

Autonomous cars constitute a new kind of large-scale technology whose implementation is assumed to have far reaching consequences on society such as lower $CO_2$ travel emissions (Greenblatt & Saxena, 2015), enhanced private mobility (Fagnant & Kockelman, 2015) and lower travel costs (Burns, 2013). However, fostering the rapid success of new technologies, which have a large-scale impact on society has always been a challenging task, because their use to a large extent depends on society's subjective perception rather than on objective facts (Currall, King, Lane, Madera, & Turner, 2006). So far it has not been examined how society perceives autonomous cars from a naïve perspective and thus, there is no empirical evidence about the psychological factors, which might explain adoption processes towards this large-scale technology. Therefore, this thesis aims to identify potential psychological causes of societal skepticism towards autonomous cars in order to theoretically understand, which factors might influence the acceptance of autonomous cars.

Interestingly, autonomous cars are a convergence of a relatively new technology (i.e., information technology) with existing relatively established technology (i.e., automobile). After two technologies merge, the perception of the new created technology can differ from the existing technology (Saad, 2006). Associations once formed with a technology (e.g., automobile) combined with another technology (e.g., information technology) might lead to new beliefs and hence new attitudes towards the new object (e.g., autonomous cars). For

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[1] This chapter is partly based on Hohenberger, Spörrle, & Welpe (2016), Hohenberger, Spörrle, & Welpe (2017a), and Hohenberger, Spörrle, & Welpe (2017b); see Appendix A for full references.

example, risks that were only associated with information technology (e.g., hostile remote control) might now be transferred onto cars and thus raise new beliefs about them (e.g., a car that can be remotely controlled by hostile entities). This is important because research from social science indicates that beliefs play a pivotal role in people's behavioral tendencies towards an object (Ajzen, 1991), which manifest in actual behavior (Bamberg, Ajzen, & Schmidt, 2003). Thus, people's beliefs about autonomous cars today might be responsible for people's usage behavior when the technology is on the market. Especially beliefs about the risks and benefits associated with the technology itself have been found to be decisive for people's tendency to use them (Carley, Krause, Lane, & Graham, 2013; Satterfield, Kandlikar, Beaudrie, Conti, & Harthorn, 2009). Hence, the first goal of this thesis is to empirically provide first subjective risk and benefit assessments associated with autonomous cars. This leads to the following research question:

*Research question 1: Which potential risks and benefits are associated with autonomous cars?*

After unveiling first assessments of autonomous cars the individual importance of those factors in adoption processes for certain subgroups of society needs to be adressed. Examining the relevance of those factors for demographic subgroups seems mandatory considering first evidence that men and women might differ in their willingness to use autonomous cars (Plötz, Schneider, Globisch, & Dütschke, 2014). This group difference might reduce the mass of potential early adopters, which is crucial for the success of new technologies (Bansal, Kockelman, & Singh, 2016; Plötz et al., 2014). So far no explanation of factors that might explain why men and women might differ in their willingness to use autonomous cars exists. Interestingly, research on other technology adoption processes suggests that affective reactions might be responsible for differences between men and women in their willingness to use technology. In general, compared to women, men

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experience more positive and less negative emotions towards information-based technology (Durndell & Haag, 2002; Levin & Gordon, 1989). Thereby, positive emotions were found to enhance and negative emotions to diminish the willingness to use technology (Czaja et al., 2006; Igbaria & Iivari, 1995). Moreover, the thesis considers chronological age as a variable that could shape the experience of emotions due to the fact that the difference in experiencing emotional intensity between sexes decreases as age increases (Thomsen, Mehlsen, Viidik, Sommerlund, & Zachariae, 2005). Thus, the second aim of the thesis is to examine the following research question:

*Research question 2: Can affective responses explain demographic differences in the willingness to use autonomous cars?*

As research on the general adoption of technology suggests, beliefs manifested in attitudes about a technology (i.e., cognitions) as well as emotions influence the adoption of them (Czaja et al., 2006; Mitzner et al., 2010). Thereby, positive attitudes, such as benefit assessments increase the tendency to adopt a technology (Currall et al., 2006), whereas negative emotions, such as anxiety, decrease it (Gelbrich & Sattler, 2014). Interestingly, psychological research posits that cognitions and emotions can operate simultaneously but with different importance (Epstein, 1994). As a final consequence, affective responses can influence existing cognitions about an object by overriding them and thus, emerge as the primary source of evaluation (Edwards, 1990; Slovic, Finucane, Peters, & MacGregor, 2004). This could mean that although people see benefits in technologies the positive effect of these cognitions on people's adoption intention could be negatively influenced (i.e., attenuated) by feelings of anxiety. However, so far, research has not considered the potential interplay between benefit assessments and anxiety on people's willingness to use autonomous cars.

Moreover, when considering the role of negative affect in technology adoption processes one variable has been neglected so far, which has been found to determine people's

coping strategy towards anxiety: self-enhancement motivation (Tsai, Chiang, & Lau, 2015). Research on motivation (Elliot & McGregor, 1999) and human values (Tsai & Lau, 2013) has indicated that people with a high (vs. low) self-enhancement motivation show different coping strategies with regard to negative affect. More precisely, people with a high need (vs. low need) to pursue their self-enhancement motivation are less reluctant to accept situations that indicate negative affect (Nicholls, 1984). Thus, the potential influence of anxiety-related affects on positive evaluations of autonomous cars might be contingent on people's individual levels of self-enhancement. This existing gap in literature is interesting because it could shed light on the question whether non-object related factors (i.e., individual values) influence the (affective and cognitive) assessment of an object and how this might determine the behavior towards the object, which leads to the following question:

*Research question 3: Are individual values responsible for how the interplay between cognition and emotion influences the willingness to use autonomous cars?*

Summarizing the aforementioned research questions, this thesis makes four contributions to existing technology adoption research and autonomous car adoption literature in particular. First, the thesis reveals risk and benefit facets that shape people's subjective perception of autonomous cars and thus, provides a base for factors that might explain society's behavior towards them. The thesis shows that performance-related (e.g., hardware) and psychological (e.g., independence) risks are prevalently associated with autonomous cars. In contrast, societal (e.g., less accidents) and personal (e.g., comfort) benefits are seen in autonomous cars and may outweigh these risks.

Second, the thesis adds new factors, which so far have not been considered in research on risk assessment of technologies (i.e., the absence of positive affect), which can guide society's adoption of them (cf. Siegrist, Keller, & Kiers, 2005; Sjöberg, 2000; Slovic, 1987). Existing research has mainly focused on the effect of positive or negative emotions on risk

perception (Slovic & Peters, 2006) but neglected to consider the absence of positive affect as a precursor for risk, too. The results in this thesis demonstrate that the automation of technologies, which were usually manually operated, shape people's belief with regard to their positive affective experience they had when using them. More concretely, the perception of a loss of positive affect (i.e., fun) is considered as a risk.

Third, the thesis extends current research on the influence of two central demographics on the adoption of autonomous cars (Payre, Cestac, & Delhomme, 2014) by showing that positive and negative affective reactions can explain biological sex differences towards the willingness to use autonomous cars. By simultaneously considering participants' age, the thesis, is able to explain under which conditions (i.e., different age classes) biological sexes differ in their willingness to use autonomous cars due to affective reactions. More precisely, the thesis shows that gender differences are especially pronounced for young men and women for negative affective reactions and decrease with increasing chronological age. In the technology adoption literature, this thesis is the first of its kind, which combines findings that (a) have shown that men are more prone towards technology (Bray, 2007; Meuter, Ostrom, Bitner, & Roundtree, 2003) as well as that (b) affective reactions are responsible for technology usage (C.-J. Lee, Scheufele, & Lewenstein, 2005; Steg, 2005), and (c) that the experience of emotions vary with age (Czaja et al., 2006) in one comprehensive model.

Fourth, this thesis contributes to the literature of autonomous car adoption by providing first empirical evidence for the influence of affective responses (i.e., anxiety) on the relationship between benefit assessment of autonomous cars and the willingness to use them. Even more interesting, the thesis demonstrates that the role of affective responses on the relationship between benefit assessments and the willingness to use autonomous cars is contingent on a non-object related, individual value: self-enhancement. These findings also contribute to the technology adoption literature in general by, for the first time, showing that

the effect of anxiety-related feelings is able to diminish the positive effect between benefit evaluations of a technology and the intention to use it. Moreover, the thesis clarifies the role of a person-related characteristic (i.e. self-enhancement) in how people process anxiety-related feelings towards a technology.

## 1.2 Theoretical background

### 1.2.1 Risk and benefit perceptions of autonomous cars

Autonomous cars constitute a new convergence between two already existing technologies: automobiles and information technology. However, as technologies from different fields converge, the perceptions of each technological concept can merge into the new technological system, which could lead to a new evaluation of the object (Saad, 2006). Understanding society's perception of a new technology is crucial due to the fact that their success mainly depends on perceptual factors (Currall et al., 2006). In particular, two cognitive factors have emerged to systematically influence the adoption of technologies: individual risk and benefit assessments (Satterfield et al., 2009). More concretely, the higher the perceived risk, the lesser the intention to adopt the technology (Featherman & Pavlou, 2003). In contrast, the higher the level of benefit perceptions the higher the willingness to adopt the technology (Cacciatore, Scheufele, & Corley, 2009).

When considering society's subjective risk and benefit perception towards autonomous cars, one age cohort seems particularly important: Generation-Y (Gen-Y). Due to their size (Loroz & Helgeson, 2013) and purchasing power (Noble, Haytko, & Phillips, 2009) they represent an influential consumer group. Furthermore, they show a change in the preference for means of transport by preferring public transport systems (Sivak & Schoettle, 2012) or car-sharing services (Nobis, 2006). Thus, considering the mass of potential

customers by the Gen-Y and their changing mobility behavior, it seems relevant to examine their risk and benefit perceptions towards autonomous cars.

By employing a qualitative approach, which is useful to understand how society perceives new phenomena (Flick, 2009), the thesis examines the risk and benefit perception of this group in Chapter 2.

### 1.2.2 Affective reactions as demographic differentiator for autonomous cars

The idea that the sexes differ in their interest towards technology is not new. Bray (2007) mentioned that "one fundamental way in which gender is expressed in any society is through technology" (p. 38). A Correspondingly, the meta-analysis by Su, Rounds, and Armstrong (2009) supports this notion by showing that men tend to prefer working with things (e.g., computer engineering), whereas women tend to prefer working with people. This tendency has also been confirmed in the adoption of new means of transportation including autonomous cars. Research from Payre, Cestac, and Delhomme (2014) has indicated that men and women differ in their willingness to use autonomous cars.

However, biological sex (even though a relevant segmentation variable) per se is a non-explaining variable, explanations for psychological factors, which underlie and explain this difference between the two dominant biological sexes are missing. This seems relevant, given the change in the mobility pattern between sexes (Kuhnimhof, Armoogum, et al., 2012; Kuhnimhof, Buehler, Wirtz, & Kalinowska, 2012). As the rate of car ownership is declining for men (Kuhnimhof, Armoogum, et al., 2012), the number of female car owners is continuously increasing (DIW, 2012). Hence, women constitute an increasingly important consumer segment, which already indicates to be less willing to use autonomous cars and thus can have a decisive impact on the subsequent pervasion of them in the market.

Interestingly, research on the adoption of technologies indicates that men and women also differ in their affective reactions towards technology (H.-J. Lee, Jeong Cho, Xu, & Fairhurst, 2010). Men tend to have more positive emotions (e.g., pleasure) in mind when interacting with, for instance, computers than women (Levin & Gordon, 1989). Conversely, women tend to associate more negative emotions (e.g., anxiety) towards them than men (Durndell & Haag, 2002). What makes both emotional reactions important is their individual importance in the technology adoption process. Higher levels of positive reactions towards a technology were found to increase people's tendency to adopt it (Igbaria & Iivari, 1995; Nysveen, Pedersen, & Thorbjørnsen, 2005), whereas the opposite is true for negative emotions (Czaja et al., 2006; H.-J. Lee et al., 2010). Thus, affective reactions might, for the first time, explain why men and women differ in their willingness to use autonomous cars.

While examining the potential explanatory role of affective reactions towards automated cars, another important demographic variable should be considered: the chronological age of the evaluating person. The reason for considering the age of the evaluators results from the focus on emotional responses as potential mediators. Current evidence suggests that the experience of emotions between sexes changes as age increases. More precisely, the experience of emotional intensity between sexes decreases as age increases (Thomsen et al., 2005). Thus, gender differences in the willingness to use autonomous cars through affective responses might be less pronounced as chronological age increases.

To sum up, previous research has found sex differences in the willingness to use various technologies, but has not provided any evidence on potential variables explaining these differences. This thesis argues that affective responses might be these explanatory variables (i.e., the mediators of this sex difference). Moreover, previous research has not yet looked at the role age might play in this context, which seems particularly important when

examining affective reactions towards stimuli. Therefore, this thesis examines the potentially moderating effects of age on the effects of biological sex on affective responses in Chapter 3.

### 1.2.3 Self-enhancement as motivator to adopt autonomous cars

As Chapter 3 focuses on the relevance of affective reactions for different demographic groups in their tendency to adopt autonomous cars, Chapter 4 aims to tie in this research by (a) introducing attitudinal variables, (b) examining the interplay between affective reactions and attitudinal variables, and (c) considering the individual importance of negative affect and attitudes for groups that can be characterized along psychometric variables, such as their value system.

Given the postulated existence of a negative effect of anxiety in the adoption process of autonomous cars, the role of non-affect-related factors, such as benefit perceptions, in this context are still unanswered. However, previous research on the adoption of new automotive technologies (e.g., electric mobility) suggests that higher levels of benefit perceptions entail a higher willingness to adopt the technology (Plötz et al., 2014). Given the assumed positive impact of autonomous cars on society in different domains, such as health (Waldrop, 2015), reduced travel times (Roncoli, Papageorgiou, & Papamichail, 2015), and costs (Burns, Jordan, & Scarborough, 2013), it can be assumed that people's subjective perception of those benefit factors influence the adoption of them. Therefore, Chapter 4 in this thesis examines the role of distinct benefit perceptions associated with autonomous cars on the willingness to use them.

Furthermore, Chapter 4 considers possible effects of negative affect, which go beyond their mere direct influence on the willingness to adopt a technology. Research on cognitions and emotions has shown that affective reactions are able to override cognitive evaluations towards an object (Edwards, 1990). Thereby, the valence of the affect (e.g., negative) aroused by an object can serve as an 'avoidance sign' for the recipient on how to behave towards the

object (Carver, 2004). Thus, due to their higher importance in the judgment process, emotions might undermine the relevance of positive evaluations in the adoption process.

Interestingly, the individual importance of the affect-cognition relationship in the adoption process and thus their strength can depend on a non-object, person-related characteristic, such as individual values (Tsai & Lau, 2013). Individual values, are 'guiding principles in the life of a person' (Schwartz et al., 2012, p. 664), which serve as standards for evaluation processes towards objects. In particular, self-enhancement is a value, which represents an individual motivation to pursue 'self-interests and relative success and dominance over others' (Schwartz, 2010, p. 226). It was shown that self-enhancement motivation can determine how people cope with negative affect and subsequently react in those situations (Nicholls, 1984; Tsai & Lau, 2013). For example, people with high levels (vs. low levels) of self-enhancement tend to recover faster from situations in which they have experienced negative affect (Tsai et al., 2015). Hence, despite the experience of negative feelings of anxiety, people with a relatively high (vs. low) need for self-enhancement might be less inhibited to approach a negatively emotionally charged situation, because they have learned to cope better with negative affect. The need to self-enhance is not limited to the coping strategies of people but also to their behavior. For example, people with a high (vs. low) need for self-enhancement seek relatively risky activities to demonstrate their abilities (Nicholls, 1984), which helps them to fulfill their goal. Interestingly, the usage of new technologies such as autonomous cars are perceived as risky (Bansal et al., 2016). Thus, it can be assumed that for people with a high need (vs. low need) of self-enhancement, feelings of anxiety aroused by autonomous cars might be perceived as less frightened and additionally serve as an approach indicator, which signals them an opportunity to fulfil their self-enhancement motivation.

In sum, this chapter of the thesis examines how benefit perceptions and feelings of anxiety towards autonomous cars influence the willingness to use them. Moreover, the thesis examines how feelings of anxiety influence the effect of benefit perceptions on the willingness to use autonomous cars. In addition, the thesis examines whether the interplay between anxiety and benefit perceptions on the willingness to use autonomous cars are contingent on individual levels of self-enhancement. This examination extends existing research on autonomous cars by, for the first time, simultaneously considering the individual importance of benefit perceptions and feelings of anxiety as well as their interplay in the technology adoption process. Moreover, the chapter sheds light on the question of the role of individual values in the adoption process of autonomous cars, which so far has not been answered.

## 1.3    Methodology

To answer the aforementioned research questions, this thesis draws on different methodological approaches. In Chapter 2, a qualitative approach was used to examine people's risk and benefit perceptions. In Chapter 3 and 4 a quantitative approach was employed to examine the effects of emotions on biological sex differences and the willingness to use automated cars as well as the effect of self-enhancement on the interplay between benefit perceptions and anxiety on people's willingness to use automated cars. The reason for the different methods used will be explained in the following.

### 1.3.1   Qualitative approach

Qualitative research is predominantly used to explore people's understanding of new phenomena in society when knowledge about it is rare (Flick, 2009). Thereby, 'the objective of qualitative research is to describe and possibly explain events and experiences, but never to predict' (Willig, 2001, p. 9). Thus, qualitative research can be used as an approach to reveal

thoughts and beliefs associated with a phenomenon in the first place, which then can be examined regarding their predictive validity in, for example, quantitative research. Since autonomous cars are a new phenomenon in society, which so far have not been qualitatively examined, this thesis aims to reveal first factors that might influence their acceptance. In this regard, the thesis follows a thematic approach (Braun & Clarke, 2006), which has been used in previous automotive research as a means to understand people's mobility behavior (Gwyther & Holland, 2014).

The thematic approach after Braun and Clarke (2006) is based on a multi-step procedure, where in a first step all answers were read. Afterwards answers were labeled and assigned to potential themes. Subsequently, all answers were read again and evaluated whether they fit with the themes previously identified. In a final step, the themes identified were reassessed to avoid similar themes. To ease the understanding behind the conceptual definition of each theme exemplarily statements are displayed.

In total, 40 participants (50% female) with an average age of $M = 23.58$ years were interviewed by a structured questionnaire in October 2013 in the main area around Munich. The questionnaire consisted of two sections. In the first section participants were asked to indicate demographic information about themselves. In the second section participants were asked about their perceptions in terms of risk and benefit associations towards autonomous cars. Answers were directly written into a blank field after the question. After participants indicated their answers they were debriefed. To ensure that all participants have the same concept of autonomous cars in mind they had to read a short definition, which briefly described the function of autonomous cars equivalent to level 4 automation after NHTSA (2015). More precisely, autonomous cars were described as cars that were able to 'perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a

design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip' (NHTSA, 2015).

### 1.3.2 Quantitative approach

Unlike qualitative research, quantitative approaches can be used to statistically verify hypotheses. While qualitative research aims to reveal thoughts and beliefs about a certain phenomenon (Willig, 2001) is unable to draw conclusions on how these findings might be interrelated. In turn, quantitative research closes this gap by allowing inferences between variables and hence their relationship to each other (Nimon & Oswald, 2013).

However, quantitative research faces the problem to ensure that the research concept that is examined is properly understood by the recipient (McGrath, 2005). One way to tackle this problem is the use of a vignette, which are 'a short, carefully constructed description of a person, object, or situation, representing a systematic combination of characteristics' (Atzmüller & Steiner, 2010, p. 128). Hence, vignettes can be used to describe hypothetical scenarios, such as the functions and capabilities of autonomous cars. In order to ensure that participants evaluate automated cars along the same definitions, the thesis translated technical definitions from the German (BASt, 2012) and American governmental institution (NHTSA, 2013) into layman's terms. Each condition later, served as a covariate in the regression models to ensure that the results found can be generalized across different levels of automation.

The general manifest multiple regression approach employed in Chapter 3 and Chapter 4, furthermore, allows inferences about the relative predictive importance of specific antecedents in the adoption process of autonomous cars by controlling the effects of other variables in the set (Agresti & Franklin, 2007). In Chapter 3, multiple mediation effects were tested by using the PROCESS macro developed by Hayes (2012). This macro creates mean-

centered variables and automatically calculates direct, indirect, and total effect sizes. In the case of multiple mediators, the macro includes both mediating variables in a parallel multiple mediator model, which allows to draw inferences about the specific indirect effect of each variable and hence their relative importance in the mediation. Moreover, assuming a moderation effect of age on the relationship between gender and the willingness to use autonomous cars through affective reactions the macro is able to consider whether indirect effects systematically differ as a function of a moderating variable (Hayes, 2013) (i.e., age). In this regard, as recommended by Aiken and West (1991), the PROCESS macro additionally examines the strength of the indirect effect for low levels (i.e., 1 SD below the mean), moderate levels (i.e., at the mean), and high levels of (i.e., 1 SD above the mean) the moderator. This sheds light on the question on how strongly the effect of sex on affective reactions is influenced by individual differences in age.

In Chapter 4, the thesis also follows a manifest regression-based approach. Due to the interest in examining the effect of the interplay between benefit perceptions and feelings of anxiety on the willingness to use autonomous cars in contingency of individual values, this thesis employs a moderated moderation analysis. Thereby, using the PROCESS macro developed by Hayes (2012) all necessary interaction terms are automatically generated by the macro and considered in the regression model. Additionally, the macro probes the slopes for the conditional effect of benefit perceptions and feelings of anxiety for low levels (i.e., 1 SD below the mean), moderate levels (i.e., at the mean), and high levels of (i.e., 1 SD above the mean) of self-enhancement. To ease the understanding of the moderated moderation (i.e., 3-way moderation) figures in Chapter 4 depict the effects visually.

## 1.4　Thesis structure, main results, and contribution

The aim of the thesis is to examine psychological factors that might influence the adoption of autonomous cars. To examine such psychological factors, the thesis is structured

in three chapters which highlight findings from qualitative and quantitative research. In Chapter 2, the goal was to reveal risk and benefit perceptions towards autonomous cars. In Chapter 3, the effects of the function between sex and age on the willingness to use autonomous cars through different affective reactions were examined. In Chapter 4, the role of individual values on the effect of the interplay between cognitions and emotions on the willingness to use autonomous cars was examined. Each specific research question, the main results as well as the contribution of each chapter are discussed in detail in the following.

The aim of Chapter 2 is to unveil thoughts and beliefs regarding risk and benefit perceptions of autonomous cars. As previous research on technologies has shown (Carley et al., 2013; Satterfield et al., 2009) higher risk perceptions can lead to lower intentions to use a technology, whereas higher benefit perceptions can lead to a higher intention to use it (Currall et al., 2006; Henson, Annou, Cranfield, & Ryks, 2008). In this regard, a qualitative survey ($N$ = 40; $M$ = 23.58 years, 50% female) was conducted in October 2013 in the area around Munich. The results show that participants are mainly concerned about performance-related (e.g., hardware) and psychological risks (e.g., less fun). When focusing on benefit perceptions participants believe that autonomous cars will be beneficial for society (e.g., less traffic congestion) and individuals (e.g., enhanced mobility) alike. The results contribute to the literature in several ways. First, they unveil a multidimensional risk and benefit structure of a new technology were knowledge about its perception is rare. Second, the thesis reveals that not only the presence of negative emotions (cf. Slovic & Peters, 2006) but also the absence of positive emotions (i.e., pleasure) can be associated with risk perceptions towards a technology.

In Chapter 3, the primary question is to explain gender differences in the willingness to use autonomous cars. As previous research has already indicated gender differences in the willingness to use them but not provided any explanation for this effect (Payre et al., 2014)

this thesis draws on research from the field of emotions, which has shown that men and women differ in their affective reactions towards technologies in general (Meuter et al., 2003). Due to the fact that the experience of emotions can vary as a function of age and gender (Stacey & Gatz, 1991), the chapter additionally considers potential age effects when examining gender differences towards autonomous cars through different affective reactions. By using a large German representative sample in terms of age, sex, and education ($N =$ 1,603) the chapter shows that men and women differ in their willingness to use autonomous cars. Moreover, the thesis is the first of its kind, which shows that affective reactions are able to explain this difference. More precisely, men tend to associate higher levels of pleasure and lower levels of anxiety towards autonomous cars, which lead to a higher intention to use them, whereas women show exactly the opposite pattern. Moreover, the thesis is able to show that the sex difference towards anxiety varies as a function of participants' age. In particular, the differential effect of sex on anxiety was more pronounced among relatively young respondents and decreased with participants' age. These findings contribute to the existing literature as follows. First, the chapter shows that sex differences in the willingness to use autonomous cars are contingent on positive and negative affective reactions towards them and thus act as parallel mediators. Second, the thesis extends current research on autonomous cars by showing that negative affective reactions (i.e., anxiety) towards autonomous cars are not equally relevant for all sexes at all levels of age.

In Chapter 4, the aim is to figure out whether individual values influence the interplay between benefit perceptions and anxiety-related affects in the adoption process towards autonomous cars. By drawing on cognition and emotion research (Edwards, 1990), the chapter postulates that anxiety-related feelings are able to influence the effect of benefit perceptions on the willingness to use autonomous cars. In the same vein, the chapter considers research from differential psychology (i.e., human values), which has shown that individual

values are responsible on how people cope with negative emotions, such as anxiety (Tsai & Lau, 2013) and thus might influence the benefit and anxiety interplay in the adoption process of autonomous cars. By using a German representative sample in terms of age, sex, and education ($N = 1,603$) the chapter shows that higher levels of benefit perceptions increase, whereas higher levels of anxiety decrease the willingness to use autonomous cars. Moreover, the chapter shows that anxiety also diminishes the positive effect of benefit perceptions on people's willingness to use autonomous cars. Additionally, the chapter is able to show that individual values influence the interplay of anxiety and benefit perceptions in the willingness to use autonomous cars. More concretely, the attenuating effect of anxiety on the positive effects of benefit perceptions on the willingness to use autonomous cars diminishes with increasing levels of self-enhancement. These results contribute to the existing research as follows. First, the chapter shows that benefit perceptions can increase the willingness to use autonomous cars. Second, the chapter shows that these effects can be influenced by negative feelings of anxiety. Third, the chapter integrates research from differential psychology emotion and cognition research in a technology adoption model, which for the first time shows that individual values (i.e., a non-object related factor) are responsible for how people react when negative feelings and benefit perceptions exist in technology adoption processes.

To sum up, in three chapters, the thesis empirically reveales psychological factors that might influence the adoption of autonomous cars. Starting by revealing risk and benefit perceptions of autonomous cars with qualitative interviews in Chapter 2, the thesis continues by using a quantiative approach in Chapter 3 and 4 to elucidate how factors from Chapter 2 as well as other factors derived from the literature influence the willingness to use autonomous cars. By doing so we examine cognitive as well as affective responses towards autonomous cars and address central demographic variables.

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# 2 Revealing autonomous car perceptions: Risk and benefit judgements of an early-stage information-based innovation through the eye of the Generation-Y

## Abstract

Research on information-based technologies posits that society's subjective risk and benefit perceptions largely influence the adoption towards them. Research on the diffusion of innovations claims that the mass of adopters is crucial for the adoption of new innovations. By focusing on a convergence of information-based and automotive technology: autonomous cars, we examined its risks and benefit perceptions among one sub-group of society, which can be considered as the majority of potential future adopters of this technology: Generation-Y. Employing an interview-based qualitative approach we identified a multidimensional risk and benefit structure associated with autonomous cars. We revealed that the Gen-Y is predominantly concerned about performance-related (e.g., hardware, software) and psychological (e.g., independence, affect) risks. Conversely, they believe that autonomous cars will entail societal (e.g., less accidents and traffic congestion) and personal (e.g., comfort, enhanced mobility) benefits. Thus, when targeting this group, both, performance-related and psychological risk dimensions (e.g., via advertising or design) should be managed to increase their mass of adopters. In the same vein, benefits for the user (e.g., ability to do other tasks while being driven) and the consequences of using the technology for society (e.g., less road accidents) should be emphasized.

Highlights

- Risk and benefit associations of autonomous cars are multidimensional
- The Gen-Y associates performance and psychological risks with autonomous cars
- The Gen-Y associates personal and societal benefits with autonomous cars
- Technical risks were seen as predominant risk facet
- Safety benefits were seen as predominant benefit facet

*Keywords*: Autonomous cars; Generation-Y; Risks; Benefits; Qualitative research, Innovation

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Brisbane, Australia.

# 3 How and why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups

**Abstract**

Current research on willingness to use automated cars indicates differences between men and women, with the latter group showing lower usage intentions. This study aims at providing a first explanation of this effect. Research from other fields suggests that affective reactions might be able to explain behavioral intentions and responses towards technology, and that these affects vary depending on age levels. By examining a sample of 1603 participants representative for Germany (in terms of biological sex, age, and education) we found evidence that affective responses towards automotive cars (i.e., anxiety and pleasure) explain (i.e., mediate) the effect of biological sex on willingness to use them. Moreover, we found that these emotional processes vary as a function of respondent age in such a way that the differential effect of sex on anxiety (but not on pleasure) was more pronounced among relatively young respondents and decreased with participants' age. Our results suggest that addressing anxiety-related responses towards automated cars (e.g., by providing safety-related information) and accentuating especially the pleasurable effects of automated cars (e.g., via advertising) reduce differences between men and women. Addressing the anxiety-related effects in order to reduce sex differences in usage intentions seems to be less relevant for older target groups, whereas promoting the pleasurable responses is equally important across age groups.

*Keywords*: Automated cars, Emotions, Age, Moderated mediation, Willingness to use, Gender

Highlights

- Men are more likely to associate positive emotions towards automated cars
- Women are more likely to associate negative emotions towards automated cars

- These findings partially explain sex differences in the willingness to use them
- These findings cannot be explained by age or education effects
- Age moderates the effect of biological sex on willingness to use through anxiety

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# 4 Not fearless, but self-enhanced: The effects of anxiety on the willingness to use autonomous cars depend on individual levels of self-enhancement

**Abstract**

The aim of our study is to examine how positive cognitive evaluations, anxiety-related affects, and the interplay between these two factors influence the willingness to use autonomous cars. We argue that the negative effect of anxiety as well as the interplay of positive evaluations and anxiety within the technology adoption process are contingent on a so far neglected facet of individual motivations, which plays a major role when dealing with anxiety towards unknown, yet status-laden, objects: self-enhancement. By employing a vignette-based online survey, we examined how people assess different levels of autonomous cars. Our results show that positive evaluations of benefits increase, whereas anxiety-related feelings decrease individual willingness to use autonomous cars; moreover, the positive effect of benefit evaluations diminished with increasing levels of anxiety. More importantly, self-enhancement emerged as a pivotal variable in this context: First, the negative effect of anxiety decreased with increasing levels of self-enhancement. Second, the attenuating effect of anxiety on the effects of positive evaluations was less pronounced with increasing levels of self-enhancement. Especially for people with low levels of self-enhancement motivation anxiety-related feelings (e.g., via strengthening self-efficacy beliefs) should be reduced. Moreover, self-enhancement values should be triggered when promoting autonomous cars.

Highlights:

- Benefit perceptions positively predict the willingness to use autonomous cars
- Anxiety perceptions negatively predict the willingness to use autonomous cars

- Anxiety attenuates the effect of benefit perceptions on the willingness to use

- Self-enhancement attenuates the negative effect of anxiety on willingness to use

- Self-enhancement moderates the interplay of anxiety and benefits on usage intentions

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# 5    Discussion[2]

## 5.1    Summary of findings

The overall objective  of this thesis was to examine psychological factors that shape the societal adoption towards autonomous cars. In Chapter 2, the focus was to investigate people's subjective risk and benefit perceptions of autonomous cars, followed by the examination of how the function of people's age and sex influence the adoption process of autonomous cars through affective reactions in Chapter 3. Finally, Chapter 4 analyzed how the interplay between affective reactions and benefit perceptions in contingency of self-enhancement influenced the adoption process of autonomous cars. The findings of all chapters are summarized in the following.

The aim of Chapter 2 was to unveil the risk and benefit structure of autonomous cars. Previous research on other technologies has shown that risk and benefit perceptions are predictors of people's intention to use a technology (Currall et al., 2006; Plötz et al., 2014). Considering the novelty of the phenomenon in society (i.e., autonomous cars) and the absence of a subjective risk and benefit assessment from a laypeople's point of view, the qualitative approach in this chapter allowed to provide first risk and benefit perceptions associated with the use of autonomous cars. Thereby, the chapter showed that predominantly performance-related (e.g., technical failure) and psychological (e.g., decrease of fun) risks shaped people's concern about autonomous cars. On the other side, social (e.g., less traffic accidents) and personal (e.g., more comfort) benefits highlighted people's interest in autonomous cars.

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[2] This chapter is partly based on Hohenberger, Spörrle, & Welpe (2016), Hohenberger, Spörrle, & Welpe (2017a), and Hohenberger, Spörrle, & Welpe (2017b); see Appendix A for full references.

Chapter 3 examined why and how men and women differ in their willingness to use autonomous cars. Thereby, the thesis proposed that emotional factors towards a technology explain why sexes differ in their willingness to use them. Moreover, to answer the question how they differ, the thesis considered participants' age as a moderating variable that influence the experience of emotional reactions towards autonomous cars. Thus, providing the answer to the question for whom (i.e., sexes) emotional reactions are especially (un)important. The thesis contributed to existing research on the adoption of autonomous cars, which so far has only provided evidence between the effect of sex on usage intentions (Bansal et al., 2016; Kyriakidis et al., 2015; Payre et al., 2014) but lacked in research, which is able to provide variables that explain this effect. The results obtained in Chapter 3 showed that affective reactions are able to explain sex differences towards autonomous cars. More precisely, men were found to associate more pleasure and less anxiety towards autonomous cars, which increased the willingness to use them, whereas the opposite effect was found for women. Thus, the thesis was able to explain for whom the effect of affect in the willingness to use autonomous cars was especially (un)important. Concretely, the effect of sex on the willingness to use autonomous cars through anxiety was especially pronounced between young men and women but decreased as participants' age increases.

Chapter 4 analyzed the effect of affective reactions and attitudes towards the willingness to adopt autonomous cars. Tie in with previous research, which has shown that affective reactions and cognitive evaluations of an object can interact with each other when predicting behavioral intentions (Clore & Huntsinger, 2009; Frijda, Kuipers, & Ter Schure, 1989; Welpe, Spörrle, Grichnik, Michl, & Audretsch, 2012), the thesis examined whether the effect of benefit perceptions on the willingness to use autonomous cars was influenced by feelings of anxiety. Moreover, Chapter 4 considered a non-object specific, person-related motivator: the need to self-enhance. As previous research has demonstrated, coping strategies

with anxiety-related feelings can vary depending on people's individual value system (Tsai & Lau, 2013). The results in Chapter 4 showed that higher level of economic, time, and safety benefit perceptions lead to a higher willingness to use autonomous cars, whereas higher levels of anxiety lead to a reverse effect. Additionally, Chapter 4 showed that with increasing levels of anxiety the positive effect of all benefit perceptions on the willingness to use autonomous cars was diminished. The chapter also showed that the negative effect of anxiety on the positive relationship between benefit perceptions and the willingness to use autonomous cars depended on individual levels of self-enhancement. More precisely, the attenuating effect of anxiety was reduced for people with low and medium levels of self-enhancement and ultimately disappeared for people with high levels of self-enhancement.

## 5.2 Implications for theory

In three chapters, this thesis empirically examined psychological factors, which influence the adoption of autonomous cars. Each chapter makes its own contribution to the existing literature in the respective field.

In Chapter 2, the main goal was to reveal risk and benefit perceptions associated with the usage of autonomous cars. Since no research so far has unveiled the risk and benefit structure regarding autonomous cars, Chapter 2 adds to the research on autonomous car adoption by providing first dimensions. Beyond the revelation of these dimensions, the chapter provides novel risk dimensions, which so far have not been examined in risk perception research: the belief in an absence of positive affect. Existing research has posit that only the presence of negative affect is responsible for risk perceptions (Slovic et al., 2004; Slovic & Peters, 2006) but not considered that the absence of positive affect could lead to the same effect. Additionally, the findings from Chapter 2 suggest that existing measures to map risk perceptions in society, such as the psychometric paradigm (Siegrist et al., 2005; Sjöberg, 2000), should include affective components to increase its explanatory power. In sum,

Chapter 2 contributes to the theoretical literature on autonomous cars as well as risk perception in general.

In Chapter 3, the aim was to examine whether affective reactions towards autonomous cars can explain gender differences towards autonomous cars and whether these reactions vary as a function of participants' age and sex. Chapter 3, adds to existing literature of technology adoption by demonstrating that the chronological age of a person can influence the effect of sex and emotional appraisal towards a technology. Existing research on technology adoption has predominantly focused on main effects of affective reactions on technology adoption (Venkatesh, 2000; Venkatesh & Bala, 2008) or mere moderation effects of age or gender on the effect of affect on usage intentions (Venkatesh, Thong, & Xu, 2012). However, research has not looked on the function of age and sex on the effect of affective reactions and technology adoption. Furthermore, the research in Chapter 3 is the first, which has introduced parallel mediators as explanatory variables for gender differences in the willingness to use autonomous cars. These findings extend existing literature on autonomous car adoption, which has found gender differences in the willingness to use them (Bansal et al., 2016; Payre et al., 2014), but not provided any variables that might explain this effect. This chapter additionally extends research on the perception of emotions in the technology adoption process for sexes across different age levels. In sum, the chapter contributed in several ways to the theoretical understanding why and how sexes differ in the willingness to use autonomous cars.

In Chapter 4, the thesis examined the influence of benefit and anxiety perceptions, as well as their interplay on the willingness to use autonomous cars in dependence of different levels of individuals' self-enhancement values. The findings in this chapter contribute to the literature in the following. First, the chapter adds new insight to technology adoption literature by demonstrating that benefit and affective reactions can interact with each other when

predicting adoption intentions. Most researchers so far have only considered a main effect of benefit perceptions or affective reactions (Venkatesh, 2000; Venkatesh, Morris, Davis, & Davis, 2003) but neglected to consider a potential interplay between them. Although anxiety has appeared as a potential mediator for attitudinal variables (Behrenbruch, Söllner, Leimeister, & Schmidt, 2013) this thesis is the first, which shows that anxiety systematically influence the effect of benefit perceptions on the willingness to use a technology. The chapter furthermore proves that individual values can influence how people cope with negative reactions associated with autonomous cars, which in turn can influence the interplay between benefit perceptions and anxiety on the willingness to use them. This extends existing research on technology adoption, which so far has only focused on the direct influence of human values on adoption intentions (Bagchi, Udo, Kirs, & Choden, 2015) by demonstrating its role as a filter for people's perception towards anxiety-related feelings. In sum, Chapter 4 enhanced the theoretical understanding of psychological factors that influence the technology adoption process of autonomous cars by combining insights from emotion, cognition, and differential psychology.

## 5.3    Implications for practice

Besides the theoretical influence of this thesis on the technology adoption literature, each of the three chapters additionally offers implications for practice. In Chapter 2, the thesis revealed different risk and benefit perceptions of autonomous cars. Given the exploratory nature of a qualitative analysis, the recommendations in the following paragraph are given without any priority regarding their importance. First, policy campaigns could highlight the societal benefits of autonomous cars on society. The results found suggest that especially information about the prevention of traffic accidents or the possibility for elderly or handicapped people to be longer mobile might facilitate the adoption of autonomous cars. Furthermore, automakers could show human weaknesses when they are driving (e.g., lack of

concentration, drowsiness) and simultaneously highlight the strengths of autonomous cars

respectively (e.g., faster reaction times). Other implications could be to highlight the comfort

of autonomous cars in monotonous task situation (e.g., braking, accelerating). On the other

side, to foster the reduction of risk perceptions media campaigns could show that technology,

which is already implemented in cars (e.g., Adaptive Cruise Control) is reliable. Another

approach, especially for automakers could be to integrate the technology in car-sharing fleets,

because people who have experienced a technology show lower risk perceptions towards it

(Pavlou, 2003). Policy makers should additionally ensure that questions of liability are

communicated in a clear manner and are clarified in advance.

In Chapter 3, the thesis analyzed psychological factors that are responsible to explain

why men and women differ in their willingness to use autonomous cars. The findings deliver

implications for practice as follows. Due to the fact that men perceive generally more positive

and less negative emotions towards autonomous cars, positive emotions should especially

fostered for this group. A strategy could be to induce motives in advertisements, such as

status, due to the fact that status motives are positively related to driving and more important

for men than women (Steg, 2005). In the same vein, the emergence of negative feelings

should be avoided for this group. In contrast, for women, especially negative feelings have to

be reduced and positive emotions be evoked. One way to reduce negative feelings of anxiety

in women could be to offer end-user trainings. Previous research on technologies has shown

that end-user trainings help to strengthen self-efficacy beliefs, which in turn can reduce

feelings of anxiety towards the technology (Bandura, 1988; Venkatesh, 2000). Given the

pronounced sex difference between young men and women with regard to anxiety

perceptions, programs such as end-user trainings should especially target young women.

Additionally, for women in general, the advantage about the safety of autonomous cars (e.g.,

protection of strangers) in comparison to other means of transport (e.g., bus) could evoke positive emotions (Gardner & Abraham, 2007).

The practical implications derived from Chapter 4 are based on the findings that benefits, anxiety-related feelings, their interplay, and the dependence of this interplay are contingent of individual levels of self-enhancement. First, the findings suggest that highlighting the benefits of autonomous cars in terms of money, safety, and time savings facilitates adoption intentions towards them. Second, negative feelings of anxiety should be diminished. More concretely, negative feelings when directly interacting with the car let to lower usage intentions. Thus, the simplicity of using an autonomous cars should be highlighted. Furthermore, to attract early adopters of the technology focus should be given to people with a high need to self-enhance. Due to the still existent effect of anxiety on the willingness to use autonomous cars for people with low and medium levels of self-enhancement, advertising measures should try induce self-enhancement motivations by means of autonomous cars for them.

## 5.4    Directions for further research

Setting the basis for identifying psychological factors that might influence the adoption of autonomous cars in society, the thesis still provides room for further research. First, the factors identified in Chapter 2 are based on qualitative research. Hence, their individual predictive validity in the adoption process of autonomous cars remains unclear. Further research could validate the factors in a quantitative, standardized research. Additionally, the sample in Chapter 2 is predominantly characterized by a young age and people who live in an urban area. Thus, their expectations might differ from people who live in a rural area due to the fact that certain phenomena are more likely to happen in urban areas (e.g., traffic congestion) (Kok, Hans, & Schutten, 2012) and people in rural areas can differ in their risk perceptions towards technology (Senocak, 2014). Moreover, it remains unclear

whether other age cohorts (e.g., Generation-X) share the same risk and benefit perceptions as this age group.

Second, although the research in Chapter 3 is able to find factors that reduce sex differences in the willingness to use autonomous cars, the factors identified are not able to fully explain this difference. Thus, other discrete emotions, besides pleasure and anxiety, such as disgust (Russell & Giner-Sorolla, 2013) could also play a role due to the fact that men and women differ in their sensitivity (Olatunji et al., 2007) and so far have not been examined in research on the adoption of autonomous cars. Moreover, the research sample consists only of people of Western Europe. However, people in Western Europe (vs. United States) tend to differ with regard to their individual importance towards certain values, such as autonomy (Shalom H. Schwartz, 2006) that are tackled by autonomous cars (e.g., give away control). Thus, their emotional response towards autonomous cars might differ and hence the overall effect of affect-based feelings.

Third, even though Chapter 4 is able to provide first benefit facets that might be responsible towards the adoption of autonomous cars their number is not limited to those identified. Thus, future research could examine the predicate validity of further benefit facets on the willingness to use autonomous cars and test whether a detrimental effect of anxiety on this effect still exists. Further research could also test whether the buffering effect of self-enhancement motivation on the interplay of benefit facets and anxiety on the willingness to use autonomous cars varies between cultures. Research on emotions has shown that Western (vs. Asian) people differ in their coping strategy towards negative affect (Hedjasie & Spörrle, 2013; Tsai et al., 2015). Particularly, individuals' strategy to use means of self-enhancement to cope with negative effect (e.g., demonstrating competence or gaining power) was found to be more prevalent in Western societies (vs. Asia) (Tsai et al., 2015; Tsai & Lau, 2013). Moreover, the effects observed could be mainly based on the characteristics of the technology

(i.e., autonomous cars) itself. People who have a high need to self-enhance are attracted by relatively risky situations (Nicholls, 1984), which provide the opportunity to show one's skills in front of others and or are related to status (Shalom H. Schwartz, 2010; Shalom H Schwartz et al., 2012). Because autonomous cars are new and hence their usage is something that at the beginning requires certain skills or courage as well as the relatively higher costs compared to traditional vehicles, their attraction for self-enhancer might decline as soon as their usage becomes ordinary. As a consequence research should conduct further studies once autonomous cars are in the market for a longer time. It is possible that other motivations then are responsible for the adoption process towards them. Lastly, all of the research conducted is based on cross-sectional data. Thus, research in the future should also focus on experiments that, for example, show scenarios where benefit descriptions about autonomous cars differ from each other to figure out, whether causal effects exist.

## 5.5    Conclusion

In three chapters, the thesis empirically provides evidence of psychological factors that influence the adoption of autonomous cars. To do so, the thesis integrates research from emotion, cognition, and differential psychology research to broaden the understanding of their role in technology adoption (i.e., autonomous cars). Additionally, the thesis offers new directions for further research in the adoption of autonomous cars in particular and technologies in general.

As with every new technology, one must calculate the risks and benefits for society that come along with its implementation. For technologies that take over human capabilities, which directly influence other people (e.g., accelerating, braking) and operate in public space, new ethical questions arise. For example, considering the capability of autarkic operating systems, such as autonomous cars, which have self-learning abilities and eventually are adaptive in their decision-making process one might ask: who will ultimately be responsible

in case of an accident? This question is not limited to autonomous cars but may be true of a lot of other technologies, which predominantly rely on artificial intelligence.

Besides the questions that come along with the implementation of technologies in society, questions on whether people should be 'guided' to adapt them in general are equally important. The paternalistic assumption that people sometimes need a nudge to know what is best for them suggests that there is an optimal solution. However, this might not always be true. For example, despite the obvious positive impact of autonomous cars on people's health by reducing the number of fatalities in traffic, society might encounter new problems such as unemployment. Hence, what is good for one party might be detrimental for another. Consequently, one must decide whether societal benefits of a technology (e.g., fewer accidents) outweigh societal risks (e.g., loss of jobs), which makes it worth to influence people to adapt it. Moreover, the automation of technologies, which replace humans as main operators by putting them into a mere observer role when using it, relieve them from their individual responsibilities, which leads to a responsibility shift towards others. This in turn, makes them dependent on those who control the technology (e.g., companies). By guiding or even obliging people to use those technologies (e.g., autonomous cars) one must keep in mind that they also steer them in the arms of companies who might have their own moral opinion of what is best for the user.

Thus, depending on the development of the impact of autonomous cars, one must decide on one's own whether he wants to use the insights from this thesis to influence people's behavior for or against autonomous cars.

## 5.6    References

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