Morality in the preference for Advanced Driver Assistance Systems

Identifying the importance of safety for other road users in consumers preference for extra car features

N. Pieters

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Identifying the importance of safety for other road users, in consumers preference for extra car features

by

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TU Delft

Preface

With this thesis I obtained my Master's degree in Tansport, Infrastructure and Logistics, at Delft University of Technology. My first idea was to do a thesis about morality of self-driving vehicles. However, Matthijs Dicke-Ogenia motivated me to shift the topic to the role of morality in the preference for Advanced Driving Assistance Systems, as these systems already are broadly available currently. I did not have to think long about this, as my interest in ADAS was touched upon before, during a course of Riender Happee. An assignment of this course was to keep in mind a car accident, and ask oneself if this accident could have been prevented, if the car(s) involved had specific types of ADAS included. I kept in mind an accident involving my friend Eline. She got hit by a taxi, and passed away later on in the hospital, being only 12 years old. Thinking about this accident, indeed it could have been prevented or at least she might have survived it, if the car had automated emergency braking or intelligent speed limiting incorporated (as the taxi was driving way too fast). However the technology might not yet fully be developed, this type of accidents could be prevented and that made it a very interesting subject for me.

First of all, I would like to express my gratitude to the committee. Matthijs Dicke-Ogenia, for your thoughts on morality, for having me speak with interesting people from Goudappel, for letting me attend and speak at two congresses, and always being supportive. Furthermore, I would like to thank Eric Molin, for always having a quick and detailed response on my questions. Haneen Farah, for your detailed comments on my work. And, Caspar Chorus, for motivating me for choice modelling during SPM1221, always being enthusiastic about the subject, and interested in the graduation process in general.

Outside the committee, there have been close friends that shared their thoughts, and have contributed to a pleasant graduation time as well. I would like to thank Xander, for reading my thesis and providing me with improvements (and putting up with me being annoyed by his advice). My housemates Belle and Leonore, for studying together and giving me rides to the TU Delft. My other two housemates Alexandra and Sophia, for always having to put up with our graduation talk and not being at home for dinner. Stephanie, my twin in graduating, having started and ended at the same day. Last but not least, I would like to thank my parents, for sponsoring me during the whole process, and organizing a nice graduation party which i look forward to.

N. Pieters
Delft, April 2019

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Introduction

1.1. The need for safer cars with ADAS

Cars enable people to travel further and faster. Sometimes, travelling at a higher speed than our brains can manage, we crash harder than our bodies can manage. Smiley and Brookhuis (1987) estimated 90% of car crashes are linked to human error, due to lack of alertness, fatigue or drowsiness. Road accidents resulted in 613 deaths, and 21.400 badly injured in 2017 in the Netherlands (Centraal Bureau Statistiek, 2018). In theory a percentage of these deaths and injuries could be prevented, if cars incorporated safety systems able to detect and override or warn for human error. These systems are also known as ADAS (Advanced Driver Assistance Systems); a wide range of ADAS are developed that automate, adapt and enhance vehicle systems for avoiding collisions and/or comfortable driving.

The costs of accidents are high to society (financially and healthwise). Therefore, road safety is gaining more attention by European policy makers (European Commission, 2018b). ADAS are seen as promising in lowering accidents and therefore costs for society. Especially, front crash prevention systems like Automated Emergency Braking (AEB) show promising results (Cicchino, 2017; Fildes et al., 2015). However, a study of Harms and Dekker (2018) showed only 5% of the entire fleet and 20% of the business fleet of newly bought cars between 2012-2016 in the Netherlands contained AEB. The respondents that did have ADAS in their car gave different reasons for including it: of the business drivers only 12% stated road safety was the most important, while for 37% this was comfort, and 42% stated it was part of the package deal and not being an informed choice. Currently, people are free to decide if they include ADAS in their car. Except for electronic stability control and anti-lock braking, ADAS are not (yet) mandatory for newly produced cars. The European Commission (2018a) has put a list online with features, including several ADAS, she thinks car makers also should include mandatory in all new car- and truck models from 2021-onwards. However, this proposition is not yet adopted; all countries can give their own interpretation to these propositions (C. Hottentot, personal communication, September 20, 2018).

Dutch Minister of Infrastructure and Waterways van Nieuwenhuizen Wijbenga (2018) indicated she will stimulate the use of driving support systems that already exist and have proven to be effective, in a policy letter about Smart Mobility: *"I want to make agreements about faster and safer introduction and use with (private) lease- and rental companies and employers associations. This includes driving assistance systems in the vehicle (such as intelligent speed adjustment) with proven contribution to road safety ... "*. Exactly how she will do this was not specified. As it might take a while before ADAS will become compulsory in the Netherlands, it is still of interest to research how people can be motivated to choose for ADAS on the short term. Mobility consultancy Goudappel Coffeng commissioned this research, as they want to give recommendations to the Dutch government on how to reach this goal.

1.2. Using morality to have more cars containing ADAS

In the current situation there is no policy intervention; ADAS is chosen out of own interest or safety consideration. The government can intervene by making ADAS more attractive and consequently influence what choices people make. For example, the Centraal Planbureau (CPB) proposes to make safe cars fiscally more attractive, or to inform consumers more about the importance of car safety (van Maarseveen et al., 2018). Another option would be to create dedicated lanes for ADAS users. This research focuses on intervention by informing consumers about the importance of safety, as van Maarseveen et al. (2018) identify it as the fastest and easiest to implement policy. Perhaps the before-mentioned incentives, or making ADAS mandatory, will be the future.

Goudappel Coffeng hypothesizes that increasing awareness of the moral dimension of car choice can be used to a certain level to make more people include ADAS in their car. Implicitly, a trade-off is made between incorporating ADAS, and the possibility to include other features when buying or leasing a car. This trade-off may result in people choosing a cheap car rather than a safe car, or spending money on extra nice looks of their car rather than on extra safety features. As a drivers choice for safety features for his car can impact safety of himself as well of other road users, this choice has a "moral dimension". It is not seen as moral in the western culture if people care about their personal and passengers safety, but not about the safety of other road users. Therefore, a distinction is made between the contribution of ADAS to safety of the driver and passengers (internal safety), and to safety for other road users (external safety).

Information provision, or "boosting", is intended to change behaviour by "changing minds". If information is provided, people will weigh up the revised costs and benefits of their actions and respond accordingly. Unfortunately, evidence suggests that people do not always respond in this "perfectly rational way" (Dolan et al., 2010). Sometimes policies successfully make people behave as the desired behaviour, but other times those policies have unintended consequences. For example, information about how many people do not have ADAS may actually encourage more people to join a "club" of which there are many members, and introducing financial incentives to behave a certain way could actually make people less likely to behave that way for free (Gneezy and Rustichini, 2000).

Goudappel Coffeng is interested in the role of morality in peoples decision to include ADAS, and how morality can be used to let people purchase ADAS instead of other features like nice leather seating (Matthijs Dicke-Ogenia, personal communication, October 4, 2018). As people not always behave perfectly rational, and policies may not always lead to the desired result, these policy measures should be researched first before implemented on a large scale (Hallsworth et al., 2010).

1.3. Research approach

This research is rather descriptive than normative. The goal is not to give an answer to the question how people *should* make the trade-off between safety and other attributes, but rather to give insight in how people currently do make this trade-off, and what the role of morality in this trade-off is.

In a stated preference experiment, respondents choose between different packages they can add in a lease car. These packages will have different costs, levels of comfort and levels of safety inherent to the type of ADAS and other features included. Two experimental groups will be constructed; one group receives a text that anticipates on morality before starting the choice tasks; the control group doesn't get this. Based on the observed choices, decision strategies of the two groups will be econometrically identified with discrete choice modelling (Chorus, 2015). The discrete choice theory assumes that consumers base their choices on the utility they derive from the attributes of each option, and a random utility component. The respondents choices are observed by conducting a survey, and from these choices preferences and trade-offs between the multiple attributes of car choice are inferred.

This study will take into account only systems at SAE level 0 or 1. In SAE level 0, the driver still keeps total control of the longitudinal (steering) and lateral (distance keeping) driving task; ADAS only warns or intervenes in specific situations. In SAE level 1, the system takes over control of the longitudinal or lateral task. Specific ADAS system(s) are chosen to conduct the research for, based on their potential in improving traffic safety and comfort.

1.4. Previous research in vehicle (option) choice

Lave and Train (1979) were the first to model vehicle choice by use of the, still widely used, multinomial logit (MNL) discrete choice model. Discrete choice models applied to vehicle choice have increased in number and complexity over the past 35 years (Greene et al., 2018). Current vehicle preference research focuses mainly into fuel type preference (e.g. Morton et al. (2016); Shin et al. (2015); Chorus et al. (2013)), and automated vehicle preference (e.g. Haboucha et al. (2017); Gkartzonikas and Gkritza (2019)). After conducting a metastudy in vehicle preference research from 2012 onwards, Greene et al. (2018) concluded that the attributes often included in vehicle choice models do not always reflect customers priorities. Vehicle price, vehicle class, fuel cost and performance are the most frequently included attributes. Safety, reliability and comfort rarely appear in literature, despite their importance to consumer decision making (Vrkljan and Anaby, 2011; Hafner et al., 2017). Greene et al. (2018) wrote in many cases this is due limited data on these characteristics and few available proxies. Next to that, these subjective attributes are difficult to operationalize into clear and meaningful attributes (Marchau et al., 2001).

Molin and Marchau (2004) did ask respondents to make their safety and comfort perceptions of ADAS packages explicit in rating tasks, and estimated how these ratings and the price of the package, in turn, affect attractiveness. However, they did not make a distinction between personal and external safety, that is needed to research the role of morality. Also, the utilities of the ADAS are not derived from respondents choices, but from rating the packages on an "attractiveness rating scale". This is rather artificial, as in real life situations the task would be to make a choice between packages (Louviere et al., 2010).

Discrete choice modelling literature on consumer preference for emerging vehicle technologies is limited (Shin et al., 2015). Shin et al. (2015) researched consumer preference for smart technology options using stated preference data in South Korea. The following options could be provided- or not provided in each package; connectivity, voice command, autonomous driving, wireless internet and a smart application (providing real-time information about parking, traffic conditions and incidents). The autonomous driving option contained two ADAS levels; a lane keeping- and speed control level. Each package with options had a certain price. Next to choosing between the packages, the respondents had to rate the "usefulness" of each separate option. Shin et al. (2015) found that price is the most important aspect driving vehicle option choice. Also, they found a negative parameter for lane-keeping technology, suggesting that consumers are reluctant to adopt lane keeping technology due to safety concerns or because they did not consider such capabilities useful or valuable at this time.

1.5. Research objectives and questions

This research aims to examine the incorporation of morality in discrete choice modelling, applied to the specific case of the choice for extra car features. A growing group of scholars is underpinning the need to do experimental data-driven research into moral judgement and moral decision making (e.g. Bauman et al., 2014; Kahane, 2013). Furtermore, Chorus (2015) wrote very few discrete choice modelling studies exist that acknowledge and incorporate the moral dimension of choice behavior.

The research objective is to increase understanding about how people take into account morality when they choose car features, and how informing people about the morality of their choices would affect preferences, and thus choices. This is done by (1) measuring how much utility is derived from an increase in perceived internal safety, as well in perceived external safety, due including ADAS in a car. The author did not find other ADAS preference research in which such a distinction between internal- and external safety improvements has been made. (2) Exploring what the role of innate morality is in this preference. And (3), exploring if a booster, on moral choice behaviour, affects this preference. This leads to the following main- and sub-research questions;

What is the role of morality in consumers preference for Advanced Driver Assistance Systems?

1. How do people perceive that Lane Departure Warning, Emergency Braking for Pedestrians/bicycles, Emergency Braking for Cars, Intelligent Speed Limiting and Adaptive Cruise Control influence internal safety, external safety and driving comfort?

2. How do perceived improvement in internal safety, -external safety and -driving comfort due the included Advanced Driver Assistance Systems weight in consumer preference for a car features package?

3. Is the effect of the included Advanced driver Assistance Systems on preference for a car features package partly or fully mediated by the perceived improvement in internal safety, -external safety and -driving comfort?

4. How does innate morality impact consumer preference for a car features package?

5. How does including a booster, that creates awareness about the responsibility for a car accident with a weaker road user, impact preference for a car features package?

1.6. Thesis roadmap

In Figure 1.1 the roadmap for this thesis is given. In the blocks, the steps that are taken are shown, with the numbers representing the associated chapters. A feedback loop is drawn towards the literature research, as the conclusions should give an addition to the literature.

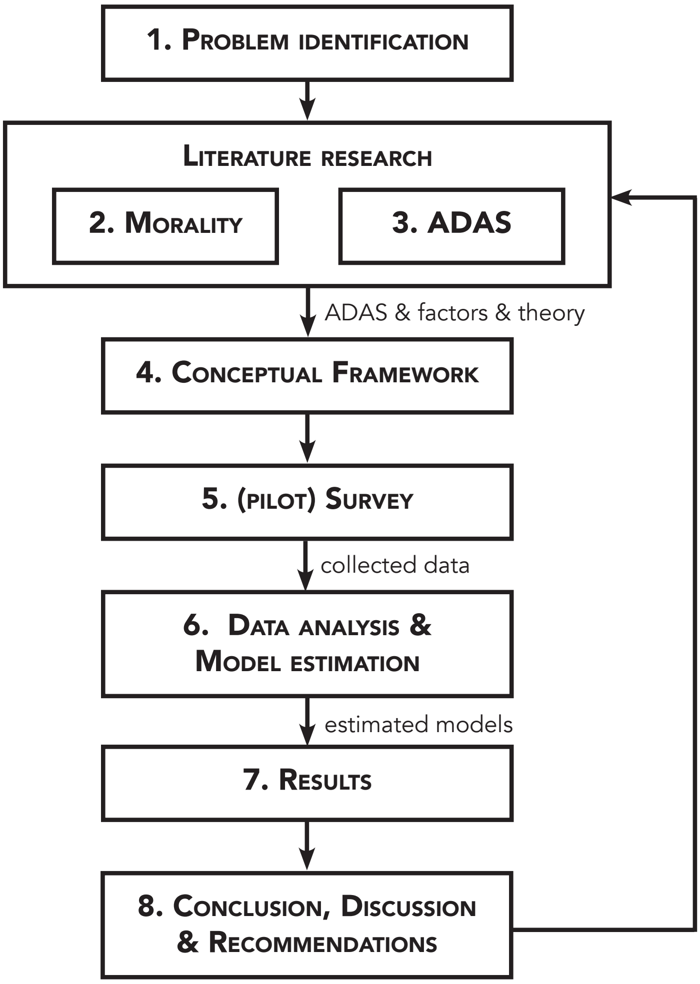


Figure 1.1: Thesis roadmap

The problem has been identified in this introduction. In chapter 2, the theoretical framework for including morality in decision making is elaborated upon. In chapter 3, literature research about factors that people take into account when choosing car features and ADAS is carried out. Based on the literature and the used methodology, a conceptual framework is constructed in chapter 4. In chapter 5, two pilot surveys are created. After evaluation of the results of the second pilot study, a final survey is developed. The data, resulting from this final survey, is analyzed in chapter 6 with ordinal regression and discrete choice modelling. In chapter 7, the results of these models are presented. In chapter 8, the main research question is answered, the experiment and conclusions are discussed, and recommendations for further research are given.

2
Morality

2.1. Moral choices

Many of the choices we make has a moral dimension. This moral dimension can be defined as the decision maker feels the choice alternatives can to some extent be categorized as "right" or "wrong" (Chorus, 2015). This moral dimension of a decision can be obvious. For example, when choosing (not) to cheat on a partner, choosing (not) to perform abortion, or choosing (not) to declare all your incomes to the government to evade paying taxes. The western view of morality is often that it is about these obvious moral dilemmas of harm and fairness; treating others right.

However, morality is a broad concept that can be more implicit (latent) as well. Ethics professor Santoni De Sio (personal communication, October 22, 2018) stated that *"each time you make a choice that is affecting other agents/stakeholders, including non-human stakeholders (the environment), this is implicitly a moral choice"*. Policy- as well consumer choices can indirectly affect safety, sustainability, justice and distribution of costs and benefits (leading to investments in certain directions). The choice (not) to include ADAS is a moral choice as well. Consumer choices have emerged as a form of political participation, through which consumers can exercise their moral and ideological beliefs about these issues (Watkins et al., 2016). The question is, if currently this moral dimension plays a role in the choice for ADAS. And, if not, how people can be initiated to think about this when purchasing or choosing a vehicle for lease.

2.2. A model of moral choice behaviour

Figure 2.1 shows the conceptual model of an individual's moral choice behavior (Chorus, 2015). It is hypothesized that moral choice behavior is the result of an interplay between the various boxes. This conceptual model can be used to create an understanding of the moral dimension of safe mobility and the choice for ADAS. The modelling effort to make one overarching model that can measure all the relationships at once would be too time consuming for this research, as some boxes are not objectively measurable or are not based on individual-based data collection. Therefore, these boxes are out of scope, however being of interest for further research. This research aims to measure the influence of the task environment (by changing the choice context), individual's personality (by measuring respondent's innate morality) and moral norms on choice behaviour.

2.2.1. Task environment

Ben-Akiva et al. (1985) described the theory of choice as a collection of procedures that define the following elements: (i) decision maker, (ii) alternatives, (iii) attributes of alternatives, and (iv) decision rule. However, it is not just information content that is influential; people may be also affected by the manner in which information on the alternatives and their attributes is presented: the choice context (Avineri, 2012). For example, by the number of alternatives, the inclusion of inferior choices in the choice set, the wording (or "framing") of the information, the order in which information is presented, and the choice of measurement unit. Goulias and Pendyala (2014) wrote that *"context is the physical, socio-emotional and mental setting in which behavior takes place"* (p. 101). In discrete choice experiments, it is the description of the choice situation; what respondents need to assume while making the choice (Molin, SEN1221 Lecture 5).

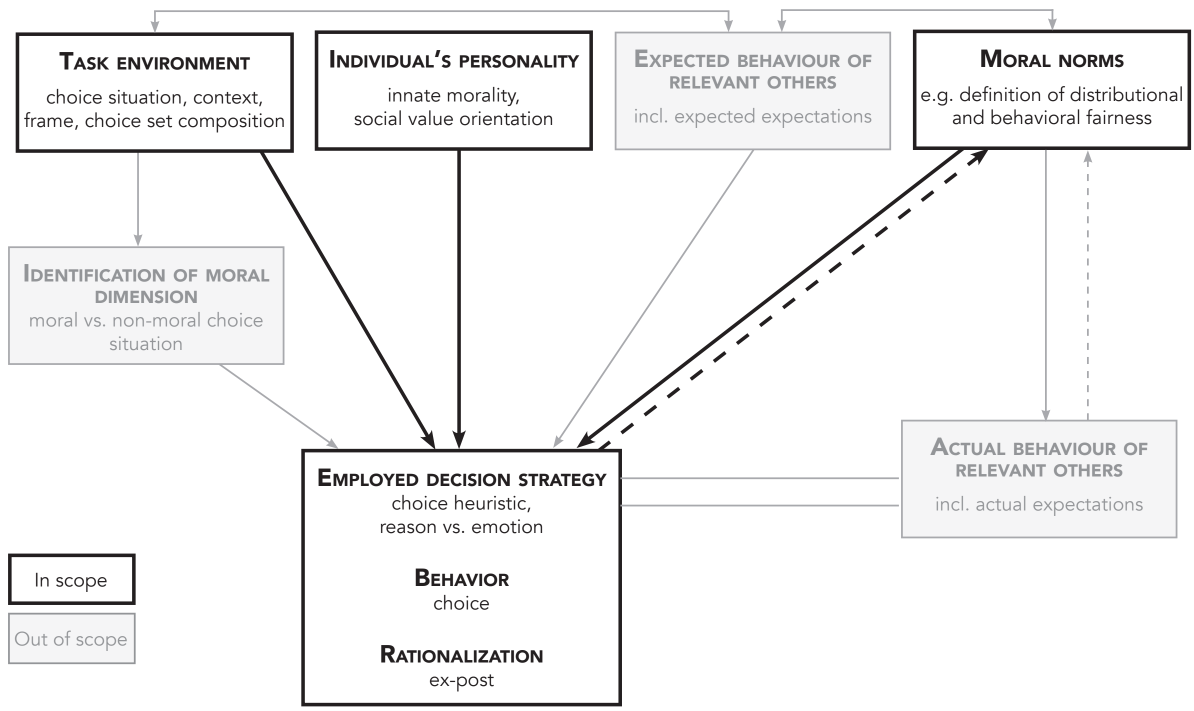


Figure 2.1: Conceptual model of an individual's moral choice behaviour, adapted from Chorus (2015) by adding scope.

By changing the task environment, can be tried to influence the decision maker in making other choices. It is hypothesized that due the presence of verbal cues about morality in the survey, people would value attributes from the moral domain as more important, choosing safety enhancing ADAS instead of other features.

2.2.2. Individual's personality and moral norms

As can be seen in Figure 2.1, *Individuals personality* (innate morality), and *Moral norms* play a role in (moral) decision making. Defining the concept "morality" is hard, as people around the world have different perceptions of what is moral behaviour, especially differing between cultures and political backgrounds (Haidt, 2012). For example, whereas one person may see being compassionate as central to his or her moral identity, another may emphasize being fair.

Therefore, Graham et al. (2012) proposed the Moral Foundations Theory (MFT), which assumes that morality consists of multiple moral foundations. In short, the theory proposes that several innate and universally available psychological systems are the foundations of “intuitive ethics". These moral foundations of "intuitive ethics" are based upon challenges that were faced by our ancestors for million years. The five moral foundations for which there is most evidence according to Graham et al. (2012) are ;

- **Harm**: This foundation is related to our long evolution as mammals with attachment systems and an ability to feel (and dislike) the pain of others. It underlies virtues of kindness, gentleness, and nurturance.

- **Fairness**: This foundation is related to the evolutionary process of reciprocal altruism. It generates ideas of justice, rights, and autonomy.

- **Ingroup**: This foundation is related to our long history as tribal creatures able to form shifting coalitions. It underlies virtues of patriotism and self-sacrifice for the group. It is active anytime people feel that it's "one for all, and all for one."

- **Authority**: This foundation was shaped by our long primate history of hierarchical social interactions. It underlies virtues of leadership and followership, including deference to legitimate authority and respect for traditions.

- **Purity**: This foundation was shaped by the psychology of disgust and contamination. It underlies religious notions of striving to live in an elevated, less carnal, more noble way. It underlies the widespread idea that the body is a temple which can be desecrated by immoral activities and contaminants (an idea not unique to religious traditions).

In case of the choice for safety-enhancing ADAS, the Harm foundation is the most obvious one that could play a role. It is assumed that if a person scores high on this foundation, they value safety-enhancing ADAS higher as well.

2.3. The right to do wrong

If citizens' behavior threatens to harm others or seems not to be in their own interest (e.g., risking severe head injuries by riding a motorcycle without a helmet), it is not uncommon for governments to attempt to change that behavior (Grüne-Yanoff and Hertwig, 2016). This results in a dilemma between intervening for peoples and society's own good, and letting people choose freely at the expense of poor outcomes (Paulin et al., 2018). In the case of ADAS, the question can be raised to what extent the government is responsible for peoples car choice behaviour, and (to what extent) she should intervene to make people buy ADAS.

Next to the costs and benefits of intervention, the type of intervention measure that is used is of importance. Policy makers have shown interest in using interventions coming forth of behavioural science to make government simpler, less expensive and more effective (Hertwig, 2017). "Nudging" (steering people unnoticed), and "Boosting" (information provision) are two types of interventions that preserve peoples freedom of choice, without forbidding any options or significantly changing economic incentives.

- **Nudging** is an intervention designed to steer people in a particular direction (Thaler and Sunstein, 2008). An example of a nudge is the Dutch organ donations system that changed from an opt-in system in which people had to make a positive choice to become an organ donator, to an opt-out system in which they are organ donator by default. An advantage of nudging is that it directly influences behaviour, without a lot of self-discipline of the decision-maker needed.

- The objective of **Boosts** is to give people the knowledge and tools to make good decisions themselves, influencing behaviour indirectly (Grüne-Yanoff and Hertwig, 2016). An example of a booster is giving an overview of different options for healthier and less healthier food. However, self-discipline is needed to let a boost work; we still don't eat healthy enough, while everyone knows it is good for you.

A comment on both types of intervention, is that the policy maker decides which subjects to nudge or boost on, implicitly implying that certain issues are more important than others. For example, only nudging or boosting on safe cars, implies this is more important than environmental friendly cars. Furthermore, nudges and boosts can have undesirable behavioural consequences, such as 'Moral self-licensing' (Merritt et al., 2010); past good deeds can make individuals engage in immoral, unethical or otherwise problematic behaviour later on.

Also, some think the government should be transparent, and stick to giving rules and applying fines. Others think that the government should do everything to protect peoples lifes, and that these kind of interventions therefore are acceptable. It is argued that nudges are less transparent; they operate behind behind the chooser's back and therefore appear manipulative (Hertwig and Grüne-Yanoff, 2017). Boosts, in comparison, require the individual's active cooperation, and therefore are more explicit, visible and transparent. As individual agency is promoted with boosts, this kind of intervention will be used to test the impact on moral choice behaviour for.

2.4. Research in moral decision making

Chorus (2015) observed a growing group of scholars arguing for the need to do experimental data-driven research into moral judgment and moral decision making (e.g. Bauman et al. (2014); Kahane (2013)). Bauman et al. (2014) argues that lots of studies of sacrificial dilemmas are unrealistic and unrepresentative of moral situations people encounter in the real world, and therefore they do not elicit the same psychological processes as other moral situations. For example the trolley problem, that is researched in the famous Moral Machine project (Massachusetts Institute of Technology, 2018), in which people judge what the most acceptable outcome is in moral dilemmas in which a driverless car must choose the lesser of two evils, such as killing two passengers or five pedestrians. According to Bauman et al. (2014) people find trolley problems humorous, rather than serious. The fact that so many people filled in the Moral Machine Project voluntarily (40 million decisions were collected from millions of people worldwide), could show that people find it amusing to make those choices. If deciding over the death of innocent people is found to be amusing, there is good reason to believe that they are at least partially disengaged from the moral issues at stake.

Therefore, in this research is focused on creating realistic choice situations, with a (more implicit) moral dimension, to be able to generalize and explain other moral situations as well. An experimental set-up is needed that combines a high level of experimental control and efficiency, with substantial levels of realism and external validity (Molin, SEN1221 Lecture 6).

2.5. Conclusion

The choice (not) to include ADAS is a choice with a moral dimension. Moral choice behaviour is hypothesized to be the result of an interplay of several factors, including task environment and innate morality. Next to exploring the role of morality in the preference for ADAS, this research aims to explore which of these factors significantly influence the role of morality. This is done by researching the effects of;

- including a booster that boosts moral choice behaviour in the task environment
- respondents innate morality, regarding the five moral foundations as stated by the Moral Foundations Theory (Harm, Fairness, Ingroup, Authority, Purity)

The experimental set-up to research this, must combine a high level of experimental control and efficiency, with a high level of validity (by creating realistic choice situations).

3
Advanced Driver Assistance Systems

When choosing (not) to include ADAS, several factors might play a role. First, is elaborated on the driving task and intervention level ADAS apply to (section 3.1). Section 3.2 is about the self-concerned, as well moral/altruistic personal driving goals ADAS can apply to. In section 3.3, the role of the composition and presentation of the choice set is elaborated upon, based on real lease car choice sets. Section 3.4 outlines what the European Commission sees as promising ADAS.

3.1. Driving task and intervention level

Each type of ADAS aims to assist in a specific task in driving, such as lane keeping, distance keeping, detection of other road users (in blind spots), parking or speed adaptation. ADAS can intervene in this driving task at different intervention levels. It can fully automate the driving task, intervene only in emergency situations, or just warn the driver for making mistakes. For example, Lane Keeping Assistance takes over the driving task of lane keeping, while Lane Departure Warning only warns in case the car leaves the lane, but doesn't intervene. Both of the systems have their pros and cons. Systems that intervene can result in people relying too much on the system, while systems that only warn might not prevent an accident in case of the driver not being able to respond in time. Therefore, car manufacturers and people can have different preferences in what types of systems to include in cars.

Systems that only warn the driver often contain words such as *warning* and *alert*. Systems that intervene often contain words such as *adaptive* or *assistance*. However, this does not always apply. The terminology for systems, which system exactly does what under what circumstances differs between car manufacturers. Broadly, the systems fall under the following categories;

- **Automated/Assistance** - systems that take over and perform certain functions (e.g. automated parking, automated emergency braking, lane keeping assistance)
- **Adaptive** - systems that change/adapt based on input from the surrounding environment (e.g. adaptive cruise control, adaptive headlights)
- **Warning/Alert** - systems that alert the driver to potential issues in their own driving or the driving of others that could increase the risk of injury to those in the vehicle (e.g. forward collision warning, lane departure warning)
- **Driver support** - systems that support the driver in carrying out his driving task, for example by increasing vision (e.g. improved night vision, reverse camera)

3.2. Personal driving goals

Molin and Marchau (2004) state that the preference for a certain type of ADAS, results from the personal driving goals people perceive that the system will apply to. These driving goals can be purely self-concerned, but they can also have a moral dimension.

Self-concerned driving goals

The following are driving goals without an explicit moral dimension that could explain preference for a system;

- **Comfort** - an import reason to include ADAS is to increase driving comfort of the driver.
- **Travel Time** - due the use of navigation, travel time can decrease.
- **Less Fines** - due speed limiting systems, people have a lower chance of getting a fine.
- **Fuel consumption** - ADAS can help in using less fuel in accelerating, which means less stops to add fuel and less fuel costs.
- **Having new technologies** - some people like to include ADAS, because they are interested in having new technologies in general. It can be seen as prestigious to have the newest systems in your car.

Altruistic (moral) driving goals

With the definition of morality as given in the beginning of chapter 2, almost every choice has a moral dimension. This definition of morality can be applied to the case of ADAS choice; what aspects, that affect other stakeholders than the driver himself, could be influenced by the choice for a vehicle and the included ADAS? The following list of driving goals with a moral dimension, and the effects on other stakeholders, is created after a brainstorm session with professor Santoni de Sio (personal communication, October 22, 2018);

- **Personal Safety** - People do not only affect themselves if they become injured due their choice for an unsafe car. They affect their friends and families. They affect their employers, by not being able to work while recovering, or having to quit working at all. Lastly, they affect the government with health costs or an unemployment allowance when not being able to work anymore.
- **Passengers Safety** - Driving an unsafe vehicle also affects passengers by increasing their chance for an accident.
- **External Safety** - Driving an unsafe vehicle affects other third parties using the road (pedestrians, bikes, other vehicles), by increasing their chance for an accident as well.
- **Environment** - The environment is impacted, by the use of materials for production of the ADAS and by fuel usage of the vehicle.
- **Traffic Flow** - Traffic flow can be impacted due to certain types of ADAS.
- **Distribution of Costs and Benefits** - Certain companies will earn more if a consumer chooses their product, implying others to miss out on this revenue. This leads to investments in certain research directions. Choosing to implement ADAS will indirectly increase development in these technologies.

This report is focused on the safety enhancing properties of ADAS, implying just the first three morality aspects. To be able to research how important safety for other road users is in the choice for ADAS, a distinction should be made between the contribution of ADAS to safety of the driver and passengers (internal safety), and to safety for other road users (external safety). The author did not find other research regarding ADAS in which such a distinction has been made.

People might differ in how they perceive the driving goals an ADAS will result in. Some people might have bad experience with the systems, and therefore perceive cars without these system as more safety or comfort enhancing. The perception of which driving goals an ADAS will result in, is in principle latent (unobservable). This implies that, to measure the importance of external safety in peoples choices, their perception on the external safety of the alternatives must be explicitly asked for. To not exhaust the respondents, only a certain amount of aspects can be explicitly asked for. As especially the safety and comfort aspects of ADAS are perceived as useful by drivers (Molin and Marchau, 2004), only these perceptions will be explicitly asked.

3.3. The presentation of ADAS in lease car choice sets

As was concluded in chapter 2, the composition of the choice set, and how choice options are presented, might influence (moral) choice behaviour. Choice situations in the survey should be realistic, so choice behaviour in real situations is mimicked as much as possible. Therefore, is explored how ADAS and other features are presented in real (online) lease car choice sets. In Appendix B, an example of the route a consumer follows when leasing a car online at ANWB.nl is shown.

Car features

The following car characteristics and options generally are included in real lease car choice sets, sorted in general-, performance-, looks-, comfort-, ADAS- and passive safety features;

- **General features** - Price per month, brand, model, amount of doors, amount of seats, size, body shape, year, weight

- **Engine performance** - Fuel type, Fuel use, Tank capacity, Energy label, CO2 emission, Horse power, Mileage
- **Looks** - Colour, type of lacquer, seating material, dashboard material, steering wheel, tinted windows
- **Comfort** - Multimedia, electric windows, electric/heated mirrors, towbar, airconditioning, seat heating, central door locking with remote control, roof rails, adjustable seats, (phone)charger
- **ADAS** - Lane keeping features, parking features, distance keeping, vehicle detection (forward and blind spot), pedestrian/cyclist detection, weather detection, navigation, adaptive lightning
- **Passive safety** - Crumple zone, safety belts, airbags, headrest, safety glass

However, a lot more lease driving companies exist, that each have their own kind of choice sets with lease cars. Next to that, most car brands have their own specific features that can be added, and have given the features a specific name. Not all characteristics can be included in the experiment in this thesis as this will result in a large amount of filled in choice sets (and respondents) needed. The car characteristics that will not be taken into account, are controlled for by telling the respondents to assume factors that are not mentioned are the same in all options.

ADAS are included individually or as a package
When leasing a car, often can be chosen from different cars, that already contain the general and performance features. Some of the looks, comfort and safety features are also already included in these cars. Once the consumer has chosen a car, he or she can choose to add more of those features against a higher price. Such packages are shown in Figure B.3 in Appendix B. There are three options to resemble this in a choice experiment;

- The respondent can choose between cars with features already included (car A, B or C);
- The car already has been chosen, and the respondent can add extra packages consisting of features (package A, B or C)
- The car already has been chosen, the respondent can choose separate features to add (feature A, B or C).

In reality, choice sets often contain combinations of these options; some attributes already are included, packages with features can be added, and some loose features can be added as well. The first option would result in more characteristics that should be taken into account, as a whole car is chosen. The last option would not make the discrete choice modelling approach applicable, in which trade-offs between combinations of ADAS and other features can be researched. Therefore, the second option will be used; a car is already chosen, and the respondents have to decide what extra package they would add.

No objective safety-rating for ADAS is available
As can be seen in the lease cars choice set from the ANWB (Appendix B.1), car safety is often not explicitly mentioned. A method to objectively determine the level of safety of ADAS systems is missing. Therefore an objective safety-rating can not be shown to consumers when purchasing or leasing a car. It is explicitly mentioned as a policy goal to create such an objective safety-rating, in a policy letter from the Dutch Minister of Infrastructure van Nieuwenhuizen Wijbenga (2018). As currently this objectively measured safety-rating is unavailable, people use their own subjective judgment on ADAS.

3.4. ADAS proposed by the European Commission

The European Commission (2018a) has put a list online with ADAS as well other types of safety features she thinks car makers should include in new models of cars and trucks from the year 2020. The list functions as a starting point for selecting ADAS to take into account in this research, as these have been proven successful in an impact study (European Commission, 2018c). The included ADAS for passenger cars and light commercial vehicles, and their definitions, are stated below;

- **Advanced Emergency Braking** - a system which can automatically detect a potential collision and activate the vehicle braking system to decelerate the vehicle with the purpose of avoiding or mitigating a collision with vehicles (moving and stillstanding) and/or vulnerable road users;
- **Lane keeping system** - a system monitoring the position of the vehicle with respect to the lane boundary and applying a torque to the steering wheel, or pressure to the brakes, at least when a lane departure occurs or is about to occur and a collision may be imminent;

- **Intelligent speed assistance** - a system to aid the driver in observing the appropriate speed for the road environment by providing haptic feedback through the accelerator pedal with speed limit information obtained through observation of road signs and signals, based on infrastructure signals or electronic map data, or both, made available in- vehicle;
- **Driver drowsiness and attention monitoring** - means a system assessing the driver's alertness through vehicle systems analysis and warning the driver if needed;
- **Advanced distraction recognition** - means a system capable of recognition of the level visual attention of the driver to the traffic situation and warning the driver if needed;
- **Emergency stop signal** - means rapid flashing stop lamps to indicate to other road users to the rear of the vehicle that a high retardation force is being applied to the vehicle;
- **Reversing detection** - means a camera or monitor, optical or detection system to make the driver aware of people and objects at the rear of the vehicle with the primary aim to avoid collisions upon reversing;
- **Tyre pressure monitoring system** - capable of giving in-vehicle warning to the driver when a loss of pressure occurs in a tyre, in the interests of optimum fuel consumption and road safety, over a wide range of road and environmental conditions.

The other safety features from the list that do not fall under the definition of ADAS, and are thus out of scope for this research, are *Event (accident) data recorder, Alcohol interlock installation facilitation* and *Enlarged head impacts protection zone.*

3.5. Conclusion

In the experiment, respondents choose between packages that contain ADAS and other car attributes (such as luxurious seating material). The included ADAS are selected from a list with ADAS that have proven to be safety enhancing, provided by the European Commission.

People can have different preferences for ADAS. The utility of an ADAS depends on its functionality, and is assumed to be (partly) mediated by the personal driving goals people perceive the ADAS will apply to. Safety- and comfort perceptions have shown to be most important in explaining the choice for ADAS in other research.

The following assumption is made regarding the extent to which a preference (and thus choice) is moral; *If the moral aspect of a choice becomes more important, there is a higher preference for packages that are perceived to enhance external safety, over packages that are perceived to enhance internal safety or comfort.* Distinguishing between internal safety (safety for people inside of the car) and external safety (safety for other road users) thus is needed to measure morality. This is summarized in Figure 3.1.

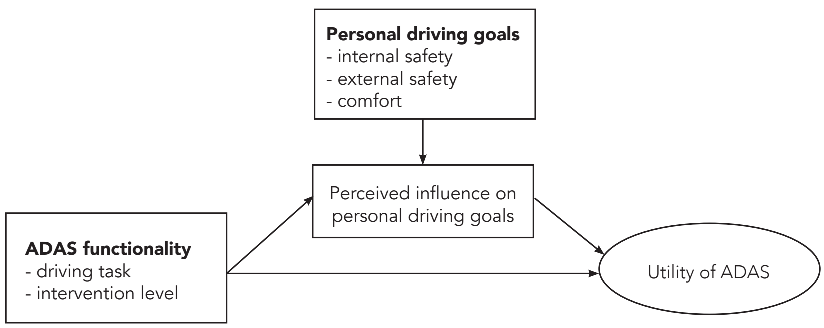


Figure 3.1: People can derive different utilities from including an ADAS in their car, depending on the ADAS functionality and perceived influence on their personal driving goals

4
Methodology

The research objective of this thesis is to increase understanding about the role of morality in consumers preference for ADAS. Next to measurement of (the role of morality in) preferences for car features, is explored what factors might influence the role of morality. In this chapter, the methodology for this is given.

In section 4.1, is explained why the preference for car features is researched by creating discrete choice models with stated preference data. In section 4.2, is outlined how a discrete choice experiment is conducted to measure this preference, and which preference is defined as moral. In section 4.3, hypotheses regarding the factors that might influence the role of morality are given, and how these are tested. Finally, the type of models that are estimated, are presented in section 4.4.

4.1. Discrete choice modelling

In subsection 4.1.1, the choice for discrete choice modelling, to measure (the role of morality in) preferences for car features, is explained. Subsection 4.1.2 elaborates on the use of stated preference data instead of revealed preference data. In subsection 4.1.3, the underlying decision rule for the discrete choice model is presented.

4.1.1. Discrete choice modelling over other methods

How people *should* behave when confronted with a moral choice situation has mostly been researched in the philosophical domain. How people *do* behave is rather part of research in the economic, sociological and psychological domain. As this research is of the latter type, some of the applied research methods of these domains are elaborated on.

Introspection is the examination of one's own conscious thoughts and feelings. To reveal the role of morality when buying or leasing a car, an option is to ask people straight away about how they make trade-offs. However, such verbal reports ex-post a trade-off should be handled with caution as evolution did not program us to deliberate trade-offs, but to make choices. People do not know exactly how they made a trade-off, as the decision making process is assumed to be done in higher order cognitive processes (Nisbett and Wilson, 1977). Research from Gigerenzer (2010) also has shown such ex-post reports contain unreliable reflections of moral behaviour. Next to that, people can hesitate to give their true trade-off as they are concerned with what others might think of them.

In the psychological domain, it is assumed that travel behavior is determined by psychological factors (habits, social norms, attitudes). Theories used to explain behavior are for example the Technology Acceptance Model (TAM), the Theory of Planned Behaviour (TPB) or the Unified Theory of Acceptance and Use of Technology (UTAUT). TPB was developed to explain human behavior in general; TAM and UTAUT were specifically developed to explain technology acceptance. These theories propose several factors that affect acceptance of a technology, with Behavioral Intention (to use a technology) and Actual Behavior (actual use of the technology) as measures of acceptance. There have been several attempts to model driver acceptance of in-vehicle technology using TAM, TPB, and UTAUT (Rahman et al., 2017). These models could be expanded by including the role of morality (Kaiser, 2006). However, a growing group of researchers is questioning if attitudes cause behavior, or if this relationship is vice versa (Kroesen et al., 2017).

Another type of method that originated in mathematical psychology, and is used in ADAS preference research, is conjoint analysis. For example, in Marchau et al. (2001) the utility of several ADAS are derived with conjoint analysis, by letting respondents rate how attractive different sets of ADAS are on an attractiveness scale. In Molin and Marchau (2004), Structural Equation Modelling (SEM) is used to estimate simultaneously how these ADAS are perceived in terms of personal driving goals, and how the personal driving goals and price, in turn, affect the overall attractiveness of these ADAS. SEM originally stems from the sociological domain.

A downside of these methods is that every variable is measured independently and no trade-off is made by the respondents. In real-life situations, the task would be some form of actual choice between alternatives rather than this more artificial ranking and rating (Louviere et al., 2010).

Discrete choice modelling is an economic, quantitative approach in which it is assumed that each choice is the outcome of a (rational) choice process, that can be described by a decision rule. Discrete choice models can describe, explain, and predict choices between two or more discrete alternatives, such as choosing between modes of transport, or between products (in this case vehicle option packages). It is assumed that each choice alternative can be described in terms of their functional (e.g. included ADAS and comfort systems), physical (e.g. included looks), and socio-economic attributes (e.g. purchase price of the package). As with discrete choice modelling, trade-offs are observed empirically, this type of model is chosen to be used in this research.

4.1.2. The use of stated preference instead of revealed preference data

In discrete choice modelling, decision strategies are econometrically identified based on observed choices. These choices can be observed in real life (revealed preference) or in experimental conditions (stated preference).

Revealed preference data would have to be supplied by (lease) companies. This data is highly valid, as people actually made these choices. However, as can be seen in Appendix B, to include safety enhancing ADAS might not even be a deliberate choice when choosing lease cars, as the consumer sometimes can only choose to add packages with all kind of systems. This makes it impossible to disentangle the utility of safety enhancing ADAS from the other features offered in these packages (like navigation, seat heating). Therefore, revealed preference will not be used in this research. A careful composed choice set is needed to be able to say something about the role of morality (the importance of external safety to the decision maker).

Stated preference data is obtained with a questionnaire. Non-existent alternatives can be tested, as the attribute values in the choice sets are chosen by the researcher. Choice alternatives can be constructed, such that the importance of all attributes can be reliably measured. Stated Choice experiments are designed for the statistically efficient analysis of decision makers' trade-offs between multiple attributes. Moral choice alternatives are almost by definition multi-attribute, and it is in the process of trading off those different attributes that many moral dilemmas arise (Bartels et al., 2015). Some attributes stem from the economic domain (price), while others refer to morality (safety for other road users).

4.1.3. Random Utility Maximization

Each Stated Choice experiment is created for estimating a specific model (or a range of models). Therefore, an underlying model needs to be specified, before creating an experimental design. The Random Utility Maximization (RUM) model, by McFadden (1973), is the most widely used model. RUM assumes that decision makers choose the alternative from which they derive the highest utility. In this research this means that employees will choose the car package that gives them the highest utility. RUM models assume that the decision makers derive a certain utility of the level of each of the attributes of each of the alternatives. This utility-component is called a part-worth utility. It is assumed that these part-worth utilities are combined to arrive at an overall utility for an alternative. This process can be approximated by the following linear additive utility function:

$$U_i = V_i + \epsilon_i = \sum_j \beta_j X_{ij} + \epsilon_i \tag{4.1}$$

where,
U_i is the utility derived from an alternative i,
V_i is the structural, or systematic, part of utility, which can be predicted by the model,
ϵ_i is the random part of utility, that cannot be predicted by the model,

X_{ij} denotes the attribute level of attribute j for alternative i,
β_j is the weight of attribute j (hence, the parameters that are estimated)

4.2. Measuring (morality in) preferences for car attributes

Preferences for car attributes can be estimated based on the stated preference data resulting from a discrete choice experiment, in which the respondent must choose between option packages that consist of an ADAS configuration and other car attributes. This is shown in Figure 4.1 beneath "alternatives". As was concluded in chapter 3, the utility of an ADAS configuration is hypothesized to be mediated by the personal driving goals (internal safety, external safety and comfort) these ADAS are perceived to apply to. This is shown beneath "perceptions" in Figure 4.1.

The extent to which a preference of a person for a package is moral, depends on how much utility this person derives from the Perceived External Safety (PES) of the ADAS configuration (shown with thick lines in Figure 4.1), compared to the utility derived from the other attributes. Recalling Equation 4.1, the part-wort utility of PES can be denoted as $\beta_{PES} * PES_i$. A higher utility derived from PES, can thus result from PES_i being higher, or β_{PES} being higher;

1. PES_i being higher means that a respondent perceives an ADAS configuration to improve External Safety more (the arrow going into "Perceived External Safety"), while internal safety and comfort are perceived to improve the same amount (or are perceived to improve less), compared to the other respondents.

2. β_{PES} being higher means that an increase of PES is more important in the choice for a package (the arrow coming out of "Perceived External Safety"), compared to an increase in PIS, PC, car attributes 2 and 3, and the utility of the ADAS configuration not captured by PIS, PES and PC.

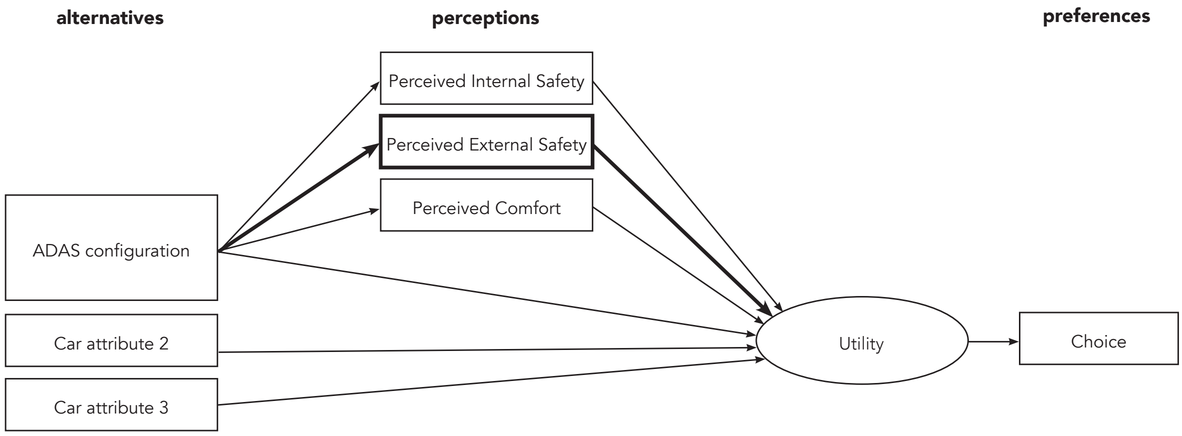


Figure 4.1: The preference for ADAS is hypothesized to be mediated by perceptions on personal driving goals

As the perceptions are latent, these are explicitly asked for in a rating task, conducted before each choice task of the discrete choice experiment. This approach of choice-tasks, in combination with explicitly asking for perceptions, is adopted from Molin et al. (2018). In their survey, first the choice alternatives (packages) from a choice set are rated one by one, on subjective aspects. Then, the entire choice set is presented, which consists of the same packages the respondent rated just before, and the respondent is asked to make a choice between these packages.

4.2.1. Rating tasks

To measure how people perceive that the included ADAS influence the three personal driving goals, first three rating tasks are conducted for each package. In these rating tasks, respondents are asked to rate configurations of ADAS on how they perceive that this would decrease or increase safety for the driver (internal safety), driving comfort of the driver, and safety for other road users (external safety). In figure 4.2, the rating tasks for a package are shown. The respondents have to choose between five options, ranging from "a lot worse" to "a lot better".

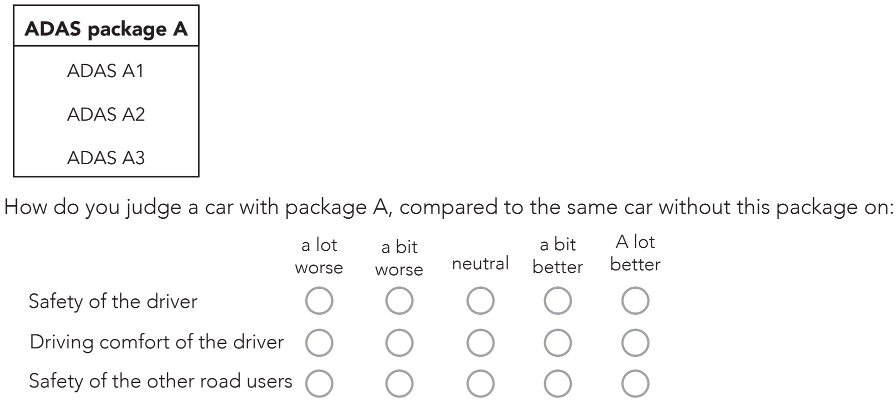


Figure 4.2: Rating task

4.2.2. Choice tasks

After rating three packages, a choice task is conducted. A choice task consists of multiple elements; attributes, alternatives and the choice question. The attributes are the selected ADAS and other car features. Alternatives are option packages that consist of combinations of these attributes. In the choice task, several of these alternatives are shown at a time; the respondent is asked which alternative he/she prefers. Figure 4.3 shows three alternatives and the choice task. To make the choice tasks easier, the alternatives contain the same ADAS packages as for which the perceptions are asked in the rating experiment before.

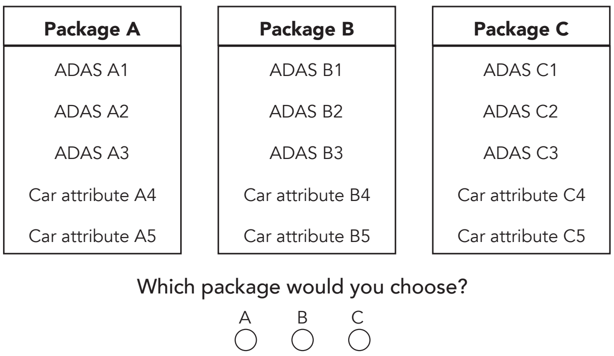


Figure 4.3: Choice task

To decide which combinations of car attributes are packed together in each alternative of each choice task, an experimental design must be created. The challenge is to have sufficient variation in the choice situations, to be able to estimate the intended utility functions in such a way that the estimated parameters are reliable (small standard errors) and valid (close to the "true" parameter value). Therefore, choice situations should resemble real world situations as much as possible, and, the choice tasks must not exhaust respondents (Molin, SPM1221 college 5). As respondents not only choose among alternatives, but also have to rate systems on comfort and safety, the total amount of choice tasks must be be limited. Too many tasks can lead to work overload for the respondents, resulting in unreliable responses due fatigue.

Therefore, an "efficient design" is used, to decide which combinations of car attributes are packed together in each alternative, and to determine the number of choice questions. The goal of an efficient design is to have maximum information extraction from each choice question. This can be achieved by balancing the utilities of the alternatives in each question; dominance of alternatives should be avoided. The closer the expected probability of an alternative being chosen lies to 1 (100%), the more limited the information about trade-offs. Use of an efficient design, results in more reliable parameters (with a smaller standard error), or less respondents required for the same reliability (Rose and Bliemer, 2009).

To create an efficient design, priors are required. Priors are estimates of the expected parameter values of the variables. These priors can be retrieved from literature, or by conducting a pilot survey. Since no literature exists with applicable priors for this research, a pilot study among a small number of respondents (approximately 30) is carried out.

4.3. Factors that might influence the role of morality

As was concluded in chapter 2, moral choice behaviour is hypothesized, among other things, to be influenced by the task environment and innate morality. The hypotheses regarding the factors that might influence the role of external safety in the preference for ADAS, are presented in Table 4.1. H1-H5 are about innate morality, and H6 is about the task environment. The choice for these hypotheses, and how the corresponding factors are included in the survey, is explained in sections 4.3.1 and 4.3.2 for innate morality and the booster respectively.

Table 4.1: Factors hypothesized to influence the role of morality in the preference for ADAS

	Hypotheses
H1	*Score on "**Harm**", correlates with preference for ADAS packages that are perceived to enhance external safety.*
H2:	*Score on "**Fairness**", correlates with preference for ADAS packages that are perceived to enhance external safety.*
H3:	*Score on "**Ingroup**", correlates with preference for ADAS packages that are perceived to enhance external safety.*
H4:	*Score on "**Authority**", correlates with preference for ADAS packages that are perceived to enhance external safety.*
H5:	*Score on "**Purity**", correlates with preference for ADAS packages that are perceived to enhance external safety.*
H6:	*If a morality "**booster**" is shown, ADAS packages that are perceived to enhance external safety are preferred more.*

4.3.1. Innate morality

To be able to research the effect of innate morality on preferences, innate morality must be expressed in a measurable construct. This results in a fatal dilemma. On the one hand, we want to make the concept "innate morality" measurable by as least as possible factors (parsimony). On the other hand, if innate morality is measured as a single construct, this conflicts with explanatory adequacy of the model, as morality actually is a plurality of ideals. Instead of measuring morality as a single construct, Graham et al. (2012) proposed measuring morality pluralistic (with five constructs), regarding the Moral Foundations Theory (MFT). These five "moral foundations", Harm, Fairness, Ingroup, Authority and Purity, were elaborated upon in section 2.2.2. They constructed the Moral Foundations Questionnaire (MFQ), with which the extent respondents rely upon each of these moral foundations can be quantified.

The MFQ is included in the survey after the rating- and choice tasks. With the resulting answers, the scores of the respondents on the different foundations can be calculated. Gray et al. (2012) (p. 108) and Harris (2010) (p.89), argue that all morality can be understood through the lens of harm, and so only the Harm foundation is truly foundational. Therefore, it is expected that mainly the Harm foundation will have an impact on the importance of External safety.

4.3.2. Booster

To research Hypothesis 6, a booster for moral choice behaviour is included in the survey for 50% of the respondents. The behavioural insights team of the Dutch government has given recommendations, on how to motivate people to perform certain behaviour in an email or letter. These recommendations are applied to decide what type of boost to apply.

- A first recommendation is to name the social norm, e.g. *"Most people choose a safe car"*. If the actual behavior does not occur that often, but people have a positive opinion about it, could be mentioned what the majority approves; e.g. *"Most people think road safety is important when choosing a car"*. However, a booster containing more factual information is preferred, as it is debatable what exactly is the norm, and to what extent the government is allowed to state this.
- A second recommendation, is to frame the message in terms of loss and profit (prevention- or promotion framing); e.g. *"Safety systems will make you a safer road user, and prevent accidents"*. However, this is not really factual as well. A more factual approach, based on Article 185 of the Road Traffic Act of 1994 ("Wegenverkeerswet"), is to state *"When you collide with a pedestrian/cyclist, you are responsible for paying at least 50% of the damage to the weaker road user, even if the collision is not your fault"*.

However being of interest, in the latter sentence mostly profit-loss is emphasized, instead of morality. Although, this rule originates from the fact that the pedestrian/bicycle is not that dangerous for others, while having a car is, therefore the car owner always being accountable for an accident. Therefore, is decided to only state in the booster that the driver is responsible for the accident, leaving the costs out. This results in the booster in Figure 4.4. As 'just-in-time' education, tied to specific behaviours, appears to be most effective (Johnson et al., 2013), this booster is shown just before the rating- and choice tasks.

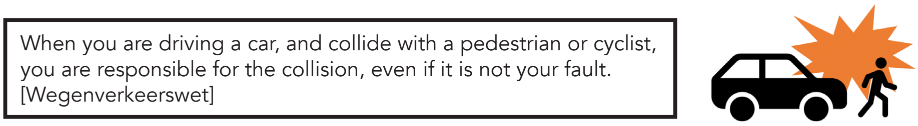


Figure 4.4: Booster

4.4. Data analysis

The goal of the data analysis, is to measure the utility derived from PES compared to the utility derived from the other attributes, and to test if the hypotheses from Table 4.1 can be accepted. Recalling, that the utility derived from PES depends on (1) the respondents PES-rating of the ADAS configuration (PES_i), and (2) the increase in utility due improvement of PES (β_{PES}), two types of models are estimated. The factors might influence morality via both ways.

First, is estimated with ordinal regression, how the respondents arrive at a PES-rating for a package, and which factors influence this (section 4.4.1). Then, is estimated with discrete choice modelling, how important this PES-rating is in decision making, and which factors influence this (section 4.4.2).

4.4.1. How do people arrive at each perception rating for ADAS packages?

Ordinal regression analysis is used to predict an ordinal outcome variable (also called dependent variable), given multiple explanatory variables. Here, the perception ratings on internal safety, external safety and comfort are the outcome variables, measured on a 5-point ordinal scale ranging from 1 (a lot worse) till 5 (a lot better). Each perception rating of an ADAS package is assumed to depend on the included ADAS, but can also depend on the factors from Table 4.1. These are the explanatory variables, of which the direct effect, as well the interaction effects with each other could affect the perceptions. For PES, this is depicted in Figure 4.5.

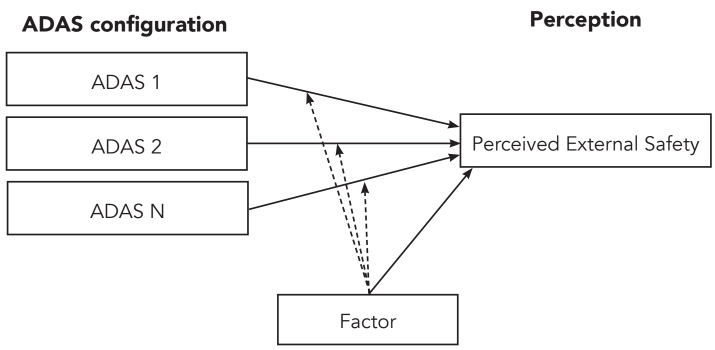


Figure 4.5: Relationships to be estimated with Ordinal Regression

With an Ordinal Regression analysis, is estimated which ADAS and factors have a significant effect on how respondents arrive at their stated external safety- (PES), internal safety- (PIS) and comfort (PC) perceptions. It will give the *odds*, that a package in which a certain ADAS is included (e.g. Emergency Braking for Pedestrians), results in a higher PIS, PES and PC rating, compared to a package without this ADAS. And, how the factors, such as gender, affect these odds.

The most popular type of ordinal regression is carried out; **Cumulative odds ordinal logistic regression with proportional odds** (Laerd Statistics). This type of ordinal regression uses cumulative categories representing the perception ratings. With Maximum Likelihood Estimation, the parameter values are searched, that maximize the log likelihood (LL), which reflects how likely it is that the observed values of the outcome may be predicted from the explanatory variables. With these parameters, odds ratios are calculated, that allow considering the effect of the explanatory variables.

4.4.2. How important is an increase of each perception in the choice for a package?

The role of perceptions in preferences for car attributes can be measured with discrete choice modeling, if we know how the respondents rated ADAS packages on PIS, PES and PC, and which choice they made out of these packages. In Figure 4.6 is shown which relations are estimated. This is done with two types of discrete choice models; MNL and ML (which are further explained below). MNL is used to quickly determine which of the interaction effects are significant, as it has a fast estimation time. ML is used to create the final model, as it accounts for the fact that multiple choices are made by each respondent (the so-called panel-effect), which the MNL model does not account for.

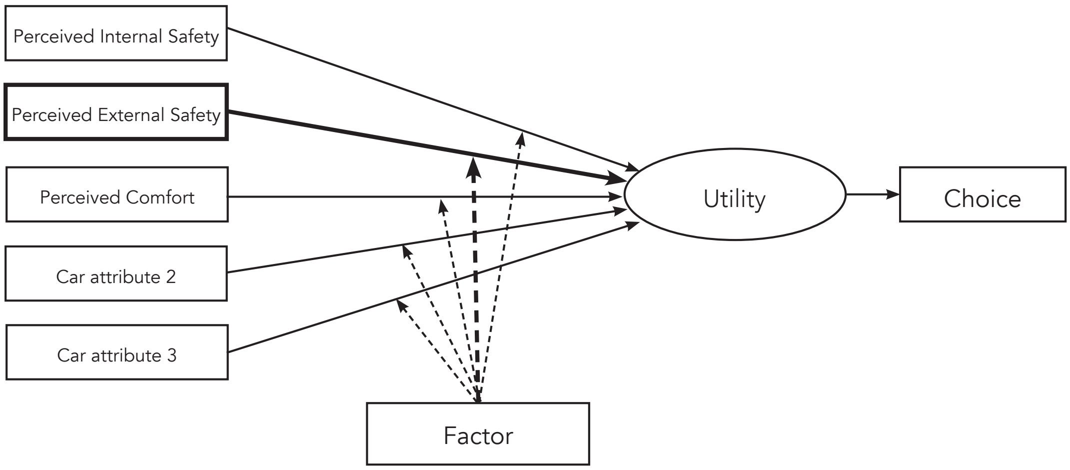


Figure 4.6: Relationships to be estimated with Discrete Choice Modelling

MNL

The most widely known discrete choice model is the MNL model. The MNL model assumes that the error term ϵ_i is independently and identically distributed according to the so-called Extreme Value Type I distribution. This results in choice probabilities taking the Multinomial Logit form as shown in formula 4.2, where p_i is the probability of choosing alternative i among a set of alternatives k, and e is the base of the natural logarithm. Parameter estimates are obtained using Maximum Likelihood Estimation routines (see Ben-Akiva et al. (1985)). In short, the model is estimated by iteratively finding the combination of βs, that make the data most likely (Chorus, SPM1221 2018).

$$p_i = \frac{e^{V_i}}{\sum_k e^{V_k}} \tag{4.2}$$

A drawback of the MNL-model, is that it ignores correlations between choices made by the same individual. As each respondent makes three choices, these choices are correlated. Each person has their own "taste", for example preferring low price options. MNL tells the model that every case (observed choice) is independent of all others, resulting in biased estimation outcomes. Despite these disadvantages of the MNL model, it can be used to quickly determine which of the interaction effects are significant, due its fast estimation time.

Panel Mixed Logit

The Mixed logit (ML) model can capture these taste- and panel effects, by allowing for unobserved heterogeneity in tastes, and making these tastes individual-specific. A taste (e.g. sensitivity for costs) is allowed to vary randomly across the population. For example, $\beta_{PIS} \sim N(\beta_{PIS}, \sigma_{PIS})$, in which β_{PIS} is the average taste for PIS, and σ_{PIS} the degree of unobserved taste variation for PIS. By doing so, it creates correlations between the unobserved utilities of similar alternatives (e.g. two low Price options) and between choices made by the same individual. ML panel models are estimated with use of simulation, as the unit of observation is the complete sequence of choices made by the individual (rather than one choice). An intelligent drawing mechanism is used for this simulation, named "Halton draws".

ML captures correlations, heterogeneity in observed utility. Now, we can try to capture these in the model, by means of interacting betas with observed variables; the factors that were hypothesized to influence morality. As estimating a ML model takes very long, only the interaction effects that turned out to be significant in the MNL model will be included.

5

Car Features Survey Design

5.1. First pilot survey (N=4)

The first pilot survey is used to understand if the choice tasks are clearly defined, and if the survey can be filled in in a reasonable time.

5.1.1. Attribute and level selection

The first step in the construction of a stated preference experiment, is the selection of salient attributes and levels of these attributes. ADAS and other car attributes are selected based on existing research, policy initiatives and present online lease company offers.

The ADAS that will be taken into account are based on the policy propositions of the European Commission. Only systems that can be included as extra packages are of interest. Systems that are often included in cars initially, such as airbags or electronic stability control, are not considered. Also, navigation is not considered as people nowadays navigate by their phones or other external devices. A balance needs to be found between, on the one hand, taking into account proven and well-known safety enhancing systems, resulting in plausible choice sets. And, on the other hand, taking into account systems that differ in their influence on the perceptions of internal safety (IS), external safety (ES) and comfort (C), enabling measurement of the importance of morality.

Table 5.1 shows mutually exclusive driving tasks, with an ADAS that does - and does not intervene in this driving task. The list of systems is checked for completeness by the spokeperson on vehicle technology of the ANWB, Chris Hottentot (personal communication, November 21, 2018). It is hard to select relevant ADAS that are expected to fulfill only a single driving goal (IS, ES or C). Systems for ES, by avoiding collisions, often also result in more IS. To be able to measure the importance of ES, a division is made between Vehicle detection- and Vulnerable road user detection systems. The latter type of systems are mainly for ES; the researcher does not expect other types of ADAS to such clearly affect ES. The other way around, features mainly for IS are hard to find as well. Active safety features with the solely purpose of IS do exist, such as airbags and seatbelts. However, these would be unlogical to be add-on features in an European survey, as they are already widely available or even mandatory. Next to that, these are not defined as ADAS.

Table 5.1: Driving tasks and intervention level (AEB stands for Automated Emergency Braking)

Driving task	no intervention	intervention
Lane keeping	lane departure warning	lane keeping assistance
Speed adaptation	cruise control	adaptive cruise control
Vulnerable road user detection	pedestrian and bicycle warning	AEB for pedestrians and bicycles
Vehicle detection	forward collision warning	AEB for vehicles
Speeding prevention	speed warning	speed limiting
Parking	reverse camera	automated parking

Selected attributes and levels

The seven selected attributes, and three corresponding levels for the first pilot survey are shown in Table 5.1.

The first five attributes are ADAS that intervene in different driving tasks (lane keeping, speed adaptation, pedestrian- and bicycle detection, vehicle detection and speed prevention), based on Table 5.1. Systems for the driving tasks "Lane keeping" and "Speed adaptation" are supposedly mainly for comfort; systems for the driving tasks "Speeding prevention", "pedestrian- and bicycle detection" and "vehicle detection" mainly for safety. From this table only the parking topic is not taken into account, as this is both for comfort and safety. In Level 0 no ADAS is included that enhances/intervenes this driving task; Level 1 warns if something goes wrong, but doesn't intervene; Level 2 also intervenes in this driving task.

Next to the ADAS, an attribute is included that contains luxe comfort- and looks features, as it is assumed that ADAS have to compete against these kind of features in lease sets (so a more real choice set is mimicked). For the extra features, in level 0 no extra sets are added, in level 1 luxe seating- and dashboard material and a multimedia-system is added. Level 3 contains the same features as level 2, with seat heating. Lastly, prices (additional on the monthly lease costs) are included.

Topic	Level 0	Level 1	Level 2
Lane keeping	-	Lane departure warning	Lane keeping assistance
Distance keeping	-	Cruise control	Adaptive cruise control
Pedestrian/ Bicycle detection	-	Pedestrian/bicycle warning	Pedestrian/bicycle warning + automated braking
Vehicle detection	-	Forward collision warning	Forward collision warning + Automated braking
Speed adaptation	-	Speed warning	Speed limiting
Extra features	-	Luxe seating and dashboard material	Luxe seating and dashboard material
	-	Multimediasystem	Multimediasystem
	-	-	Seat heating
Price	+ 0 euro/month	+ 20 euro/month	+ 40 euro/month

Figure 5.1: Attributes and Levels first pilot survey

5.1.2. Alternative and choice set construction

The number of choice alternatives in each question (the choice set) has to be chosen. It is chosen to use 3 alternatives per choice set, as this results in more information per choice than 2 alternatives per choice set. This results in less completed choices needed.

The choice sets will be sequentially constructed, as only generic attributes are used (all alternatives have the same attributes and levels). The choice sets contain unlabeled alternatives; car package 1, car package 2 and car package 3. There is no reason to assume that respondents will systematically prefer the first, second or third alternative.

To construct alternatives, specific attribute levels are combined according to an experimental design (a fractional factorial design) with Ngene. Ngene is software dedicated to the design of Stated Choice experiments (ChoiceMetrics, 2018). With this amount of attributes and levels, 18 choice sets were needed, that were blocked in 3 blocks (6 choice sets per respondent). In Appendix D examples of a rating and a choice task in the pilot survey are given.

5.1.3. Results - the survey is complicated/long

The researcher carried out this first pilot survey with 4 close relatives. They all stated that the survey was too long and complicated. They quit early, or only chose the cheapest packages as a countermeasure. Therefore, it was decided to quit the first pilot early, change the composition of the choice sets, and carry out a new pilot.

5.2. Second pilot survey (N=34) - for estimating priors

Based on the reactions of the respondents of the first pilot survey, a second (final) pilot survey was created. The main difference between the first and second pilot is that the three attribute levels that were included in the first pilot, are reduced to two attribute levels in the final pilot. This doesn't matter for achieving the goal of the survey, as long as the chosen systems differ in IS, ES and C perceptions.

5.2.1. New attribute and level selection

As the amount of attribute levels is reduced to two (the system/feature is included, or is not included), one system from each driving goal in Figure 5.1 is selected. The chosen systems are shown below in Figure 5.2. For the driving tasks "Speeding prevention", "Vehicle detection" and "Bicycle/pedestrian detection", systems are included that only intervene in emergency situations/driving too fast, as these are especially for safety. For the driving tasks "Lane keeping" and "Speed adaptation", systems are included mainly for comfort (however these can be seen as safety enhancing as well).

Figure 5.2: ADAS taken into account (adapted from National Safety Council (2018))

- **Lane Departure Warning [IS, ES en C]** - warns if the vehicle leaves its lane unannounced. People can perceive this to be for IS, ES and C. However, some people might have bad experiences with such systems, not perceiving it as comfortable/safety enhancing.
- **Emergency Braking for pedestrian/Bicycles [ES]** - brakes automatically for pedestrians or cyclists in emergency situations.
- **Emergency Braking for vehicles [IS, ES]** - brakes automatically for cars in emergency situations.
- **Intelligent Speed Limiting [IS, ES]** - Limits the vehicles speed to the appropriate speed for that road. Is for safety, but might also be for comfort (against speed fines). People might find this not comfortable, as they prefer to over-speed.
- **Adaptive Cruise Control [IS, ES en C]** - Adaptive Cruise Control is mainly for comfort (for example during congestion), but also for internal and external safety as it keeps a distance from the vehicle in front. Just Cruise control would only be for comfort. However, such a system is a system too common to be chosen as an additional system in lease cars nowadays (Dicke-Ogenia, personal communication).

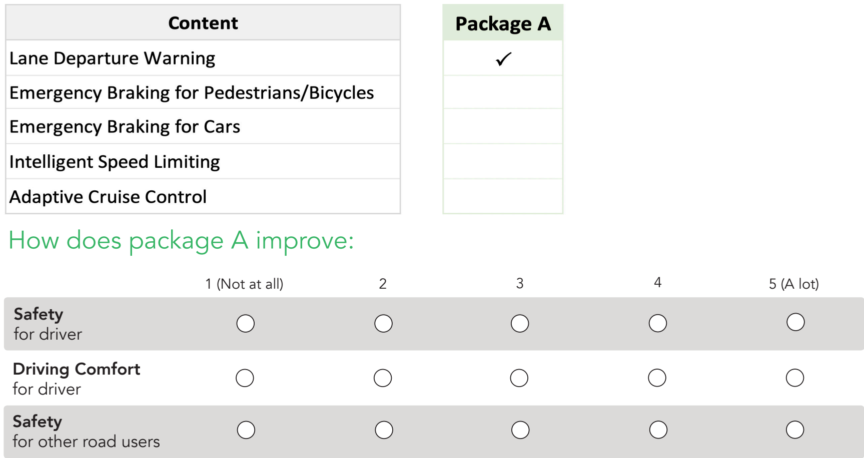
Attributes	Level 1	Level 2
Lane Departure Warning		✓
Emergency Braking for Pedestrians/Bicycles		✓
Emergency Braking for Cars		✓
Intelligent Speed Limiting		✓
Adaptive Cruise Control		✓
Luxe seating- and dashboard material and Luxe multimediasystem		✓
Price per month	€10	€20

Figure 5.3: Attributes and Levels in the second pilot survey (a check mark means the system is included)

From the first pilot study (N=4) was learned more factors (attributes and levels) result in too many and too complicated choice tasks. Therefore, other factors are out of scope, as the choice context should not become too time consuming.

5.2.2. New alternative and choice set construction

Again, alternative and choice set construction is done according to a fractional factorial design, created with Ngene. Again, the design consists of 3 unlabeled alternatives per choice set. Examples of the resulting rating- and choice tasks in the final pilot are shown in Figures 5.4 and 5.5 respectively.

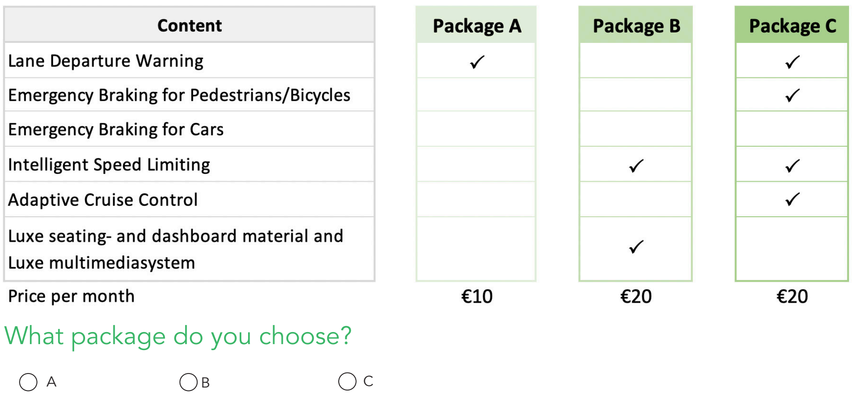


Content	Package A
Lane Departure Warning	✓
Emergency Braking for Pedestrians/Bicycles	
Emergency Braking for Cars	
Intelligent Speed Limiting	
Adaptive Cruise Control	

How does package A improve:

	1 (Not at all)	2	3	4	5 (A lot)
Safety for driver	○	○	○	○	○
Driving Comfort for driver	○	○	○	○	○
Safety for other road users	○	○	○	○	○

Figure 5.4: Example of a rating task in the pilot survey



Content	Package A	Package B	Package C
Lane Departure Warning	✓		✓
Emergency Braking for Pedestrians/Bicycles			✓
Emergency Braking for Cars			
Intelligent Speed Limiting		✓	✓
Adaptive Cruise Control			✓
Luxe seating- and dashboard material and Luxe multimediasystem		✓	
Price per month	€10	€20	€20

What package do you choose?

○ A ○ B ○ C

Figure 5.5: Example of a choice task in the pilot survey

5.2.3. Results

The respondents for the pilot study are acquaintances of the researcher. In total, 40 respondents started the survey, of which 34 finished all questions. Only the complete answers have been taken into account (therefore N=34). It must be noted that part of the respondents are students (with a low income and not yet having a car).

Priors

This pilot survey results in priors (best guesses on parameter values), that are needed to create the efficient design for the final survey. These RUM parameters, estimated with PandasBiogeme (Bierlaire, 2018b), can be found in Table 5.2. The parameter values (β_V) are a proxy for attribute importance; it represents the in-/decrease in utility (V) of an alternative due to an attribute changing from level 0 to level 1. All parameters have the expected sign. Insignificancy of these parameters doesn't matter, as they are pilot survey results with a relatively small number of respondents.

Comments of the respondents

The main comment of the respondents on this survey was that some combinations of systems and prices don't make sense. For example, package F is cheaper than package D, but contains the same features plus

Table 5.2: RUM Parameters of the car systems package pilot survey (N=34)

	β_V	SE	t-test	p-value
Lane Departure Warning (LDW)	0.18	0.21	0.85	0.40
Emergency Braking for Pedestrians/Bicycles (EBP)	1.51	0.24	6.22	4.84e-10
Emergency Braking for Cars (EBC)	1.43	0.28	5.13	2.91e-07
Intelligent Speed Limiting (SL)	0.45	0.18	2.55	0.01
Adaptive Cruise Control (ACC)	0.99	0.19	5.13	2.92e-07
Luxe seating- and dashboard material and Luxe multimediasystem (LUX)	1.35	0.25	5.42	5.89e-08
Price (PR)	-0.115	0.027	-4.4	1.11e-05

even more. This is due the fact that a fractional factorial design was used, that may result in unlogical combinations.

Furthermore, there were three small comments. (1) Some respondents received the e-mail with the survey (that was sent via www.surveymonkey.nl) in the spam-inbox. Therefore the e-mail, with a link in it, should be sent by the researcher herself. (2) A respondent said it would be more clear if the pictures of the systems are placed above each page. Furthermore, there is no explanation or picture of the luxe multi-mediasystem dashboard material, while there is for the other systems. This is because the other systems are ADAS. This could be underlined more in the final survey. (3) Of the question if you would really take the package, the answer doesn't fit with the question.

5.3. Final survey

The final survey will be constructed based on the same attributes as were used in the pilot survey (see Figure 5.3), as no comments were given by the respondents in the last pilot survey on these attributes. The only difference between the pilot and the final survey is that less choice tasks per person are asked, as now an blocked efficient design is created based on the obtained priors.

5.3.1. Choice set construction

The number of required choice sets is determined by the number of parameters to be estimated, and the information obtained from each choice. The amount of parameters is 7. Each choice set adds 2 degrees of freedom; this means 2 choice probabilities can be observed (if A is chosen in the choice set [A, B, C], the choice probability between A and B and between A and C can be observed). The minimum number of choice sets is determined by the amount of indicator variables divided by the degrees of freedom per choice set (7 / 2 = 3,5). So, the minimum number of choice sets is 4.

The choice sets for the final survey are created by specifying a D-efficient design, which seeks to minimize the standard errors (Rose and Bliemer, 2009). The design is created with Ngene, and is robust for estimating RUM models. The Ngene code, and resulting efficient design, can be found in Appendix F.1.

With this design, 6 choice sets need to be created that are blocked into 2 blocks, as not too many choice tasks can be carried out by each person. Blocking means that the design is divided in several blocks, and each respondent fills in one of those blocks. This results in 3 choice sets that need to be filled in by each respondent.

5.3.2. Survey contents

The final survey can be found in Appendix F.2. The survey consists of introductory questions, a booster, package ratings and choices, accident related questions, the Moral Foundations Questionnaire (MFQ) and personal characteristics questions.

Introductory questions

To be sure that the respondents understand the functions of the systems that are asked for in survey, first a question will be asked about each ADAS system. The information is given in the form of questions, as just an explanation of the systems might be perceived as boring by the respondents.

Lane departure warning

This system warns if your car leaves its lane without indicating direction.
Do you have “**Lane departure warning**” in your car?

- ◯ I have it, and use it
- ◯ I have it, but don’t use it
- ◯ I don’t have it, but would like to use it
- ◯ I don’t have it, and would not like to use it
- ◯ I dont’ know if I have it

Figure 5.6: Introductory question

Booster
The booster is used as described in section 4.3.2. 50% of the respondents sees the booster. As respondents often don’t read the explanatory text very careful, they answer a question about the booster as well. This is done to increase the probability the respondent reads the information.

When you are driving a car, and collide with a pedestrian or cyclist, you are responsible for the collision, even if it is not your fault. [Wegenverkeerswet]

Did you know this?
- ◯ Yes
- ◯ No

Figure 5.7: Booster question

Package ratings and choices
Each respondent has to fill in 3 choice sets. For each choice set, three rating questions are asked (for package A, B and c), before the respondent has to make a choice between these three packages. In Figure 5.8 a rating question is shown. Compared to the second pilot survey, the question as well rating scale are changed. In Figure 5.9, a choice question is shown. The choice question stayed the same. Compared to the final pilot, both questions have a slightly different design, due the modelling software.

Accident related questions
Two questions about car accidents are asked, as these are hypothesized to influence preference for ADAS.

- If the respondent had an accident with a car in the past two years.
- If the respondent has a close relative that had a car related accident in the past two years.

Moral Foundations Questionnaire (MFQ-30)
Next, the Dutch translation of the "MFQ-30" is included (Haidt, 2008). In the MFQ-30, first the respondent has to rate how important 15 considerations are when they decide whether something is right or wrong, on a 6-point scale ranging from "not at all relevant" till "extremely relevant". Then, the respondent has to indicate to what extent they agree with 15 sentences on a six-point scale, ranging from "strongly disagree" to "strongly agree". Also, two check questions are included, that are designed both to force people to use the bottom end of the scale, and to catch and cut participants who respond with last three response options (MoralFoundations.org, 2008). Including the check-questions, the MFQ-30 exists of 32 questions.

1. For the first check question, the respondent has to rate how relevant *"Whether or not someone was good*

Content	Package A	Package B	Package C
Lane Departure Warning	✓		
Emergency Braking for Pedestrians/Bicycles	✓		
Emergency Braking for Cars			
Intelligent Speed Limiting			
Adaptive Cruise Control	✓		

How do you judge a car with package A, compared to the same car without this package on:

	a lot worse	a bit worse	neutral	a bit better	A lot better
Safety of the driver	○	○	○	○	○
Driving comfort of the driver	○	○	○	○	○
Safety of the other road users	○	○	○	○	○

Figure 5.8: Example of a rating task in the final survey

Content	Package A	Package B	Package C
Lane Departure Warning	✓	✓	
Emergency Braking for Pedestrians/Bicycles	✓	✓	✓
Emergency Braking for Cars		✓	
Intelligent Speed Limiting			✓
Adaptive Cruise Control	✓		✓
Luxe seating- and dashboard material, and Luxe multimediasystem		✓	✓
Price per month	€10	€20	€10

Which package do you choose?

○ A

○ B

○ C

Figure 5.9: Example of a choice task in the final survey

at math" is when deciding whether something is right/wrong. The answers "somewhat relevant", "very relevant" and "extremely relevant" are considered "wrong".

2. For the second check question, the respondent indicates how much he agrees with the statement *"It is better to do good than to do bad."* The answers "strongly disagree", "moderately disagree" and " slightly disagree" are considered wrong.

Personal characteristics

Socio-economic factors are asked at the end. These are used to get an understanding of the respondent group that the research will be representative for. Also, these can be included in the model estimation, as explanatory variables.

- Gender: male or female
- Age: year of birth
- Highest level of completed education: High school, MBO, HBO or WO
- Bruto monthly income: "€0-10.1000", "€10.000-20.000", etc
- Car ownership: no car, private lease, business lease or privately owned
- Driving frequency: (almost) every day, 5-6 days/week, etc.
- Children: "living at home" and/or "not living at home" or "none"

5.3.3. Survey routing

First, each respondent will get the same introductory questions. Then, each respondent is "randomized" assigned to whether he gets a booster or not, and to the choice sets from block 1 or 2. As Panelclix gains respondents real quickly, this randomization is done by the minute they start to fill in the questionnaire (see Table 5.3 for the version per starting minute). For example, if a respondent starts the survey at 15:44, he will get a survey with the booster, and choice sets from block 1. If a respondent starts the survey at 15:45, he will fill in a survey without a booster, and choice sets from block 1. After the choice sets, each respondent gets the same personal- and morality questions.

Table 5.3: Survey versions

ID.start minute	Introductory questions	Booster	Choice sets Block 1	Choice sets Block 2	Personal questions	Morality questions (30)
0, 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56	X	X	X		X	X
1, 5, 9, 13, 17, 21, 25, 29, 33, 37, 41, 45, 49, 53, 57	X		X		X	X
2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58	X	X		X	X	X
3, 7, 11, 15, 19, 23, 27, 31, 35, 39, 43, 47, 51, 55, 59	X			X	X	X

5.3.4. Number of respondents required

A parameter β is statistically significant if the t-value $|t| > 1.96$. As $t = \beta/SE$; $|\beta| > 1.96 * SE$ for statistical efficiency. The SE is normally only known if the data is available, however, assuming the prior is correct, the standard error (SE) for $N = 1$ for a given experimental design can be calculated. Based on the efficient design given by Ngene, the number of respondents required to assure parameters are statistically significant, the so-called *Sp-estimates*, are calculated and given in Table 5.4. Price has the highest Sp-estimate (230 respondents), as it has the smallest prior. However, as a blocked design is used, more respondents is preferred.

Table 5.4: Amount of respondents needed to reach statistical significance of each parameter

Prior	**LDW**	**EBP**	**EBC**	**SL**	**ACC**	**LUX**	**PR**
Fixed prior value	0.176	1.51	1.43	0.449	0.989	1.35	-0.115
Sp estimates	119.659	4.931	3.636	16.056	6.401	4.277	229.257

6

Data Analysis and Model Estimation

section 6.1 presents how the survey data is collected and prepared for data analysis. In section 6.2 is elaborated on the respondents that filled in the questionnaire, and if the sample is representative for the Dutch population. In section 6.3, the scores of the respondents on the five moral foundations are estimated, based on the Moral Foundations Questionnaire. section 6.4 presents the binomial variables that are used in the models. In section 6.5, the distribution- and correlation of the perception ratings are analyzed. In sections 6.6 and 6.7, is elaborated on how the models for the ordinal regression- and discrete choice models are estimated.

6.1. Data collection and preparation

Data is collected with the online panel Panelclix at 19 February 2019. Panelclix pays respondents a small fee after completing a survey. The only prerequisite for respondents to participate in the survey was to have a drivers license. In total, the budget allowed 424 respondents completing the survey, with an average completion time of 10 minutes and 25 seconds.

Online data collection is fast and relatively cheap compared to conducting (in-depth) interviews. Consequently, the quality of the data might be lower. There is a risk that respondents only complete the questionnaire to receive the fee, not putting in effort. Panelclix already takes measures to prevent these cheaters from participating in surveys (see Coenders (2012)). However, the respondents could suffer from survey fatigue due the length of the survey, resulting in less accurate answers near the end. Therefore, respondents are removed based on the "cheater check questions" included in the Moral Foundation Questionnaire (see section 5.3.2). One wrong answer could be simply a mistake, therefore excluding too many participants. Therefore, if one of the check question is answered "wrong", the other answers of the respondent are more closely examined. In total, 33 respondents are removed based on the following reasons;

- If the respondent gave the same answer to all other MFQ questions, also called "straight-lining", the respondent is removed. For example, if the respondent picked the fifth option in all MFQ questions, including the check question which he has answered "wrong". 27 respondents are removed this way.
- If a "wrong" answer is given on both check questions, the respondent is removed. 6 more respondents are removed this way.

After removal of potentially fraudulent respondents, 391 respondents are left for analysis. 47% of these respondents filled in the choice sets from block 1, while 53% filled in the choice sets from block 2. 49% of all respondents saw the booster before starting the choice set, of which 95% stated that they already knew about this rule.

6.2. Respondents characteristics

The distribution of the age of the respondents, compared with the distribution of the whole Dutch population with a drivers license in January 2019 is shown in Table 6.1. Except for the 75 years old, the respondent group is similar to the Dutch population with a drivers license in age. Other characteristics of the respondents, and if available, a comparison with the Duch population are shown in Table 6.1 as well. The respondent group is representative for both genders.

Table 6.1: Distribution of respondents Age, Gender, Education, Income and Car ownership (in percentages of N = 391), for age compared to the Dutch population with a drivers license in January 2019 Centraal Bureau Statistiek (2019b), for the others compared to the total Dutch population that was 18+ years old in 2018 Centraal Bureau Statistiek (2019a)

		Respondents	**Dutch population with a drivers license (2019)**
Age	18-19 years	1,3%	1,8%
	20-29 years	12,5%	14,6%
	30-39 years	15,9%	15,9%
	40-49 years	22,0%	18,0%
	50-59 years	22,0%	20,1%
	60-69 years	17,6%	16,2%
	70-74 years	6,6%	6,7%
	75+ years	2,0%	6,8%
		Respondents	**Dutch population (2018)**
Gender	Male	51,2%	51,0%
	Female	48,8%	49,0%
Education	High school	17,9%	
	MBO	40,9%	
	HBO	29,2%	
	WO	12,0%	
Income	<10.000	7,4%	
	10.000-20.000	15,9%	
	20.000-30.000	20,5%	
	30.000-40.000	22,8%	
	40.000-50.000	15,3%	
	50.000-60.000	11,0%	
	60.000-100.000	5,3%	
	>100.000	1,8%	
Car ownership	Private lease	6,1%	
	Business lease	4,6%	
	Privately owned	78,8%	
	None	10,5%	

ADAS ownership and desirability
The distribution of answers to the first 5 questions, that were used to explain the systems to the respondents, can be seen in Figure 6.2. Generally, people that don't have ADAS, would like to have it. Especially, the two Emergency Braking systems and Adaptive cruise Control are desired. Intelligent Speed Limiting and Lane Departure Warning are less desired. This gives an estimate of the preferences that will be found in the discrete choice model with ADAS.

Table 6.2: Ownership and desirability of Advanced Driver Assistance Systems (N=391)

	LDW	**EBP**	**EBC**	**SL**	**ACC**
I have it, and I use it (it is on)	12%	10%	12%	16%	31%
I have it, but I don't use it (it is off)	6%	3%	4%	7%	9%
I don't have it, but I would like to have it	57%	70%	70%	47%	43%
I don't have it, and I would not like to have it	22%	12%	11%	26%	14%
I don't know if I have it	4%	4%	4%	4%	2%

6.3. Respondents scores on the moral foundations

To score each respondent on each of the five moral foundations, the MFT prescribes to take the mean of six specific questions of the MFQ (MoralFoundations.org, 2008), which can be found in Appendix G. For each respondent, the scores on the 5 moral foundations are calculated, of which the distributions are presented in Table 6.3. At average, the Harm foundation is scored highest, followed by Fairness. Harm and Fairness are thus, at average, the two most important foundations for the respondents, and Ingroup is the least important.

Table 6.3: Distribution, mean and median of all respondents' scores on the five moral foundations

	Harm	**Fairness**	**Ingroup**	**Authority**	**Purity**
4-5	18%	14%	2%	3%	6%
3-4	43%	40%	23%	27%	26%
2-3	34%	39%	49%	55%	49%
1-2	5%	8%	23%	14%	18%
0-1	0%	0%	4%	1%	2%
Mean	3,32	3,21	2,52	2,74	2,75
Median	3,33	3,17	2,5	2,67	2,67

6.4. Binomial variables

The variables that are included as explanatory factors in the models, are converted to the binomial level for ease of modelling. These are shown in Table 6.4. Beneath "% of respondents" is stated which percentage of the respondents scored positive on this factor (value 1).

Next to the factors that were mentioned in section 4.3, that are included to test the hypotheses, other socio-economic variables are included in the models as explanatory variables. **Gender** and **Age** are the most common used socio-economic variables in research regarding driver acceptance of in-vehicle technology (Rahman et al., 2018). Level of **Education** is included, as highly educated people might be better informed about the safety improvements due ADAS. Whether a person has **Children** might influence morality, as this makes people more caring and wanting to give the right example. Having been involved in a **Car accident**, might make people more aware of the dangerous aspect of driving a car, and therefore preferring external safety. As price is also included as a car attribute, **Income** is included in the models as well.

As from section 6.3 resulted that the mean and median of all scores on the moral foundations lie around 3, is chosen that a "high" score on a moral foundation is above 3, and a "low" score is 3 or lower.

Table 6.4: Variables

Variable	**Variable has value 1 if the respondent...**	**% of respondents**
Booster	had the booster included in his/her survey	49%
Age 65 +	is 65 years or older	19%
Gender	is female	49%
high Education	his/her highest level of education is HBO or WO	41%
Children	has children	67%
Harm	scores above 3 on the Harm foundation	61%
Fairness	scores above 3 on the Fairness foundation	54%
Ingroup	scores above 3 on the Ingroup foundation	25%
Authority	scores above 3 on the Authority foundation	30%
Purity	scores above 3 on the Purity foundation	32%
Accident self	has been involved in a car accident (past 2 years)	13%
Accident relative	has a close relative involved in a car accident (past 2 years)	24%
low Income	has a bruto yearly income below 20.000 euro	23%

All factors are included in this format in the ordinal regression- as well discrete choice models, except for "Age 65+". Age is included as a binomial variable in the discrete choice models, but as a continuous variable in the regression models.

6.5. Safety and comfort perception ratings of ADAS packages

Each respondent had to rate their perception on internal safety-, comfort- and external safety improvement of a vehicle due each ADAS package in the choice sets. In total, 10.557 perception ratings are collected (391 respondents x 3 choice sets x 3 packages x 3 perceptions). The distribution and correlations between the three rated perceptions are given in Table 6.5.

Most answers (+-94%) are in the range from 3 (neutral) till 5 (a lot better). Most respondents perceive that the packages improve safety and/or comfort. The correlations between the 3 perceptions should be as low as possible (to be sure people understand the difference). The correlations PIS-PC and PIS-PES are higher, compared to PC-PES. This could be due the fact that PIS-PC are both about people inside of the car, and PIS-PES are both about safety. PC-PES are more clearly different concepts.

Table 6.5: Distribution and correlations of observed perception ratings (N=10.557)

Rating	Perceived Internal Safety	Perceived Comfort	Perceived External Safety
1 (a lot worse)	2%	1%	1%
2 (a bit worse)	5%	5%	4%
3 (neutral)	31%	31%	23%
4 (a bit better)	44%	43%	45%
5 (a lot better)	19%	19%	26%
Mean	3,74	3,74	3,92
Median	4	4	4
Stand. Dev.	0,87	0,88	0,86

Correlations
PIS-PC 0,63
PIS-PES 0,61
PC-PES 0,53

6.6. Ordinal regression models

As was said in section 4.4, **cumulative odds ordinal logistic regression with proportional odds** is carried out, to explore which ADAS and factors have a significant effect on how the respondents arrive at their stated external safety-, internal safety- and comfort (PC) perceptions. The parameters are estimated by conducting ordinal regression analysis with SPSS, that is a statistical software package. First, the concept of Binomial Logistic Regression (for binary outcomes) is explained in section 6.6.1, as the key concepts are the same for ordinal logistic regression. Then, the concept of ordinal logistic regression (for ordinal outcomes) is explained in section 6.6.2. Finally, the model estimation procedure is presented in section 6.6.3

6.6.1. Binomial logistic Regression

Logistic regression is used for the analysis of binary outcome variables. These outcomes are coded as 1 if the event does occur (success), and 0 if the event does not occur (failure). The Odds express the likelihood of this event occurring, relative to the likelihood of this event not occurring. If we know the probability of an event occurring, the odds are given by Formula 6.1.

$$\text{Odds} = \frac{\text{Prob(success)}}{1 - \text{Prob(success)}} = \frac{\text{Prob(success)}}{\text{Prob(failure)}} \tag{6.1}$$

A logit is the natural log of the odds of an event occuring, as shown in equation 6.2. Where ln means the natural log.

$$\text{logit} = ln\left(\frac{\text{Prob(success)}}{\text{Prob(failure)}}\right) \tag{6.2}$$

The log odds of an event occurring (a success) can be modelled as a linear expression of a set of explanatory variables. This regression equation can be generalized to include any number of explanatory variables;

$$ln\left(\frac{\text{Prob(success)}}{\text{Prob(failure)}}\right) = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \cdots + b_n x_n \tag{6.3}$$

6.6.2. Ordinal logistic regression

Instead of modelling the probability of an individual event, as in binomial logistic regression, in ordinal logistic regression we are considering the probability of that event and all others above it in the ordinal ranking. Therefore, we are concerned with *cumulative* probabilities and odds, rather than probabilities and odds for discrete categories.

An ordinal logistic regression can be considered as a series of binomial logistic regressions, run simultaneously on cumulative logits. Essentially, cumulative logits split an ordinal dependent variable in two, with lower values (categories) of the ordinal dependent variable considered the event/success, and all higher categories considered the non-event/failure. The cumulative categories for the perceptions are shown in Table 6.6. As there are 5 categories of the ordinal outcome variable (each perception is measured in 5 categories), there are 4 cumulative logits (j) for each perception. Due the standard settings of SPSS, we are considering the probability of giving a certain rating or lower in the ordinal ranking as the "target category".

Table 6.6: Cumulative categories for the Perceptions

j	"Target category"	Other categories
1	Prob (cat. ≤ 1) *"a lot worse"*	Prob (cat. > 1) *"a bit worse", "neutral", "a bit better" or "a lot better"*
2	Prob (cat. ≤ 2) *"a lot worse" or "a bit worse"*	Prob (cat. > 2) *"neutral", "a bit better" or "a lot better"*
3	Prob (cat. ≤ 3) *"a lot worse", "a bit worse" or "neutral"*	Prob (cat. > 3) *"a bit better" or "a lot better"*
4	Prob (cat. ≤ 4) *"a lot worse", "a bit worse", "neutral" or "a bit better"*	Prob (cat. > 4) *"a lot better"*

For each cumulative logit, a separate binary logistic regression could be estimated. However, this may lead to estimating more parameters than are necessary to account for the relationships between the explanatory variables and the outcome. Instead of estimating four separate models, a cumulative odds model estimates the odds of being at or above a given threshold, across all cumulative splits, in a single model. Simultaneously, the effects of the set of explanatory variables, across these possible consecutive cumulative splits in the outcome, are considered in this model. To do this, the simplifying assumption is made that the effects of the explanatory variables are the same across the different thresholds; the assumption of proportional odds.

The above will lead to a logistic regression (expressed in logit terms) where the intercepts (called thresholds) will differ for each cumulative logit, but the slope coefficients will remain the same. This is expressed in equation 6.4, with the categories as presented in 6.6, denoted by j. In this equation, the ADAS are included as explanatory variables, in which each ADAS has value 0 if this ADAS is included, and 1 if it is not included in the package.

$$\ln\left(\frac{\text{Prob (cat. } \leq \text{j)}}{\text{Prob(cat.} > \text{j)}}\right) = \alpha_j - \left(\beta_{LDW} * LDW + \beta_{EBP} * EBP + \beta_{EBC} * EBC + \beta_{SL} * SL + \beta_{ACC} * ACC\right) \tag{6.4}$$

The parameters of the cumulative odds model consist of a separate intercept term at each threshold, denoted by α_j, and slope coefficients for the effect of each explanatory variable, denoted by βs. The threshold coefficients α_j are not usually interpreted individually. They represent the point (in terms of a logit), where perceptions might be predicted into the higher categories. The minus sign after α_j lets positive coefficients of the explanatory variables (βs) represent higher predicted values, and negative coefficients represent lower predicted values.

Estimating predicted probabilities

The logistic function transforms the log odds (or logits) to express them as predicted probabilities. Figure 6.1 shows the relationship between the log odds of an event occurring and the probabilities of the event as created by the logistic function. This function gives the distinct S shaped curve.

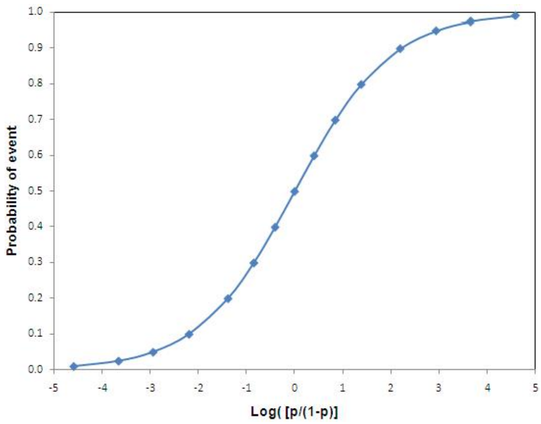


Figure 6.1: The logistic function (Strand et al., 2011)

First, the reverse of the log (called the exponential or anti- logarithm) is applied to both sides of the equation, eliminating the log on the left hand side, so the odds can be expressed as:

$$\frac{P}{1-P} = \frac{\text{Prob(success)}}{1-\text{Prob(success)}} = \text{Exp}(a+bx) \tag{6.5}$$

Then, the formula can be rearranged to solve for the value P as in equation 6.6. With this formula, the predicted probability of an event can be calculated for each individual providing a set of data.

$$Prob(Success) = \frac{\text{Exp}(a+b_1x_1+...)}{1+\text{Exp}(a+b_1x_1+...)} \tag{6.6}$$

6.6.3. Ordinal regression model estimation procedure

SPSS ordinal regression always automatically takes the LAST category of a nominal or ordinal explanatory variable as the reference category. For example, this means that an ADAS being included is the reference category. As this is a bit hard to interpret, the ADAS and variables of Table 6.4 are recoded such that an ADAS not being included, and scoring value 0 on the variables of Table 6.4 (for example; not having children, the booster not being included), are the reference categories.

1. First, a cumulative odds model is estimated for each perception, based on Equation 6.4. The resulting parameters and model estimates are presented in Table 7.1.

2. Then, the direct- and interaction effects of the variables on the perceptions are tested, by including them separately in the ordinal regression model of step 1. One by one, the most insignificant interaction effect is removed, resulting in only the significant interaction effects, and/or a (in)significant direct effect of each variable.

3. Last, a new ordinal regression model is created for each perception, including the significant effects that resulted from step 2. If a direct effect is insignificant, but it is part of an interaction effect that is significant, it is included in the model as well. The parameters that turned out insignificant in this "full model", are removed one by one as well (the most insignificant first), except if they are part of a significant interaction effect. The resulting parameters are shown in Table 7.3.

For the final equations, the direct- and interaction effects should be added after $\beta_{ACC} * ACC$ in equation 6.4. For example, the direct and interaction effects of high Education in the equation for PIS should be added with $\beta_{highEdu} * highEdu + \beta_{EBP}^{highEdu} * highEdu * EBP$, in which $highEdu$ has value 1 if a respondent is highly educated, and 0 if he is not. $\beta_{highEdu}$ denotes the slope coefficient of the direct effect of high Education on PIS. $\beta_{EBP}^{highEdu}$ denotes the slope coefficient of the interaction effect of high Education with EBP being included.

6.7. Discrete Choice Models (DCM)

From the observed choices, discrete choice models are estimated that indicates whether Perceived Internal Safety (PIS), Perceived External Safety (PES), Perceived Comfort (PC), Luxurious features (LUX) or Price (PR) have a stronger effect on utility, and as such on choices. To research to what extent the perceptions mediate the effects of the ADAS, also discrete choice models are estimated in which choices are made based on the included ADAS, instead of the perceptions. The discrete choice models are estimated with Pandasbiogeme, a Python package designed for estimating parameters of discrete choice models using maximum likelihood estimation (Bierlaire, 2018b).

6.7.1. DCM based on perceptions

Equation 6.7 presents the utility function for the packages, on which the first discrete choice models are based. PIS_i, PES_i and PC_i represent the scores for perceived internal safety, external safety and comfort given for this package, with values ranging from 1 to 5. LUX_i has value 1 if the luxe seating material and multi-mediaystem are included, or value 0 if it these are not included in package i. PR_i has value 1 if the package costs 20 euro/month, and 0 if the package costs 10 euro/month. Each corresponding β represents the weight of this attribute in decision making.

$$U_i = \beta_{PIS} * PIS_i + \beta_{PES} + PES_i + \beta_{PC} * PC_i + \beta_{Lux} * Lux_i + \beta_{PR} * PR_i \tag{6.7}$$

1. **MNL**
   We start with the equation as denoted in Equation 6.7, and add an interaction effect one at a time. For example, the interaction effect of the booster with PES is denoted by $\beta_{PES}^{Booster}$. When calculating the utility a person derives from a package, the relevant part of the utility function for PES becomes $\beta_{PES} * PES_i + \beta_{PES}^{Booster} * Booster * PES_i$, in which $Booster$ denotes if the booster was included in the survey of the respondent (1) or not (0). By adding each interaction effect to the model, iteratively, is explored which of the personal characteristics and the booster have a statistically significant effect on the choice for an ADAS package. A parameter is statistically significant at the (conventional) 95% confidence level, if the absolute t-value is above 1.96. However, some of these effects correlate with each other, explaining the same variance. When all the found significant effects are added in the same model, this results in some of these effects turning out to be insignificant. Again, one by one, the most insignificant effect is removed from this model. The resulting parameters are presented beneath "MNL", in Table 7.4.

2. **Panel ML 1 - without interactions**
   Then, is estimated with a Mixed Logit model how PIS, PES and PC, luxe and price weight at average in consumers preference for a package. First, a model with just the attributes is estimated with 1000 Halton draws, in which all of the betas for attributes were allowed to be heterogeneous. Thus, σ_β's are calculated for each of the attributes. No significant levels of unobserved heterogeneity for the PC parameter were found (the σ_β for PC was insignificant), hence it is estimated as a crisp parameter. This model, with only PIS, PES, Luxe and PC allowed to be heterogeneous, is estimated again with 1000 Halton draws. The resulting parameters are presented beneath "Panel ML-1" in Table 7.4.

3. **Panel ML 2 - with interactions**
   With the interaction-effects resulting to be significant from the full MNL model, and the sigma's resulting to be significant in the panel ML-1 model, another ML model is estimated. This is expected to make the sigmas estimated in panel ML-1 smaller, as these are "explained away" by the factors.

This resulted in the following utility function;

$$\begin{aligned} U_i = {} & \beta_{PIS} * PIS_i \\ & + \beta_{PES} * PES_i \\ & + \beta_{PC} * PC_i + \beta_{PC}^{Fairness} * \text{Fairness} * PC_i \\ & + \beta_{LUX} * LUX_i + \beta_{LUX}^{Age} * \text{Age} * LUX_i \\ & + \beta_{PR} * PR_i + \beta_{PR}^{lowIncome} * \text{lowIncome} * PR_i \\ & + \epsilon_i \end{aligned} \tag{6.8}$$

With $\beta_{PIS} \sim N(\beta_{PIS}, \sigma_{PIS})$, $\beta_{PES} \sim N(\beta_{PES}, \sigma_{PES})$, $\beta_{LUX} \sim N(\beta_{LUX}, \sigma_{LUX})$, $\beta_{PR} \sim N(\beta_{PR}, \sigma_{PR})$.

6.7.2. DCM based on attributes

Lastly, models are estimated in which choices are made based on the included ADAS, instead of the perceptions. The utility of a car alternative in this model thus consists of the included ADAS, the included luxurious features, the price of the total package and the corresponding betas. The model fit of these models is compared to the model fit of the DCM based on perceptions, to research whether the perceptions are fully, or partly, mediated by the ADAS functionalies.

In the final version of the MNL model based on ADAS, luxe and price; *EBC*highFairness, EBP*Gender, LUX*age(65+), PR*Gender, SL*haveChildren, SL*lowIncome* are significant. However, in the ML model, *PR * income* turned out to be insignificant. Therefore this is not taken into account in the final model specification. The final ML model is created with 1000 Halton draws, in which the betas for EBP, SL, LUX and PR are heterogenous. The final MNL, ML-1 and ML-2 can be found in section 7.5.

6.8. Model fit

McFadden's Pseudo R^2

With linear regression, the R-squared statistic is used to determine the amount of variance explained by the model. However, as ordinal regression model is about probabilities, different versions of the R-squared statistic are used, called pseudo R-squared statistics. Pseudo R-squared statistics approximate the amount of variance explained, rather than calculate it precisely. The Mcfadden Pseudo R-squared is presented for the ordinal regression models, that ranges from 0-1, with higher values indicating that more variance is explained.

McFadden's Rho-squared

Model fit of the discrete choice models is compared based on the McFadden's rho-squared (see Ben-Akiva et al. (1985)), that gives the percentage of initial uncertainty from the side of the analyst, that is eliminated by the estimated model. It is estimated by dividing the likelihood of the estimated model, by the likelihood of the model if all parameters are set to 0.

The Rho-squared can also range from 0 - 1, in which 0 means the model does no better than throwing a dice, and 1 means the data perfectly fits the model. There is no rule of thumb for what is a 'good' fit, so it is used in a relative sense, to compare model fit between the discrete choice models.

$$\text{McFadden's Rho-squared} = \frac{LL_\beta}{LL_0} \tag{6.9}$$

Likelihood Ratio Test

Model fit across models can be compared with the Likelihood Ratio test. This estimates the probability that a model fits better due coincidence (i.e., sample pecularities). Therefore, the Likelihood Ratio Statistic (LRS) must be calculated (equation 6.10), and looked up if this is above the critical Chi-square value for the 5% significance level.

$$LRS = -2 * (LL_A - LL_B) \tag{6.10}$$

7
Results

As discussed in chapter 4, we are interested in the weights of the perception ratings, luxe and price (β_{PIS}, β_{PES}, β_{PC}, β_{LUX} and β_{PR}) in relation to each other. Furthermore, we are interested in how the factors (the booster and the five moral foundations) affect these weights and the perception ratings (PIS_i, PES_i and PC_i).

In section 7.1, the average effects of the ADAS on the perception ratings are presented. In section **??**, is presented what effect the ADAS and factors have on the perception ratings. Section 7.3 presents the weights of these safety and comfort perceptions, against the weights of luxe and price. Section 7.4 presents the effects of the factors on the weights of the five ADAS, luxe and price, to see if the perceptions are only partly or fully mediated by the perceptions. Section 7.5 links the results to the hypotheses of section 4.3.

7.1. Effect of the ADAS on the perceptions at average

The average effects of the ADAS on the perception ratings of a package, according to ordinal regression equation 6.4, can be found in Table 7.1. The parameters in this model consist of four thresholds and five slope coefficient, that are all highly statistically significant ($p < .0005$), as assessed with the Wald test. This table is used for interpreting which ADAS are perceived to improve at average Internal Safety, Comfort and External safety most. For this purpose, only the slope coefficients of the ADAS (representing the β's of equation 6.4) are considered, located in the "B" columns. Each slope coefficient is expressed as the change in log odds due including this ADAS. A higher value, means a higher increase in probability for a high perception rating if this ADAS is included in a package, when everything else is left unchanged.

Table 7.1: Parameters and Model fit of the Ordinal Regression models

	Perceived Internal Safety (PIS)			**Perceived Comfort (PC)**			**Perceived External Safety (PES)**		
	B	**SE**	**Wald**	**B**	**SE**	**Wald**	**B**	**SE**	**Wald**
Treshold [Perception rating = 1]	-2.858	.164	302.212	-3.140	.171	337.897	-3.245	.185	307.905
[Perception rating = 2]	-1.401	.114	150.637	-1.477	.113	171.422	-1.728	.120	206.804
[Perception rating = 3]	.882	.103	73.541	.680	.102	44.712	.440	.103	18.342
[Perception rating = 4]	2.971	.115	673.104	2.699	.112	579.134	2.592	.112	531.102
Lane Departure Warning (LDW)	.517	.066	61.997	.265	.065	16.641	.346	.066	27.587
Emergency Braking for Pedestrains (EBP)	.786	.071	123.111	.567	.070	65.738	1.412	.074	364.557
Emergency Braking for Cars (EBC)	.868	.071	150.660	.474	.069	46.748	.822	.071	133.842
Intelligent Speed Limiting (SL)	.385	.065	34.696	.512	.065	61.401	.202	.066	9.420
Adaptive Cruise Control (ACC)	.351	.066	28.500	.642	.066	94.664	.179	.066	7.358
Mc Fadden's pseudo R^2		.027			.020			.047	

To illustrate this, the parameters from Table 7.1 are used to estimate the cumulative probability for rating each of the five PES categories, if a package consists of only ACC, if a package consists of ACC & EBP, and if a package consists of ACC & EBC. Therefore we use equation 6.6. For the ACC package, the probability that Rating 1 ("not at all") is given is 3%, as EXP(-3.245-.179)/(1+EXP(-3.245-.179))= 0,03. For a package in which

EBP as well ACC are included; the probability that this low rating is given is only 0.7%, as EXP(-3.245-.179-1.412)/(1+EXP(-3.245-.179-1.412))= 0,007. The cumulative probabilities can be calculated this way for the other cumulative categories as well, resulting in Table 7.2. By looking at these probabilities, can be seen that a package with EBP indeed has a higher probability for a high PES rating, than a package with EBC (see as well the higher change in log odds for EBP compared to EBC in Table 7.1).

Table 7.2: Predicted probabilities for the cumulative categories, for a package with only ACC, a package with ACC and EBP, and a package with ACC and EBC

	only ACC	ACC & EBP	ACC & EBC
PES Rating 1	3%	1%	2%
PES Rating 1 or 2	13%	4 %	6%
PES Rating 1, 2 or 3	56%	24%	36%
PES Rating 1, 2, 3 or 4	92%	73%	83%
PES Rating 1, 2, 3, 4, or 5	100%	100%	100%

By keeping in mind that a higher coefficient, means a higher probability for a high perception score, the other coefficients of the ADAS in Table 7.1 are interpret as well. All have a positive sign, which means that at average each ADAS is perceived to improve all three driving goals. The following observations can be made, by looking at the relative improvement of the perceptions due each of the five ADAS;

- Both the emergency braking systems (EBP and EBC) score high in perceived increase in internal, as well external safety. This is expected, as emergency braking has showed to be most promising in lowering car accidents (Cicchino, 2017; Fildes et al., 2015).
- EBP and EBC were included as separate attributes, so a clear distinction can be made between packages that are perceived to increase mainly external safety, and packages that are perceived to mainly increase internal safety. It was expected that EBP is mainly perceived to improve external safety. Indeed, people perceive that EBP adds most to external safety, and less to internal safety, compared to EBC.
- This difference for PES is very clear (1.1412 for EBP and .822 for EBC). However, the difference for PIS is less clear (.786 for EBP and .868 for EBC). This relatively high increase in the PIS rating if EBP is included in a package makes less sense, as EBP brakes for pedestrians/bicycles. These are assumed to not really pose a threat for people inside of the car. Also, the relatively high coefficients for increase in comfort for the two emergency braking systems are unexpected, as these are only meant for safety. It could be that people perceive the fact that they have less chance of an accident as comfort enhancing. Another possibility for these unexpected ratings could be that the respondents don't fully understand the functionality of these systems.
- ACC was added as an attribute, so packages would be included that are perceived to mainly improve comfort. Indeed, ACC leads to the highest increase in comfort, and the lowest increase in safety of all ADAS.

The result of the McFadden pseudo R^2 is worth mentioning as well. Comparing these, shows that the proportion explained variance of the PES model is much higher than of PIS and PC. Hence, PES of a package can be predicted with more precision than PIS and PC. Possibly, interactions between attributes play a bigger role in the PIS and PC models and/or respondents are more heterogeneous in their external safety perceptions than in their internal safety- and external safety perception.

7.2. Effect of the ADAS and factors on the perceptions

In addition to the five ADAS, several direct and interaction effects with the booster, moral foundations, and socio-economic variables were found to be significant. These are shown in Table 7.3. The effects in italic are insignificant by themselves, however they have a significant interaction effect with one of the ADAS, and therefore are included in the model. The higher pseudo R^2 values, shows that these models are better at explaining variance than the models without interaction effects. Again, the model for PES best explains variance of these three.

Booster

Showing the booster to people, results in them giving significantly lower ratings to PIS, PC and especially PES.

Table 7.3: Ordinal regression parameters with personal characteristics and booster

	Perceived Internal Safety			Perceived Comfort			Perceived External Safety		
	B	**SE**	**Wald**	**B**	**SE**	**Wald**	**B**	**SE**	**Wald**
1 (thresholds)	-2.428	.225	116.018	-2.699	.204	174.411	-3.116	.202	237.285
2	-.956	.192	24.650	-1.026	.160	41.393	-1.592	.146	118.726
3	1.418	.188	56.668	1.203	.154	61.124	.640	.133	23.004
4	3.650	.197	342.315	3.344	.164	417.627	2.943	.143	422.789
Lane Departure Warning (LDW)	.592	.071	69.905	.268	.065	16.748	.358	.067	28.804
Emergency Braking for Pedestrains (EBP)	.488	.139	12.234	.616	.102	36.330	1.063	.108	96.433
Emergency Braking for Cars (EBC)	.717	.110	42.654	.520	.103	25.605	.853	.072	139.793
Intelligent Speed Limiting (SL)	.391	.066	34.975	.524	.066	63.255	.217	.067	10.640
Adaptive Cruise Control (ACC)	.365	.066	30.218	.818	.091	80.738	.183	.067	7.459
Booster	-.309	.065	22.457	-.205	.064	10.104	-.425	.066	41.935
Harm	*(-.107)*	*.138*	*.596*	.190	.081	5.447	*(-.037)*	*.104*	*.131*
Harm * EBP	.512	.139	13.543				.665	.132	25.523
Harm * EBC	.304	.138	4.870						
Fairness	.500	.085	34.541	.348	.084	17.201	.647	.085	57.566
Authority	.399	.087	20.770	.337	.111	9.284	.298	.088	11.442
Authority * EBP				.532	.141	14.268			
Purity	-.175	.086	4.166	-.229	.110	4.351	-.189	.086	4.802
Purity * EBC				.317	.139	5.201			
Age (continuous)	.009	.002	15.136						
Gender	*(-.087)*	*.090*	*.936*	.195	.089	4.749			
Gender * EBP	.277	.128	4.696						
Gender * ACC				-.333	.126	6.961			
high Education	.216	.094	5.235	.257	.130	3.928			
high Education * EBP	-.289	.130	4.924	-.455	.136	11.133			
high Education * EBC				-.316	.136	5.372			
Children				.156	.069	5.165	.207	.069	.9.018
Accident self	*(-.005)*	*.136*	*.001*						
Accident self * LDW	-.446	.189	5.98						
Accident relative				.250	.075	11.170			
low Income	-.241	.080	9.071	-.289	.079	13.192	-.315	.077	16.941
Mc Fadden's pseudo R^2		.062			.050			.082	

This could be due the fact that people that saw the booster are more inclined on the moral aspect. The effect is biggest for perceived external safety, which has the most clear moral aspect.

Moral foundations
Next, the effects of the moral foundations are presented. All moral foundations, except Ingroup, play a significant role. There are only interaction effects of the moral foundations with EBP and EBC. These are also the systems that most explicitly have a moral dimension, as they mostly are perceived to improve safety. Moral people could thus be more inclined to safety.

- People that score high on the Harm foundation, perceive that comfort increases more than people that score low in harm. However, the interaction effects are highest; they perceive that EBP improve internal as well external safety much more, and they also perceive that EBC improves internal safety more.
- There are only direct effects of **Fairness**, with all three perceptions, that are fairly high.
- **Authority** also has positive direct effects on all three perceptions, however a bit lower. Interestingly, people that score high on authority perceive EBP to be more comfort enhancing.
- People that score high on **Purity**, give at average lower perception ratings to all perceptions. However, they perceive EBC to be more comfort enhancing.

Other interesting effects

- An older respondent, gives higher PIS ratings at average. Unlike the other variables, Age is a continuous variable. Therefore, the effect should be multiplied with the age of the respondent. Marchau et al. (2001) also found that driving assistance is more preferred by older drivers.
- Women perceive that driving comfort is increased more by ADAS, than men. Marchau et al. (2001) also found that women prefer systems at average more than men. This could be due women are generally less sure about their driving style. However, woman are less comfortable with ACC.
- An interesting effect is that EBP is perceived less safety enhancing by highly educated people, than by lower educated people. Also, both EBP and EBC are perceived as less comfort enhancing than by highly educated people. This means that the unexpected high parameters of EBP for PIS and PC ratings, and of EBC for PC ratings in Table 7.1 can be explained by education. Lower educated people might not fully understand the functionality of EBP and EBC.
- Respondents with children perceive that, at average, comfort and external safety are more enhanced. They could be more inclined on these aspects, as comfort increases for the whole family that uses the car, and parents are more aware of the dangers of cars for children.
- A low income results in, at average, lower PIS, PES, PC ratings. This could be due poor people having no interest in these "extra" options, as they would not be able to include them anyway due the costs.

7.3. Effect of the factors on the weights of the perceptions, luxe and price

As the ways in which ADAS and the factors are perceived to change personal driving goals are now known, the question arises of the ways in which these perceived changes affect overall preference for a package with ADAS.

The weights of the perceptions, luxe and price in the preference for ADAS packages are shown in the first five rows in Table 7.4. The weights for the perceptions represent the increase in utility of a package due an improvement of 1 point (e.g. from rating 4 to rating 5). The weight for Luxe represents the increase in utility if the luxe systems are included, compared to a package in which these are not included. The weight for price represents the increase in utility if a package is 20 euro/month, instead of 30 euro/month. As the perceptions on the included ADAS can have values ranging from 1-5, and luxe and price both only can have value 0 or 1, the magnitude of the betas can not easily be compared. Relative importance can be inferred, by multiplying each perception parameter with 5 (the attribute range that is present in the data).

The sigmas of these ADAS reflect the unexplained heterogeneity of the parameters of the ADAS, as shown in the two panel ML models. In the second ML model the heterogeneity is lower than in the first ML model, as some of the heterogeneity is explained away by the included interaction effects.

Table 7.4: DCM perceptions

	MNL			panel ML-1			panel ML-2		
	Est.	**SE**	**t**	**Est.**	**SE**	**t**	**Est.**	**SE**	**t**
Perceived Internal Safety (PIS)	.384	.083	4.63	.544	.121	4.51	.547	.124	4.43
Perceived Comfort (PC)	.231	.092	2.53	.720	.105	6.87	.428	.134	3.19
Perceived External Safety (PES)	.354	.068	5.19	.526	.121	4.35	.489	.118	4.15
Luxe (LUX)	.384	.083	4.63	.738	.119	6.20	.710	.131	5.43
Price (PR)	-.523	.075	5.19	-1.16	.148	-7.84	-1.00	.160	-6.27
Sigma Perceived Internal Safety				-.862	.197	-4.38	.857	.205	4.19
Sigma Perceived External Safety				-.721	221	-3.26	.610	.230	2.65
Sigma Luxe				1.14	.166	6.84	.913	.160	5.70
Sigma Price				1.75	.188	9.34	1.73	.187	9.22
PC * high Fairness	.392	.129	3.03				.435	.185	2.35
LUX * age (65+)	-.596	.169	-3.53				-.765	.249	-3.07
LUX * low Income	.408	.167	2.44				.543	.240	2.26
PR * low Income	-.545	.168	-3.24				-.684	.294	-2.32
0-LL		-1288.672							
Final-LL		-1120.012			-1079.270			-1068.808	
Rho-squared		.131			.163			.171	

The following observations can be made by looking at the panel ML-1 model, that shows the average weights;

- At average, PC has most impact on utility (3.6 utils), followed by PIS (2.72 utils), PES (2.63), Price (-1.16 utils) and lastly Luxe (.738 utils).
- At average, packages with ADAS that increase perceived comfort and safety for themselves, are preferred over ADAS that improve safety for other road users. In research of Molin and Marchau (2004), the driving-safety perception and driving-comfort perceptions both had the largest effect on overall attractiveness as well. However, both effects were equally high, while here perceived driving comfort is more important than perceived safety for drivers themselves (.720 versus .544), which means that changes in perceived internal safety are more important than changes in perceived comfort.
- As expected, preference for a package decreases with an increasing price.
- Most heterogeneity between respondents exists within the weight of price- and luxe, as shown by the high sigmas. There is no significant heterogeneity within the weight of PC.

The following observations can be made regarding the factors, by looking at the panel ML-2 model, in which some of the heterogeneity is explained by the interaction effects with the factors.

- The effects of the booster on the weights are very small, and therefore not included in the Table.
- Also, the effects of education and children were insignificant.
- People with a high score on fairness, perceive a high comfort rating as more important, which is an unexpected effect as comfort does not have an explicit moral aspect.
- People that are 65+ years old, perceive luxe as less important.
- People with a low income, perceive luxe as more important than people with a high income. Also, as expected, they perceive a low price as more important than people with a high income.

7.4. Effect of the factors on the weights of the five ADAS, luxe and price

The same type of models are created as in section 7.3, but now with the ADAS included as attributes, instead of the perceptions. The result is shown in Table 7.5. These models have higher Rho squared values, thus a better model fit. This means preference for an ADAS is not explained by just its perceived internal safety, external safety and comfort improvements.

Table 7.5: DCM Attributes

	MNL			panel ML-1			panel ML-2		
	Est.	**SE**	**t**	**Est.**	**SE**	**t**	**Est.**	**SE**	**t**
Lane Departure Warning (LDW)	.814	.081	10.08	.965	.121	7.97	.971	.123	7.87
Emergency Braking Pedestrians (EBP)	1.84	.152	12.15	2.38	.209	11.41	2.14	.232	9.21
Emergency Braking Cars (EBC)	1.11	.135	8.26	1.46	.156	9.35	1.23	.189	6.49
Intelligent Speed Limiting (SL)	.526	.122	4.32	1.30	.138	9.37	.737	.189	3.89
Adaptive Cruise Control (ACC)	1.15	.105	10.95	1.42	.149	9.51	1.42	.151	9.36
Luxes (LUX)	1.08	.111	9.68	.976	.144	6.73	1.16	.160	7.28
Price (PR)	-.299	.092	-3.25	-.677	.139	-4.89	-.463	.180	-2.57
Sigma EBP				.963	.268	3.60	1.03	.264	3.90
Sigma SL				.894	.210	4.25	-.869	.219	-3.96
Sigma LUX				-1.05	.220	-4.76	-.994	.229	-4.35
Sigma PR				1.60	.218	7.34	-1.63	.223	-7.33
EBP * Gender	.339	.146	2.32				.540	.239	2.26
EBC * high fairness	.324	.145	2.24				.476	.214	2.23
LUX * Age65+	.713	.187	-3.82				-1.06	.298	-3.57
PR * gender	-.317	.133	-2.38				-.514	.254	-2.03
SL * have children	.367	.139	2.64				.613	.211	2.90
SL * low Income	.545	.166	3.28				.880	.252	3.49
0-LL	-1288.672								
Final-LL	-953.872			-943.342			-920.486		
Rho-squared	.260			.268			.289		

7.5. Linking the results to the hypotheses

Now we know how the perceptions are influenced by the factors (the booster being present, the innate morality scores and personal characteristics), as shown in Table 7.3. Also, we know how the weights of these perceptions in the preference for a package with extra car attributes, are affected by these factors, as shown in the panel ML-2 model in Table 7.4. By comparing the interaction effects in Table 7.3, and the interaction effects in the panel ML-2 model in Table 7.4, we can say something about the hypotheses regarding innate morality and the booster, that were presented in Table 4.1 in section 4.3.

If one of the perception ratings or weights of the perceptions are significantly different for a certain group (factor), while the others remain the same, this means the part-worth utility of this attribute is higher for this group (i.e., this attribute adds more utility to people that score positive on this factor), thus preference is higher.

- H1: *Score on "**Harm**", correlates with preference for ADAS packages that are perceived to enhance external safety.*

  People that score high on Harm, give higher PC ratings (+.156). They perceive PIS to be more increased by EBP (+.512) and EBC (+.304). They perceive PES to be more increased by EBP (+.665). The weights are not different. So, compared to people that score low on the Harm foundation, they prefer packages with EBP more, as they perceive this increases internal and external safety more. Also, they slightly prefer packages with EBC, as they perceive these increase Internal safety more.

- H2: *Score on "**Fairness**", correlates with preference for ADAS packages that are perceived to enhance external safety.*

  People that score high on Fairness, give higher PES(+.647), PIS(+.500) and PC(+.348) ratings. Also, PIS weights significantly more for people that score high on fairness. Thus the part-worth utilities of PES as well PIS increase.

- H3: *Score on "**Ingroup**", correlates with preference for ADAS packages that are perceived to enhance external safety.*

  This hypothesis is rejected for this sample. Ingroup scores do not have a significant effect on perception ratings or the weights. The ingroup foundation is about patriotism, loyalty, group feeling. These are clearly other concepts than morality in the sense of safety.

- H4: *Score on "**Authority**", correlates with preference for ADAS packages that are perceived to enhance external safety.*

  PES (+.298), PC(+.337) and PIS(+.298) all have higher part-worth utilities, and are thus more important. However, the part-worth utilities of PIS and PC increase more than the part-worth utility of PES. PC increases for people that score high on authority, if EBP is included (+.532).

- H5: *Score on "**Purity**", correlates with preference for ADAS packages that are perceived to enhance external safety.* For people that score high on purity, PIS (-.175), PC (-.229) and PES (-.198) are generally less important. EBC is generally more perceived to increase comfort (+.317).

- H6: *If a morality "**Booster**" is shown, ADAS packages that are perceived to enhance external safety are preferred more.*

  This hypothesis is rejected. Generally, lower PIS (-.309), PC (-.205) and PES(-.425) ratings are given when the booster is included, but the weights do not change due the booster. This means that due the booster, the part-worth utility of PIS, PC and mainly PES become lower, compared to the other attributes. I.e., PIS, PC and PES become less important in the choice for a package due including the booster, which is actually the opposite effect of the goal of the booster. This means that indeed people do not always respond in the perfect rational way, and . Perhaps this could also be due that a lot of people already knew about the booster beforehand, namely 95%.

8
Conclusion, Discussion and Recommendations

8.1. Conclusion

In this research, the role of morality in consumers preference for Advanced Driver Assistance Systems (ADAS) and other car features is studied. A preference for a package is more moral, if there is a higher preference for packages of which the included ADAS are perceived to enhance safety for other road users, over packages of which the included ADAS are perceived to enhance safety or driving comfort of the driver himself. It can be concluded that, when choosing an extra package with car attributes, at average the perceived increase in safety and driving comfort for the driver himself weights more than the perceived increase in safety for other road users.

However, these preferences differ slightly among subgroups. Concerning socio-demographics, an important observation is that people with a low income are more sensitive for price. And with the money they can spend they prefer to buy luxe systems over ADAS, as they perceive ADAS to be less safety and comfort enhancing than people with a high income. Furthermore, is observed that lower educated people might not fully understand the functionality of Emergency braking systems, and therefore overestimate how these increase comfort. Another observation is that for older people, luxe is less important, while the perceived safety improvement due ADAS for themselves is more important.

Also is researched what the role of innate morality is on the preferences. Interestingly, innate morality has a higher impact on the preferences than for example gender. For people that score high on Fairness, Harm and Authority, safety is more important. However, for people that score high on purity, comfort and safety improvements due the ADAS are less important.

Furthermore, it can be concluded that a booster, that creates awareness about responsibility for car accidents, does have an impact on the preferences. However, the effect of this booster is opposite of the intended effects. People thus indeed do not always respond perfectly rational, and this underlines the importance of first testing a booster before applying in real life.

The effect of the included Advanced driver Assistance Systems on preference for a car features package is only partly mediated by the perceived improvement in internal safety, -external safety and -driving comfort due this package. Therefore it is also important that people like the functionality (which driving task it applies to, which intervention level, which road circumstances it can apply to) of the ADAS, next to their perceived improvement in the driving goals.

8.2. Discussion

In section 4.1.1 is outlined why Discrete choice modelling, with a stated choice experiment is carried out in this research. Some points of discussion inherent to this method, and the data analysis, questioning validity of the outcomes, are outlined in chapter.

The definition of morality
When answering the question what the role of morality in the trade-off between ADAS and other car features is, should be noted first that a moral choice for one person, might not be seen as a moral choice for another person. Morality is subjective.

The choices don't have consequences
The downside of stated preference research in general is that the answers of the respondents can be biased as the choices are made in an imaginary choice situation. As the respondent does not really get the package he chooses, the consequence of the choice is not felt. Therefore, the experiment is said to be not *incentive-compatible* (Ben-Akiva et al., 2019). If the respondents have a realistic chance of really getting what they say they prefer, they are unlikely to misrepresent their preferences and risk getting an inferior outcome. However incentive-compatible experiments are preferred, Dong et al. (2010) showed experiments without incentive compatibility are predictive as well.

Moral hypocrisy
Batson (2011) argued that individuals are motivated by moral hypocrisy rather than moral integrity; individuals want to appear moral, while avoiding the costs of actually being moral. This could result in people giving higher scores on the moral foundation questionnaire.

In reality ADAS are not explicitly explained
Before the choice situations, all ADAS are first explained, which is not done in real life before choosing a package. However, as the goal of this study is to estimate consumers "genuine" trade-offs, rather than forecast market demand, the respondents need to understand the trade-offs clearly (Ben-Akiva et al., 2019). Furthermore, only the ADAS attributes are explicitly explained before making choices, which is not done for the luxurious entertainment system and -seating material. This could result in people focusing more on the included ADAS than they would normally do.

The order of rating and choice tasks
It is unknown if by explicitly asking about safety and comfort first, these aspects could influence the choice made after more than they normally would, as respondents are made more conscious of these aspects (Molin et al., 2018). However, if the choice is made before the ratings are asked, respondents could base their perceptions on the choice they made before (self-fulfilling prophecy). Also, by placing the rating tasks before the choice task, decision making is made easier as the respondents have already studied the packages separately before having to make a choice between all of them.

The experimental design is statistically optimized for a certain decision rule
The experimental designs used for deciding which attributes are included in each package are statistically optimized for the Random Utility Maximization decision rule. However, it is unknown whether designs that are optimized for a certain decision rule, trigger this decision rule on the side of the respondent (Van Cranenburgh and Collins, 2018). This could mean that, if the experimental design would be optimized for a different decision rule, this would result in different trade-offs.

In reality more attributes and attribute levels
A stated choice experiment should mimic the environment the consumer will face in the real market as good as possible (Ben-Akiva et al., 2019). In real life, there are many more attributes that could be included in an extra package, that are not taken into account in the stated preference survey. Also, more attribute levels could be of interest for the respondents. For example, also the type of road and weather circumstances under which the ADAS works might be of interest to the respondents. This has not been taken into account in the choice sets. To reflect real world choice situations, more attributes and attribute levels should be included. However, in the first pilot survey more attributes and attribute levels were taken into account, resulting in respondents quitting the survey early. Therefore is chosen to limit the amount of attributes and attribute levels, to 7 attributes in 2 levels.

No "no purchase" option
As in real life respondents might choose not to include an extra package at all, a "no package" option should be included in the choice situations. However, in this experiment the respondents always have to choose a package. This is done, as a "no package option" may be used by the respondents as an easy way out, to avoid difficult trade-offs (Molin, SPM1221 Lecture 6). This results in the fact that in reality, choices could be different.

The difference between leasing and buying a car
This research is focused on people leasing cars. However, the descriptives showed that only 10.7% of respondents has a lease car. This means that there is a possibility that a lot of the respondents don't have experience with leasing, and what is a normal price range for an optional package. It could be researched if choice behaviour is different if the choices are made in a situation where a privately owned car has to be chosen.

Consumer-citizen duality
The survey questions are asked in the consumer perspective. Individuals assign comparatively less value to safety in their role as consumer, than in their role as citizen (Mouter et al., 2018). Therefore, private choices not fully reflect citizens' preferences over public goods and means, which is known as the "consumer-citizen duality". People might think that all people should include ADAS, but themselves they don't choose to implement it. Therefore, before creating policy on making ADAS mandatory, it is of interest to do research from the citizen perspective.

Check questions might lower quality of the data
Emerging research on this topic and found that much of it advises against eliminating these respondents from most datasets (Anduiza and Galais 2016; Berinsky, Margolis, and Sances 2014; 2016; Hauser et al. n.d.; Miller and Officer 2009). The very mechanism that is intended to detect low-quality responses in a live survey actually induces respondents to produce lower quality responses throughout the rest of the survey in ways that are not as immediately detectable (Vannette 2016).

Innate morality actually is a latent variable
The concepts regarding innate morality (Harm, Fairness, Ingroup, Authority, Purity) are modelled as if they are observed variables. However, in reality these are latent variables. Actually, these moral foundations should be modelled with a hybrid choice model, in which the moral foundation questions are included as indicators for the latent moral foundations. In Bierlaire (2018a) is explained how such a hybrid choice model can be created.

Perceptions are included as continuous variables in the Discrete Choice Models
The perception ratings are taken into account as ordinal variables in the ordinal regression model. However, they are taken into account as continuous variables in the Discrete Choice Models. In the Discrete Choice Models, the perception ratings should have been taken into account as discrete variables as well. However, it is chosen not to do this, as it is easier tho interpret a single parameter for each perception, instead of multiple. It is debated that often it is acceptable to threat an ordinal variable as a linear variable Pasta (2009).

No proportional odds in the ordinal regression model on Perceived External Safety
An important assumption for ordinal regression is that there are proportional odds. The proportional odds assumption does not hold for PES. The test of the PO assumption has been described as *"anti-conservative, that is it nearly always results in rejection of the proportional odds assumption, particularly when the number of explanatory variables is large (Brant, 1990), the sample size is large (Allison, 1999; Clogg and Shihadeh, 1994) or there is a continuous explanatory variable in the model (Allison, 1999)."* (O'Connell, 2006, p. 26). Actually, the data should have been examined using a set of separate logistic regression equations, to explicitly see how the logodds for the explanatory variables vary at the different thresholds. However, it is chosen not to do this, as one parameter per explanatory variable is easier to interpret.

Employed Decision strategies could differ
In the discrete choice models and the hybrid choice model, it is assumed that the RUM-decision rule is used. However, the behavioral realism (how tastes/preferences are translated into choices) of the RUM-decision rule is debated, since the utility of the alternatives does not depend on reference levels, or on the perfor-

mance of other alternatives in the choice set (see, e.g. McFadden (1999)). Assuming a different underlying decision rule, or enabling respondents to vary their decision rule, could result in different parameter estimates.

The Moral Foundations

Previous research has shown the foundations as proposed at MoralFoundations.org (2008) fit less with data collected with a translation of the MFQ in non-english speaking countries (Yilmaz et al., 2016; Nilsson and Erlandsson, 2015; Bobbio et al., 2011). As in this research a translation of the MFQ is used as well, the thrustworthiness of the sum-scores is analyzed with the Cronbach's alpha. The Cronbach's alpha gives the proportion of the variance of the sumscore that is measured trustworthy, and can range from 0 till 1. Equation 8.1 gives the Cronbach's alpha (α), with k = the amount of indicators, and r = the average correlation between these indicators.

$$\alpha = \frac{kr}{1+(k-1)r} \tag{8.1}$$

The resulting Cronbach's alphas for all moral foundations, as proposed by the MFT, are shown in Table 8.1. The Cronbach's alpha should be above 0.70 to be called trustworthy. In table 8.1, can be seen that only the Harm and Fairness foundations initially fulfill this.

Exploratory Factor Analysis (EFA) is conducted in Appendix H, to measure which underlying constructs, and associated indicators (MFQ questions), the data shows most prove for. However, this did not resulted in easily interprettable fators. Furthermore, using the same constructs as proposed at MoralFoundations.org (2008), makes the outcomes of this research comparable to other research regarding moral foundations.

Table 8.1: Cronbach's alpha for the five moral foundations scores

Moral foundation	α
Harm	.703
Fairness	.706
Ingroup	.646
Authority	.599
Purity	.615

8.3. Recommendations

The results showed that morality plays a role in the choice for ADAS, to a certain extent. As people prefer car feature packages they perceive will improve their own safety and comfort, a recommendation is to create ADAS packages that include comfort- as well safety enhancing features. Or, to sell safety enhancing ADAS as if they are very comfortable as well. Furthermore, should be taken into account that lower educated people might not fully understand ADAS functions. So, a good explanation of these systems is needed.

Latent class models

Furthermore, latent class model could be estimated, which groups individuals based on the likelihood that they belong in that group. These latent classes can differ in terms of attribute weights for certain attributes, and they can differ in terms of the applied decision rule.

By estimating a latent class model of the existing data-set, can be researched how the population can be divided in different segments, each with preferences for certain ADAS. This knowledge can be used to create ADAS packages that are perceived to be safety- and comfort enhancing, for each segment, increasing the chance that people choose to include such a package.

Furthermore, Chorus (2015) proposed to research how decision rules differ in moral choice situations with Latent Class Models (LCM). A reference-dependent alternative decision rule that could be used by respondents in moral situations, is Random Regret Minimization (RRM). RRM is a more "emotional rule" than RUM, as people are assumed to choose the option that gives them the least regret, instead of the option from which they derive the highest utility (G. Chorus et al., 2008). It is also of interest to research if people use a different decision rule, if the issue at stake is more treated like a moral issue (such as by including a booster).

To research decision rule heterogeneity, a new survey should be carried out, as in this research the attributes are binomial (a package is included or not), while ordinal attributes are needed for measuring RRM models. Also, an experimental design should be created that is optimized for RUM as well RRM (Van Cranenburgh and Collins, 2018).

It is expected that no single decision rule will stand out as being successful in describing all sorts of moral choice behaviours. It is expected that the applied decision rule differs across decision makers and choice situations. The aim should thus be, to try and infer with the latent class approach which rule of moral decision making applies when and for whom (Chorus, 2015).

Financial incentives

As people with a lower income rather spend their money on luxe instead of ADAS could be researched what role financial incentives play. Next to the fact that this could let more people choose to implement ADAS, it is interesting to see how this affects the used decision rule. Financial incentives could move people from a "moral" to a "non-moral" decision making class. People could have more attention for the incentive instead of the safety of people.

Hybrid Choice Model

To improve the estimates that were done in this research, a Hybrid Choice Model (HCM) could be estimated, that also includes the moral foundations as latent variables in the discrete choice model, based on the given answers on the MFQ. The HCM can be modelled by use of a roadmap for estimating choice models with latent variables, created by Bierlaire (2018a).

Test the booster with revealed preference research

The booster resulted to have the opposite effect. However, it would be interesting to test whether the booster in reality also has the opposite effect, thus with a revealed preference experiment.

Apply the method to other cases

This research aimed to examine the incorporation of morality in discrete choice modelling. It presents a method for researching the role of morality in decision making, within the theoretical framework of discrete choice theory and discrete choice experiments. This method, in which innate is measured with the Moral Foundations Questionnaire, could be applied to other cases as well, in which the moral dimension might play a role.

A

Scientific Paper

The role of perceived increase in safety for other road users in consumers preference for Advanced Driver Assistance Systems

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Abstract

This research examines the incorporation of morality in discrete choice modelling, applied to the specific case of the choice for ADAS in lease. Implicitly, the decision to include or exclude ADAS in a car affects the safety of the driver himself and other road users. Therefore this decision has a moral dimension; a moral dilemma arises during the trade-off between safety, comfort, and investments in ADAS. This research describes a stated preference experiment in which respondents choose between different lease cars option packages. The target respondents need to make trade-offs between costs, comfort, and safety provided by ADAS. The results show that a higher perceived safety and comfort for the driver/passengers are both more preferred than a higher perceived safety for other road users. Also, the results show that innate morality plays an important role in these preferences, which is tested regarding five moral foundations. Furthermore, a booster that aims at increasing moral choice behaviour is tested, which results to have the opposite effect.

Keywords: ADAS, morality, booster, road safety

1. Introduction

Cars enable people to travel further and faster. Sometimes, travelling at a higher speed than our brains can manage, we crash harder than our bodies can manage. Smiley and Brookhuis (1987) estimated 90% of car crashes are linked to human error, due to lack of alertness, fatigue or drowsiness. In theory a percentage of road accidents could be prevented, if these cars incorporated safety systems able to detect and override or warn for this human error, also known as ADAS (Advanced Driver Assistance Systems). A wide range of these ADAS are developed that automate, adapt and enhance vehicle systems for avoiding collisions and/or comfortable driving.

Implicitly, a trade-off is made between incorporating ADAS, and the possibility to include other features when buying or leasing a car. This trade-off may result in people choosing a cheap car rather than a safe car, or spending money on nice looks of the cars rather than on safety features. As a drivers choice for safety features for his or her car impacts the safety of the driver as well other road users, this choice has a ”moral dimension”. A distinction can be made between the contribution of ADAS to safety for the driver and passengers (internal safety), and to safety for other road users (external safety). Molin and Marchau (2004) showed that increase in driving safety and driving comfort are perceived as the most important driving goals in the choice for ADAS, over decrease in travel time and fuel consumption. However, it is unknown whether (perceived) internal safety improvement is equally important as (perceived) external safety improvement due ADAS.

In the choice for ADAS, attributes with a moral dimension (such as external safety), as well attributes with a non-moral dimension (such as price) play a role. It is in the process of trading off those different attributes that moral dilemmas arise Bartels et al. (2015). Therefore, this choice behaviour is studied within the framework of discrete choice theory (DCT) and discrete choice experiments (DCE), which is particularly suitable to study trade-offs between multiple attributes.

Moral choice behaviour is hypothesized by Chorus (2015) to be the result of an interplay of several factors, including task environment and innate morality. Next to exploring the role of morality in the preference for ADAS, this research aims to explore which of these factors significantly affect the role of morality. This is done by researching the effects of including a Booster, that is supposed to boost moral choice behaviour, in the task environment. And, by researching the effect of respondents innate morality, regarding the five moral foundations as stated by the Moral Foundations Theory (Harm, Fairness, Ingroup, Authority and Purity) Graham et al. (2012).

This paper intends to examine the role of morality, concerning the importance of external safety, in the preference for ADAS, within the framework of discrete choice modelling. This research is rather descriptive than normative. The goal is not to give an answer to the question what people *should* prefer when choosing between safety and other attributes. The goal is to give insight into what driving goals people currently prefer to increase by including ADAS, and what the role of morality in this is. Furthermore, this paper aims to examine the incorporation of morality in discrete choice modelling in general. A growing group of scholars is underpinning the need to do experimental data-driven research into moral judgement and moral decision making (e.g. Bauman et al. (2014); Kahane (2013)). Chorus (2015) wrote very few discrete choice modelling stud-

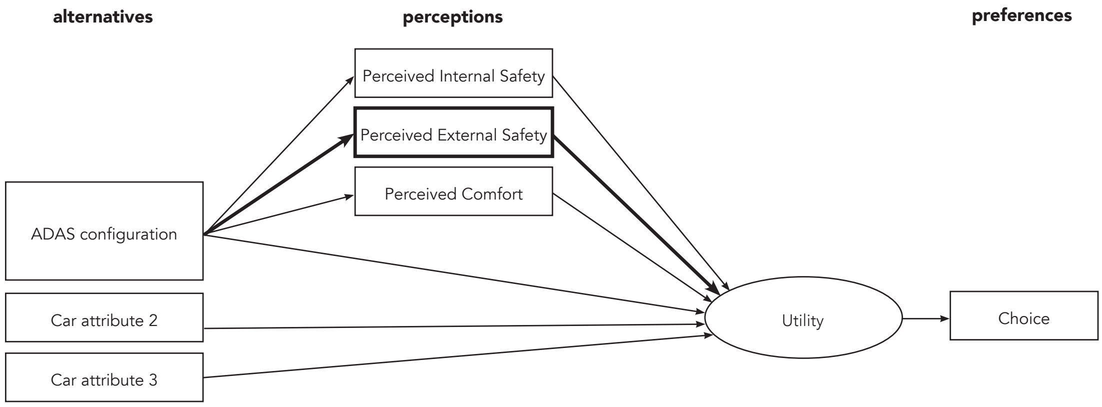

Figure 1: Conceptual Framework

ies exist that acknowledge and incorporate the moral dimension of choice behavior.

2. Conceptual Framework and Hypothesis

To study preferences, we leverage the paradigm of Discrete Choice Theory (see e.g., Ben-Akiva et al. (1985)) and Discrete Choice Experiments. More specifically, the research is conducted within the Random Utility Framework (McFadden (1973)), which assumes that people choose that alternative from a set of available options from which they derive the highest utility; and that part of utility that can be related to observable factors (such as attributes of alternatives) while another part is random, from the viewpoint of the analyst. From each level of the attributes of each of the alternatives, a certain utility is derived, called the part-worth utility. In this study, the attributes are ADAS that can be included in a car. The alternatives describe combinations of attributes, and thus represent packages of ADAS and other car attributes.

Because it is complicated to assess safety and comfort objectively, and because consumers make choices among alternatives based on their perception of the alternatives (as opposed on their objective characteristics), we will explicitly measure the perceptions on ADAS. It is hypothesized that the Perceived Internal Safety(PIS), Perceived External Safety (PES) and Perceived Comfort (PC) of the included ADAS in a package, mediate the effects of the ADAS. This conceptual framework is shown in Figure 1.

The Booster, and innate morality (Harm, Fairness, Ingroup, Authority, Purity and Booster), can impact utility through the weight of the perceptions, as well through the perception ratings. The following hypothesis are tested;

- H1: *Score on Harm, correlates with preference for ADAS packages that are perceived to enhance external safety.*
- H2: *Score on Fairness, correlates with preference for ADAS packages that are perceived to enhance external safety.*
- H3: *Score on Ingroup, correlates with preference for ADAS packages that are perceived to enhance external safety.*
- H4: *Score on Authority, correlates with preference for ADAS packages that are perceived to enhance external safety.*
- H5: *Score on Purity, correlates with preference for ADAS packages that are perceived to enhance external safety.*
- H6: *If a morality "Booster" is shown, ADAS packages that are perceived to enhance external safety are preferred more.*

3. Methodology

3.1. Selecting Advanced Driver Assistance Systems

A balance needs to be found between, on the one hand, taking into account proven and well-known safety enhancing systems, resulting in plausible choice sets. And, on the other hand, taking into account systems that differ in their influence on the perceptions of internal safety (IS), external safety (ES) and comfort (C), enabling measurement of the importance of morality. It is hard to select relevant ADAS that are expected to fulfill only a single driving goal (IS, ES or C). Systems for ES, by avoiding collisions, often also result in more IS. Five attributes eventually are selected; Lane Departure Warning, Emergency Braking for Pedestrians, Emergency Braking for Cars, Intelligent Speed Limiting and Adaptive Cruise Control. To be able to measure the importance of ES, a division is made between Emergency Braking for Cars, which is expected to mainly enhance PIS, and Emergency Braking for Pedestrians/Bicycles, which is expected to mainly enhance PES.

3.2. Choice- and Perception rating- tasks construction

Next to the ADAS, the attribute "Luxe seating- and dashboard material, and multimedia-system" is included, as it is assumed that ADAS have to compete against these kind of features in lease sets (so a more real choice set is mimicked). Furthermore, prices (additional on the monthly lease costs) are included for each package.

To arrive at alternatives from which the participants choose during the DCE, the attribute levels are combined according an experimental design. As respondents not only choose among alternatives, but also have to rate systems on comfort and safety,

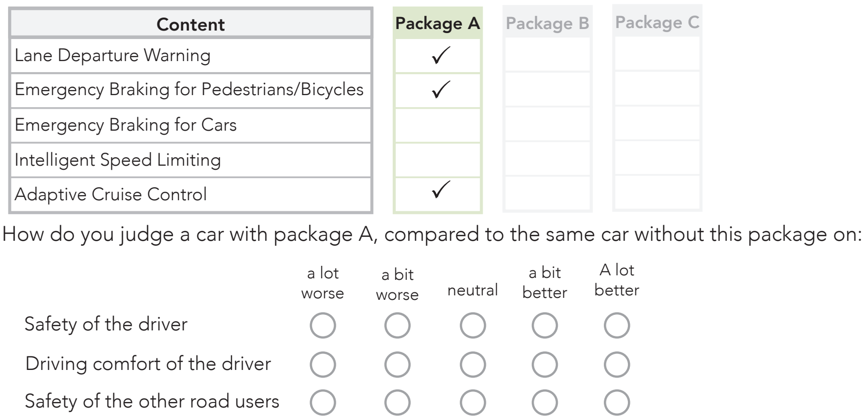

Figure 2: Perception Rating Task

the total amount of choice tasks must be be limited. Therefore, an ”efficient design” is used, to decide which combinations of car attributes are packed together in each alternative, and to determine the number of choice questions. Since no literature exists with applicable priors for this research, a pilot study among a small number of respondents (approximately 30) is carried out, to obtain priors for the efficient design. Choice sets for the pilot survey are constructed according a fractional factorial design, filled in by 34 respondents recruited from the personal network of the researcher. A MNL RUM model is estimated from the observed choices, of which the estimated parameters are used as priors for constructing the efficient design in the final design.

Finally, a blocked D-efficient design is created with these priors, which seeks to minimize standard errors Rose and Bliemer (2009). This results in 3 choice tasks per respondent, in which they have to choose between 3 packages each. Such a choice task, is shown in Figure 3.

Before each choice task, the three packages are each rated on Safety of the driver, Driving comfort of the driver and Safety of the other road users, on five-point scales running from (1) a lot worse till (5) a lot better. Such a rating task is shown in Figure 2.

3.3. The five Moral Foundations and the Booster

The five moral foundations are measured with a Dutch version of the Moral Foundations Questionnaire Haidt (2008), the MFQ-30. These consists of 30 statements, out of which scores on each of the five moral foundations can be calculated.

The booster that is included for 50% of the respondents, contains the following statement; *”When you are driving a car, and collide with a pedestrian or cyclist, you are responsible for the collision, even if it is not your fault.*”, which refers to a Dutch laws that aims to protect pedestrians and cyclists. To be sure that people read the statement, a check-question is included after the booster, questioning whether or not people already knew this rule.

3.4. Data collection and sample

Data is collected with the online panel Panelclix at 19 February 2019. Panelclix pays respondents a small fee after completing a survey. The only prerequisite for respondents to participate in the survey was to have a drivers license. In total, the budget allowed 424 respondents completing the survey. Table 1 presents the distribution of the respondents personal characteristics.

Table 1: Distribution of personal characteristics (N = 391)

Age	18-19 years	1,3%
	20-29 years	12,5%
	30-39 years	15,9%
	40-49 years	22,0%
	50-59 years	22,0%
	60-69 years	17,6%
	70-74 years	6,6%
	75+ years	2,0%
Gender	Male	51,2%
	Female	48,8%
Education	Low	17,9%
	Middle	40,9%
	High	41,2%
Income	<10.000	7,4%
	10.000-20.000	15,9%
	20.000-30.000	20,5%
	30.000-40.000	22,8%
	40.000-50.000	15,3%
	50.000-60.000	11,0%
	60.000-100.000	5,3%
	>100.000	1,8%
Car ownership	Private lease	6,1%
	Business lease	4,6%
	Privately owned	78,8%
	None	10,5%

3.5. Model estimation

In this section, is elaborated on the model estimation procedures applied for the rating and the choice experiments.

Content	Package A	Package B	Package C
Lane Departure Warning	✓	✓	
Emergency Braking for Pedestrians/Bicycles	✓	✓	✓
Emergency Braking for Cars		✓	
Intelligent Speed Limiting			✓
Adaptive Cruise Control	✓		✓
Luxe seating- and dashboard material, and Luxe multimediasystem		✓	✓
Price per month	€10	€20	€10

Which package do you choose?

◯ A

◯ B

◯ C

Figure 3: Choice Task

As the perceptions are given on a 5-point ordinal scale, Ordinal logistic regression is conducted to examine which ADAS, and which of the Factors have significant (interaction)-effects on the perception ratings. First a ordinal regression is estimated for each perception;

$$\ln\left(\frac{\text{Prob (cat. } \leq \text{j)}}{\text{Prob (cat. ¿ j)}}\right) = \alpha_j - (\beta_{LDW} * LDW + \beta_{EBP} * EBP + \beta_{EBC} * EBC + \beta_{SL} * SL + \beta_{ACC} * ACC$$

in which α_j represents the threshold coefficients. The direct- and interaction effects of the Factors are included separately. One by one the most insignificant parameter is removed, except if they are part of significant interaction effects, till only significant effects are left. For each perception the significant effects are included together, and the insignificant parameters again are removed one by one (the most insignificant first), except if they are part of a significant interaction effect. The significant direct- and interaction effects, their estimated parameters as well t-values are presented in Table 2.

From the choices observed in the choice experiment, we estimated a series of logit models, to explore interactions with the Factors. This resulted in the following specification of the utility function;

$$\begin{aligned}U_i = {} & \beta_{PIS} * PIS_i \\ & + \beta_{PES} * PES_i \\ & + \beta_{PC} * PC_i + \beta_{PC}^{Fairness} * \text{Fairness} * PC_i \\ & + \beta_{LUX} * LUX_i + \beta_{LUX}^{Age} * \text{Age} * LUX_i \\ & + \beta_{PR} * PR_i + \beta_{PR}^{lowIncome} * \text{lowIncome} * PR_i \\ & + \epsilon_i\end{aligned}$$

where: PIS_i, PES_i and PC_i represent the scores for perceived internal safety, external safety and comfort given for this package, with values ranging from 1 to 5. LUX_i has value 1 if the luxe seating material and multi-mediaystem are included, or value 0 if it these are not included in package i. PR_i has value 1 if the package costs 20 euro/month, and 0 if the package costs 10 euro/month. Each corresponding β represents the weight of this attribute in decision making.

As assessed with a panel Mixed Logit (ML) model with 1000 Halton draws, substantional levels of heterogeneity are found for PIS, PES, PR and LUX. Model estimation results are reported in Table 3.

4. Results

In this section, the modeling results are presented and discussed. First, the results of the safety- and comfort perceptions experiment is discussed, and how the factors influence these. Then, the same is done for the ADAS package choice. Finally, the results are linked to the hypotheses.

4.1. Safety and comfort perception

Table 2 presents the effects of the ADAS and the factors on the perception ratings of a package. Each slope coefficient is expressed in the change of log odds. A higher value means a higher increase in probability for a high perception rating if this ADAS is included in a package, when everything else is left unchanged. The effects between brackets are insignificant, but included as it has a significant interaction effect.

- EBP as well EBC score high in internal, as well external safety. This is expected, as emergency braking has showed to be most promising in lowering car accidents (Cicchino, 2017; Fildes et al., 2015).
- These were included as separate attributes, so a clear distinction could be made between internal and external safety enhancing packages. Indeed, people perceive that EBP adds most to external safety, and less to internal safety, compared to EBC. This difference for PES is very clear (1.1412 for EBP and .822 for EBC). However, the

difference for PIS is less clear (.786 for EBP and .868 for EBC). The relatively high increase in the PIS rating if EBP is included in a package makes less sense, as EBP brakes for pedestrians/bicycles. These are assumed to not really pose a threat for people inside of the car. Also, the relatively high coefficients for increase in comfort for the two emergency braking systems are unexpected, as these are only meant for safety. It could be that people perceive the fact that they have less chance of an accident as comfort enhancing. Another possibility for these unexpected ratings could be that the respondents don't fully understand the functionality of these systems.
- ACC was added as an attribute, so packages would be included that are perceived to mainly improve comfort. Indeed, ACC leads to the highest increase in comfort, and the lowest increase in safety of all ADAS.

Showing the booster to people, results in them giving significantly lower ratings to PIS, PC and especially PES. This could be due the fact that people that saw the booster are more inclined on the moral aspect. The effect is biggest for perceived external safety, which has the most clear moral aspect.

All moral foundations, except Ingroup, play a significant role. There are only interaction effects of the moral foundations with EBP and EBC. These are also the systems that most explicitly have a moral dimension, as they mostly are perceived to improve safety. Moral people could thus be more inclined to safety.

- There are only interaction effects of Harm with the safety perceptions. People that score high on the Harm foundation, perceive that EBP and EBC improves internal safety more than people that score low in harm. They also perceive that EBP improves external safety more.
- There are only direct effects of Fairness, with all three perceptions, that are fairly high.
- Authority also has positive direct effects on all three perceptions, however a bit lower. Interestingly, people that score high on authority perceive EBP to be more comfort enhancing.
- People that score high on Purity, give at average lower perception ratings to all perceptions. However, they perceive EBC to be more comfort enhancing.

Other interesting effects;

- An older respondent, gives higher PIS ratings at average. Unlike the other variables, Age is a continuous variable. Therefore, the effect should be multiplied with the age of the respondent. Marchau et al. (2001) also found that driving assistance is more preferred by older drivers.
- Women perceive that driving comfort is increased more by ADAS, than men. Marchau et al. (2001) also found that women prefer systems at average more than men. This could be due women are generally less sure about their driving style. However, woman are less comfortable with ACC.
- An interesting effect is that EBP is perceived less safety enhancing by highly educated people, than by lower educated people. Also, both EBP and EBC are perceived as less comfort enhancing than by highly educated people. This means that the unexpected high parameters of EBP for PIS and PC ratings, and of EBC for PC ratings in the model with just the ADAS can be explained by education. Lower educated people might not fully understand the functionality of EBP and EBC.
- Respondents with children perceive that, at average, comfort and external safety are more enhanced. They could be more inclined on these aspects, as comfort increases for the whole family that uses the car, and parents are more aware of the dangers of cars for children.
- A low income results in, at average, lower PIS, PES, PC ratings. This could be due poor people having no interest in these "extra" options, as they would not be able to include them anyway due the costs.

4.2. ADAS package choice

As the ways in which ADAS and the factors are perceived to change personal driving goals are now known, the question arises of the ways in which these perceived changes affect overall preference for a package with ADAS. The weights of the perceptions, luxe and price in the preference for ADAS packages are shown in the first five rows in Table 3.

The weights for the perceptions represent the increase in utility of a package due an improvement of 1 point (e.g. from rating 4 to rating 5). The weight for Luxe represents the increase in utility if the luxe systems are included, compared to a package in which these are not included. The weight for price represents the increase in utility if a package is 20 euro/month, instead of 30 euro/month.

The sigmas of these ADAS reflect the unexplained heterogeneity of the parameters of the ADAS, as shown in the two panel ML models. In the second ML model the heterogeneity is lower than in the first ML model, as some of the heterogeneity is explained away by the included interaction effects.

The following observations can be made by looking at the panel ML-1 model, that shows the average weights;

- At average, PC has most impact on utility (3.6 utils), followed by PIS (2.72 utils), PES (2.63), Price (-1.16 utils) and lastly Luxe (.738 utils).
- At average, packages with ADAS that increase perceived comfort and safety for themselves, are preferred over ADAS that improve safety for other road users. In research of Molin and Marchau (2004), the driving-safety perception and driving-comfort perceptions both had the largest effect on overall attractiveness as well. However, both effects were equally high, while here perceived driving comfort is more important than perceived safety for drivers themselves (.720 versus .544), which means that changes in perceived internal safety are more important than changes in perceived comfort.
- As expected, preference for a package decreases with an increasing price.

Table 2: Ordinal regression

	Perceived Internal Safety (PIS)		Perceived Comfort (PC)		Perceived External Safety (PES)	
	B	**B**	**B**	**B**	**B**	**B**
1 (thresholds)	-2.858	-2.428	-3.140	-2.699	-3.245	-3.116
2	-1.401	-.956	-1.477	-1.026	-1.728	-1.592
3	.882	1.418	.680	1.203	.440	.640
4	2.971	3.650	2.699	3.344	2.592	2.943
Lane Departure Warning (LDW)	.517	.592	.265	.268	.346	3.58
Emergency Braking for Pedestrains (EBP)	.786	.488	.567	.616	1.412	1.063
Emergency Braking for Cars (EBC)	.868	.717	.474	.520	.822	.853
Intelligent Speed Limiting (SL)	.385	.391	.512	.524	.202	.217
Adaptive Cruise Control (ACC)	.351	.365	.642	.818	.179	.183
Booster		-.309		-.205		-.425
Age (continuous)		.009				
Gender		*(-.087)*		.195		
Gender * EBP		.277				
Gender * ACC				-.333		
high Education		.216		.257		
high Education * EBP		-.289		-.455		
high Education * EBC				-.316		
Children				.156		.207
Accident self		*(-.005)*				
Accident relative				.250		
low Income		-.241		-.289		-.315
Harm		*(-.107)*		.190		*(-.037)*
EBP * Harm		.512				.665
EBC * Harm		.304				
Fairness		.500		.348		.647
Ingroup						
Authority		.399		.337		.298
Authority * EBP				.532		
Purity		-.175		-.229		-.189
Purity * EBC				.317		
Mc Fadden's pseudo R^2	.027	.062	.020	.050	.047	.082

- Most heterogeneity between respondents exists within the weight of price- and luxe, as shown by the high sigmas. There is no significant heterogeneity within the weight of PC.

The following observations can be made regarding the factors, by looking at the panel ML-2 model, in which some of the heterogeneity is explained by the interaction effects with the factors.

- The effects of the booster on the weights are very small, and therefore not included in the Table.
- Also, the effects of education and children were insignificant.
- People with a high score on fairness, perceive a high comfort rating as more important, which is an unexpected effect as comfort does not have an explicit moral aspect.
- People that are 65+ years old, perceive luxe as less important.
- People with a low income, perceive luxe as more important than people with a high income. Also, as expected, they perceive a low price as more important than people with a high income.

4.3. Discussion of Results

Both the emergency braking systems (EBP and EBC) score high in perceived increase in internal, as well external safety.

5. Conclusion and Discussion

In this research, the role of morality in consumers preference for Advanced Driver Assistance Systems (ADAS) and other car features is studied. A preference for a package is more moral, if there is a higher preference for packages of which the included ADAS are perceived to enhance safety for other road users,

Table 3: DCM perceptions

	MNL			panel ML-1			panel ML-2		
	Est.	**SE**	**t**	**Est.**	**SE**	**t**	**Est.**	**SE**	**t**
Perceived Internal Safety (PIS)	.384	.083	4.63	.544	.121	4.51	.547	.124	4.43
Perceived Comfort (PC)	.231	.092	2.53	.720	.105	6.87	.428	.134	3.19
Perceived External Safety (PES)	.354	.068	5.19	.526	.121	4.35	.489	.118	4.15
Luxe (LUX)	.384	.083	4.63	.738	.119	6.20	.710	.131	5.43
Price (PR)	-.523	.075	5.19	-1.16	.148	-7.84	-1.00	.160	-6.27
Sigma Perceived Internal Safety				-.862	.197	-4.38	.857	.205	4.19
Sigma Perceived External Safety				-.721	221	-3.26	.610	.230	2.65
Sigma Luxe				1.14	.166	6.84	.913	.160	5.70
Sigma Price				1.75	.188	9.34	1.73	.187	9.22
PC * high Fairness	.392	.129	3.03				.435	.185	2.35
LUX * age (65+)	-.596	.169	-3.53				-.765	.249	-3.07
LUX * low Income	.408	.167	2.44				.543	.240	2.26
PR * low Income	-.545	.168	-3.24				-.684	.294	-2.32
0-LL	-1288.672								
Final-LL	-1120.012			-1079.270			-1068.808		
Rho-squared	.131			.163			.171		

over packages of which the included ADAS are perceived to enhance safety or driving comfort of the driver himself. It can be concluded that, when choosing an extra package with car attributes, at average the perceived increase in safety and driving comfort for the driver himself weights more than the perceived increase in safety for other road users. As people prefer car feature packages they perceive will improve their own safety and comfort, a recommendation is to create ADAS packages that include comfort- as well safety enhancing features. Or, to sell safety enhancing ADAS as if they are very comfortable as well.

However, these preferences differ slightly among subgroups. Concerning socio-demographics, an important observation is that people with a low income are more sensitive for price. And with the money they can spend they prefer to buy luxe systems over ADAS, as they perceive ADAS to be less safety and comfort enhancing than people with a high income. As people with a lower income rather spend their money on luxe instead of ADAS could be researched what role financial incentives play. Next to the fact that this could let more people choose to implement ADAS, it is interesting to see how this affects the used decision rule. Financial incentives could move people from a "moral" to a "non-moral" decision making class. People could have more attention for the incentive instead of the safety of people.

Furthermore, is observed that lower educated people might not fully understand the functionality of Emergency braking systems, and therefore overestimate how these increase comfort. This underlines the importance of a good explanation of these systems.

Also is researched what the role of innate morality is on the preferences. Interestingly, innate morality has a higher impact on the preferences than for example gender. For people that score high on Fairness, Harm and Authority, safety is more important. However, for people that score high on purity, comfort and safety improvements due the ADAS are less preferred.

Furthermore it can be concluded that a booster, that creates awareness about responsibility for car accidents, does have an impact on the preferences. However, the effect of this booster is opposite of the intended effects. People thus indeed do not always respond perfectly rational Dolan et al. (2010), and this underlines the importance of first testing policies such as a booster before applying in real life Hallsworth et al. (2010).

The downside of stated preference research in general is that the answers of the respondents can be biased as the choices are made in an imaginary choice situation. As the respondent does not really get the package he chooses, the consequence of the choice is not felt. Therefore, it is recommended to create these models as well with data collected from revealed preference research.

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B
Lease Car Choice Example

In this appendix, screenshots are given from the private lease car choice sets from ANWB. People first have to select a car, as can be seen in Figure B.1. Then, they can see the features that are standard included, as can be seen in Figure B.2. Next, they can add extra packages, as is shown in figure B.3.

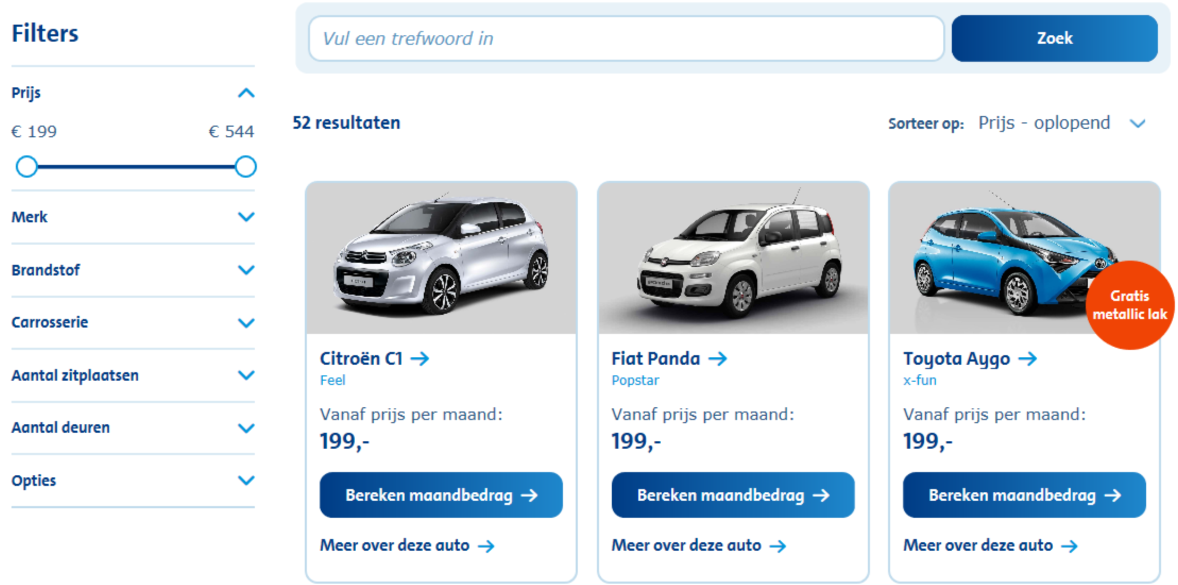

Figure B.1: Lease car choice set of www.ANWB.nl

1. Auto en contract samenstellen 2. Persoonlijke gegevens 3. Gegevens controleren

Citroën C1

Uitvoering	Feel
Carrosserie	Hatchback (5 deurs)
Motor (vermogen in pk)	VTi 68 S&S 51 kW (72pk)
Transmissie	Handgeschakeld
Brandstof	Benzine
Bekleding	Stof – zwart met rode accenten 'Zebra Red'

Standaarduitrusting

- 12V aansluiting in middenconsole
- 14-inch stalen wielen met wieldop 'Star'
- 6 Airbags (bestuurder + passagier / zij-airbags/ gordijnairbags)
- ABS, ESP, ASR, BAS
- Afsluitbaar dashboardkastje
- Bandenreparatiekit
- Bluetooth handsfree en streaming audio A2DP, 4 luidsprekers en stuurwielbediening
- Boordcomputer
- Buitenspiegels in carrosseriekleur (of Noir Caldéra i.g.v. carrosseriekleur Pacific Green)
- Centrale vergrendeling met afstandsbediening
- DSGi: indirect bandenspanningdetectiesysteem
- Dashboardstrip en omlijsting multimedia uitgevoerd in 'Gris Satin'
- Deelbare achterbank (50/50)
- Deurgrepen in carrosseriekleur
- Elektrisch bedienbare ruiten voor
- Hill start assist
- Hoofdsteunen achter
- ISOFIX bevestigingspunten achterbank
- In hoogte verstelbaar stuurwiel
- In hoogte verstelbare bestuurdersstoel
- Instelbare snelheidsbegrenzer
- LED dagrijverlichting
- Neerklapbare achterbank
- Opschakelindicator
- Pack Comfort met toerenteller, lederen stuurwiel en versnellingspookknop en handbediende airconditioning
- Plafonniere verlichting voor
- Radio / MP3-speler met USB en Jack aansluitingen
- Ruitenwisser achter
- Van binnenuit verstelbare buitenspiegels
- Variabele elektrische stuurbekrachtiging

Figure B.2: Standard included features of the citroen C1

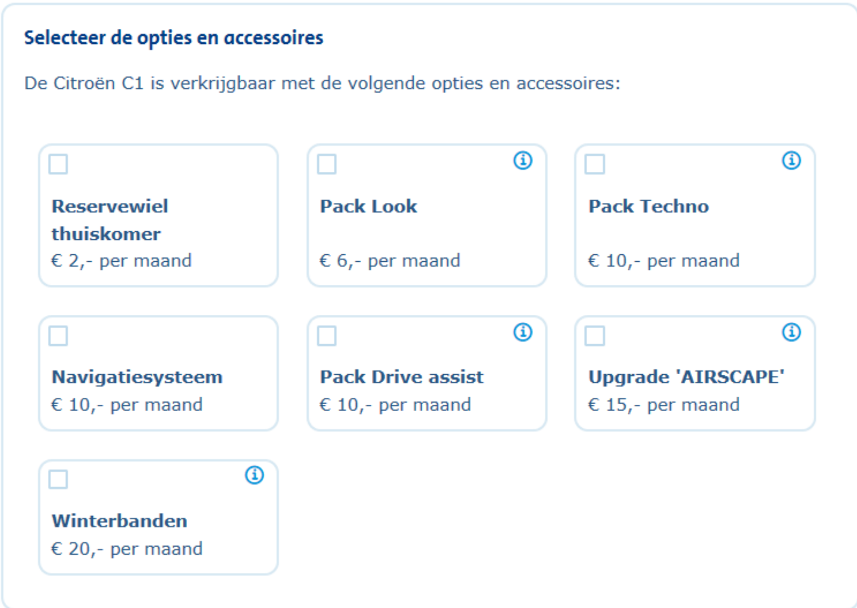

Figure B.3: Adding extra packages

C

ADAS Selection

Some (educated) guesses are made, regarding to what extent each of these ADAS will contribute to each driving goal.

Table C.1: ADAS rated on internal/external safety and comfort

System	Personal safety	External safety	Comfort
AEB for driving and stillstanding vehicles ahead	++	+	+/-
AEB for pedestrians and cyclists	+/-	++	+/-
Alcohol interlock installation	+	++	-
Drowsiness and attention detection	+	++	-
Distraction recognition / prevention	+	++	-
Intelligent speed assistance	+/-	++	-
Lane keeping assistance	+	+/-	++
Lane departure warning	+	+/-	+/-
Reverse camera or detection system	+/-	++	+/-
Cruise Control	+/-	++	+/-
Adaptive Cruise Control	+/-	++	+/-
Pedestrian airbags	+/-	++	+/-
Reversing camera or detection system	+/-	++	+/-
Blind spot monitor	+/-	++	+/-
Automated parking	+/-	++	+/-
Night vision improvement	+/-	++	+/-
Forward collision warning	+/-	++	+/-

D

First Pilot Survey

One of the rating- and choice tasks that were the result of the syntax, and are used in the pilot, can be found in Figures D.1 and D.2 respectively.

Topic	package A
Lane keeping	-
Distance keeping	Adaptive cruise control
Pedestrian/Bicycle detection	Pedestrian/bicycle warning
Vehicle detection	-
Speed adaptation	Speed warning

7. How do you consider that package A improves ..

	1 (not at all)	2	3	4	5 (a lot)
Safety for yourself as a driver	○	○	○	○	○
Comfort for yourself as a driver	○	○	○	○	○
Safety for other road users	○	○	○	○	○

Figure D.1: A rating task in the first pilot survey

Topic	package A	package B	package C
Lane keeping	-	Lane keeping assistance	Lane departure warning
Distance keeping	Adaptive cruise control	Adaptive cruise control	Adaptive cruise control
Pedestrian/ Bicycle detection	Pedestrian/bicycle warning	Pedestrian/bicycle warning	Pedestrian/bicycle warning + Automated braking
Vehicle detection	-	Forward collision warning	-
Speed adaptation	Speed warning	-	-
Extra features	Luxe seating and dashboard material	-	Luxe seating and dashboard material
	Multimediasystem	-	Multimediasystem
	Seat heating		
Price	+ 40 euro/month	+ 20 euro/month	+0 euro/month

10. Which car package would you choose?

◯ A ◯ B ◯ C

Figure D.2: A choice task in the first pilot survey

The respondents gave the following comments on the pilot survey;

- Someone stated he would never buy a car without Cruise control. This is a system too common nowadays in new cars to be optional. For the other four ADAS topics, it could be an option an option on a new car.
- It is unclear to the respondent what kind of seating/dashboard material is included when nothing is said about it. Therefore this will be named "normal seating/dashboard material".
- The ratings are a bit hard (what does each number mean?). A respondent proposed to include Likert scale questions.
- There are too many factors to compare. People stated they would just go for the cheapest option because it was too much work to compare everything.
- It takes a long time to read all the systems that are included in a package.
- The respondents were annoyed as the explanation was too long, and some didn't even read it.
- A respondent said you have to compare "apples to oranges" when you have to compare the extra features with the ADAS.
- The colours might be misleading. For example, a green package might be initiating to consist better features than a red package.

E Second Pilot Survey

For the second pilot survey, the following things were changed compared to the first pilot survey;

- The amount of choice tasks is reduced by taking into account only two attribute levels, instead of three, for each topic. This doesn't discharge the goal of the survey, which is to research the importance of external safety.
  - speed limiting and speed warning is taken together into the more widely known ISA.
- This made it possible to indicate with just a check mark if a system is included, instead of respondents having to read in text which system is included.
- The introductory questions at the start are changed as less systems are taken into account. Instead of the question which system for each task the respondent prefers, is asked how they would rank the utility of these questions.
- To reduce the amount of explanation given at once, the explanation is integrated in the questions.
- The packages all have different shades of the same colour.

The coding scheme that is used for choice set construction, can be found in Table E.1. For Lane keeping, the 0 and 1 were changed, as otherwise packages would exist that don't include systems, but do have a price.

Table E.1: The NGene coding scheme

Attributes	Levels	Parameters
		LK
Lane Keeping (LK)	Lane Departure Warning	0
	No "	1
		PD
Pedestrian Detection (PD)	Automated Braking for Pedestrians/bicycles	1
	No "	0
		VD
Vehicle Detection (VD)	Automated Braking for Vehicles	1
	No "	0
		SA
Speed Adaptation (SA)	Intelligent Speed Limiting	1
	No "	0
		DK
Distance Keeping (DK)	Distance Keeping	1
	No "	0
		EX
Extra (EX)	Luxe seating and dashboard material and Luxe multimediasystem	1
	Normal "	0
		PR
Price (PR)	€10 per month	1
	€20 per month	0

F
Final Survey

F.1. Design

```
design
;alts = alt1, alt2, alt3
;rows = 6
;eff = (mnl,d)
;block = 2
;model:
U(alt1) = bLDW[0.176]*LDW[0,1] + bEBP[1.51]*EBP[0,1]+bEBC[1.43]*EBC[0,1] + bSL[0.449]*SL[0,1] +
bACC[0.989]*ACC[0,1] + bLUX[1.35]*LUX[0,1] + bPR[-0.115]*PR[0,1] /
U(alt2) = bLDW*LDW + bEBP*EBP + bEBC*EBC + bSL*SL + bACC*ACC + bLUX*LUX + bPR*PR /
U(alt3) = bLDW*LDW + bEBP*EBP + bEBC*EBC + bSL*SL + bACC*ACC + bLUX*LUX + bPR*PR
$
```

Figure F.1: Ngene code design for choice part final survey

Choice situation	**alt1. ldw**	**alt1. ebp**	**alt1. ebc**	**alt1. sl**	**alt1. acc**	**alt1. lux**	**alt1. pr**	**alt2. ldw**	**alt2. ebp**	**alt2. ebc**	**alt2. sl**	**alt2. acc**	**alt2. lux**	**alt2. pr**	**alt3. ldw**	**alt3. ebp**	**alt3. ebc**	**alt3. sl**	**alt3. acc**	**alt3. lux**	**alt3. pr**	**Block**
1	1	1	0	0	1	0	0	1	1	1	0	0	1	1	0	1	0	1	1	1	0	1
2	0	1	0	0	0	1	1	1	0	1	1	1	0	0	1	0	0	1	0	0	1	2
3	1	0	0	1	1	1	1	0	0	0	0	1	0	1	0	1	1	0	0	0	0	2
4	0	0	1	1	0	1	0	0	1	0	0	1	0	0	1	1	0	1	0	0	1	1
5	0	1	1	1	1	0	1	0	0	1	1	0	1	1	1	0	1	0	1	1	0	1
6	1	0	1	0	0	0	0	1	1	0	1	0	1	0	0	0	1	0	1	1	1	2

Figure F.2: Design for choice part final survey

F.2. Final survey

Goedendag!

We onderzoeken uw voorkeur voor extra’s in auto’s (optiepakketten). Het beantwoorden van onze vragen duurt ongeveer 15 minuten. Uw antwoorden gebruiken we alleen voor dit onderzoek en blijven anoniem.

Bedankt voor uw tijd en medewerking.

Uw ervaring met autosystemen

We willen graag van 5 systemen weten of u deze heeft en gebruikt, of zou willen hebben en gebruiken.

Dit systeem waarschuwt wanneer uw auto zonder dat u richting aangeeft de rijstrook verlaat.

Heeft u een **"Waarschuwing bij verlaten rijbaan"** in uw auto?

- ◯ Ik heb het, en gebruik het
- ◯ Ik heb het, maar maak er geen gebruik van
- ◯ Ik heb het niet, maar zou het wel willen gebruiken
- ◯ Ik heb het niet, en zou het ook niet willen gebruiken
- ◯ Ik weet niet of ik het heb

Noodrem voor voetgangers/fietsers

Dit systeem remt automatisch voor voetgangers of fietsers in noodsituaties, om een aanrijding te voorkomen.

Heeft u een **"Noodrem voor voetgangers/fietsers"** in uw auto?

- Ik heb het, en het staat aan
- Ik heb het, maar het staat uit
- Ik heb het niet, maar ik zou het wel willen hebben
- Ik heb het niet, en zou het ook niet willen hebben
- Ik weet niet of ik het heb

Noodrem voor andere auto's

Dit systeem remt automatisch voor een andere auto in noodsituaties, om een botsing te voorkomen.

Heeft u een **"Noodrem voor andere auto's"** in uw auto?

- Ik heb het, en het staat aan
- Ik heb het, maar het staat uit
- Ik heb het niet, maar ik zou het wel willen hebben
- Ik heb het niet, en zou het ook niet willen hebben
- Ik weet niet of ik het heb

Intelligente snelheidsbegrenzer

Dit systeem zorgt ervoor dat uw auto de ter plekke geldende snelheidslimiet niet (langdurig) overschreidt.

Heeft u een **"Intelligente snelheidsbegrenzer"** in uw auto?

- Ik heb het, en gebruik het
- Ik heb het, maar maak er geen gebruik van
- Ik heb het niet, maar zou het wel willen gebruiken
- Ik heb het niet, en zou het ook niet willen gebruiken
- Ik weet niet of ik het heb

Adaptieve cruise control

Uw auto houdt een door u ingestelde constante snelheid aan, en past zich indien nodig aan de snelheid van de auto voor u aan.

Heeft u **"Adaptieve Cruise Control"** in uw auto?

- Ik heb het, en gebruik het
- Ik heb het, maar maak er geen gebruik van
- Ik heb het niet, maar zou het wel willen gebruiken
- Ik heb het niet, en zou het ook niet willen gebruiken
- Ik weet niet of ik het heb

Wanneer u als automobilist een voetganger of fietser aanrijdt bent u verantwoordelijk, zelfs als de aanrijding niet uw schuld is. [Wegenverkeerswet]

Wist u dit?

- ◯ Ja
- ◯ Nee

Uw voorkeur voor pakketten van autosystemen

Stelt u voor dat u een (private) lease auto aan het kiezen bent. De auto heeft u al gekozen, maar nog geen optiepakket.
De gekozen auto zelf bevat nog geen hulpsystemen.

Eerst vragen we uw mening over drie pakketten met hulpsystemen ten aanzien van:
- De veiligheid van de bestuurder
- Het rijgemak van de bestuurder
- De veiligheid van andere weggebruikers

Daarna vragen we u een keuze te maken tussen deze verschillende pakketten.

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan	✓		
Noodrem voor voetgangers/fietsers	✓		
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer			
Adaptieve cruise control	✓		

Hoe beoordeelt u een auto met pakket A, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	◯	◯	◯	◯	◯
Het rijgemak van de bestuurder	◯	◯	◯	◯	◯
De veiligheid van andere weggebruikers	◯	◯	◯	◯	◯

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan		✓	
Noodrem voor voetgangers/fietsers		✓	
Noodrem voor andere auto's		✓	
Intelligente snelheidsbegrenzer			
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket B, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers			✓
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer			✓
Adaptieve cruise control			✓

Hoe beoordeelt u een auto met pakket C, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Beneden ziet u opnieuw de pakketten A, B en C. Een luxe optie en de prijs van het pakket (deze betaalt u maandelijks zelf) zijn toegevoegd. Selecteer het pakket dat u kiest bij uw lease-auto, gegeven de inhoud en de prijs van de pakketten.

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan	✓	✓	
Noodrem voor voetgangers/fietsers	✓	✓	✓
Noodrem voor andere auto's		✓	
Intelligente snelheidsbegrenzer			✓
Adaptieve cruise control	✓		✓
Luxe stoel- en dashboard materiaal en Luxe multimediasysteem		✓	✓
Prijs per maand	€10	€20	€10

Welk pakket kiest u?

- ◯ A
- ◯ B
- ◯ C

Op de volgende pagina's beantwoordt u nog 2 keer dezelfde vragen over andere pakketten.

Hier beoordeelt u opnieuw 3 nieuwe pakketten (D, E en F). Daarna maakt u een keuze tussen deze pakketten.

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's	✓		
Intelligente snelheidsbegrenzer	✓		
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket D, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	◯	◯	◯	◯	◯
Het rijgemak van de bestuurder	◯	◯	◯	◯	◯
De veiligheid van andere weggebruikers	◯	◯	◯	◯	◯

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers		✓	
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer			
Adaptieve cruise control		✓	

Hoe beoordeelt u een auto met pakket E, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan			✓
Noodrem voor voetgangers/fietsers			✓
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer			✓
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket F, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan			✓
Noodrem voor voetgangers/fietsers		✓	✓
Noodrem voor andere auto's	✓		
Intelligente snelheidsbegrenzer	✓		✓
Adaptieve cruise control		✓	
Luxe stoel- en dashboard materiaal en Luxe multimediasysteem	✓		
Prijs per maand	€10	€10	€20

Welk pakket kiest u?

- ◯ D
- ◯ E
- ◯ F

Hier beoordeelt u 3 nieuwe pakketten (G, H en I). Daarna maakt u een keuze tussen deze pakketten.

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers	✓		
Noodrem voor andere auto's	✓		
Intelligente snelheidsbegrenzer	✓		
Adaptieve cruise control	✓		

Hoe beoordeelt u een auto met pakket G, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	◯	◯	◯	◯	◯
Het rijgemak van de bestuurder	◯	◯	◯	◯	◯
De veiligheid van andere weggebruikers	◯	◯	◯	◯	◯

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's		✓	
Intelligente snelheidsbegrenzer		✓	
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket H, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan			✓
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's			✓
Intelligente snelheidsbegrenzer			
Adaptieve cruise control			✓

Hoe beoordeelt u een auto met pakket I, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan			✓
Noodrem voor voetgangers/fietsers	✓		
Noodrem voor andere auto's	✓	✓	✓
Intelligente snelheidsbegrenzer	✓	✓	
Adaptieve cruise control	✓		✓
Luxe stoel- en dashboard materiaal en Luxe multimediasysteem		✓	✓
Prijs per maand	€20	€20	€10

Welk pakket kiest u?

- ◯ G
- ◯ H
- ◯ I

Uw voorkeur voor pakketten van autosystemen

Stelt u voor dat u een (private) lease auto aan het kiezen bent. De auto heeft u al gekozen, maar nog geen optiepakket. De gekozen auto zelf bevat nog geen hulpsystemen.

Eerst vragen we uw mening over drie pakketten met hulpsystemen ten aanzien van:
- De veiligheid van de bestuurder
- Het rijgemak van de bestuurder
- De veiligheid van andere weggebruikers

Daarna vragen we u een keuze te maken tussen deze verschillende pakketten.

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers	✓		
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer			
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket A, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	◯	◯	◯	◯	◯
Het rijgemak van de bestuurder	◯	◯	◯	◯	◯

De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan		✓	
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's		✓	
Intelligente snelheidsbegrenzer		✓	
Adaptieve cruise control		✓	

Hoe beoordeelt u een auto met pakket B, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan			✓
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer			✓
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket C, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Beneden ziet u opnieuw de pakketten A, B en C. Een luxe optie en de prijs van het pakket (deze betaalt u maandelijks zelf) zijn toegevoegd. Selecteer het pakket dat u kiest bij uw lease-auto, gegeven de inhoud en de prijs van de pakketten.

Inhoud	Pakket A	Pakket B	Pakket C
Waarschuwing bij verlaten rijbaan		✓	✓
Noodrem voor voetgangers/fietsers	✓		
Noodrem voor andere auto's		✓	
Intelligente snelheidsbegrenzer		✓	✓
Adaptieve cruise control		✓	
Luxe stoel- en dashboard materiaal en Luxe multimediasysteem	✓		
Prijs per maand	€20	€10	€20

Welk pakket kiest u?

- ○ A
- ○ B
- ○ C

Op de volgende pagina's beantwoordt u nog 2 keer dezelfde vragen over andere pakketten.

Hier beoordeelt u opnieuw 3 nieuwe pakketten (D, E en F). Daarna maakt u een keuze tussen deze pakketten.

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan	✓		
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer	✓		
Adaptieve cruise control	✓		

Hoe beoordeelt u een auto met pakket D, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer			
Adaptieve cruise control		✓	

Hoe beoordeelt u een auto met pakket E, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers			✓
Noodrem voor andere auto's			✓
Intelligente snelheidsbegrenzer			
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket F, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket D	Pakket E	Pakket F
Waarschuwing bij verlaten rijbaan	✓		
Noodrem voor voetgangers/fietsers			✓
Noodrem voor andere auto's			✓
Intelligente snelheidsbegrenzer	✓		
Adaptieve cruise control	✓	✓	
Luxe stoel- en dashboard materiaal en Luxe multimediasysteem	✓		
Prijs per maand	€20	€20	€10

Welk pakket kiest u?

◯ D
◯ E
◯ F

Hier beoordeelt u 3 nieuwe pakketten (G, H en I). Daarna maakt u een keuze tussen deze pakketten.

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan	✓		
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's	✓		
Intelligente snelheidsbegrenzer			
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket G, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	◯	◯	◯	◯	◯
Het rijgemak van de bestuurder	◯	◯	◯	◯	◯
De veiligheid van andere weggebruikers	◯	◯	◯	◯	◯

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan		✓	
Noodrem voor voetgangers/fietsers		✓	
Noodrem voor andere auto's			
Intelligente snelheidsbegrenzer		✓	
Adaptieve cruise control			

Hoe beoordeelt u een auto met pakket H, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan			
Noodrem voor voetgangers/fietsers			
Noodrem voor andere auto's			✓
Intelligente snelheidsbegrenzer			
Adaptieve cruise control			✓

Hoe beoordeelt u een auto met pakket I, t.o.v. dezelfde auto zonder dit pakket op:

	1 (veel slechter)	2 (iets slechter)	3 (neutraal)	4 (iets beter)	5 (veel beter)
De veiligheid van de bestuurder	○	○	○	○	○
Het rijgemak van de bestuurder	○	○	○	○	○
De veiligheid van andere weggebruikers	○	○	○	○	○

Inhoud	Pakket G	Pakket H	Pakket I
Waarschuwing bij verlaten rijbaan	✓	✓	
Noodrem voor voetgangers/fietsers		✓	
Noodrem voor andere auto's	✓		✓
Intelligente snelheidsbegrenzer		✓	
Adaptieve cruise control			✓
Luxe stoel- en dashboard materiaal en Luxe multimediasysteem		✓	✓
Prijs per maand	€10	€10	€20

Welk pakket kiest u?

- ○ G
- ○ H
- ○ I

Bent u betrokken geweest bij een aanrijding in de afgelopen 2 jaar?

- ☐ Ja, terwijl ik auto reed
- ☐ Ja, terwijl iemand anders auto reed
- ☐ Ja, ik ben aangereden door een auto terwijl ik liep of fietste
- ☐ Nee
- ☐ Anders

Wanneer anders, graag specificeren hoe

Zijn mensen in uw directe omgeving betrokken geweest bij een aanrijding in de afgelopen 2 jaar?

- ☐ Ja, terwijl hij/zij liep of fietste
- ☐ Ja, terwijl hij/zij in een auto zat
- ☐ Nee
- ☐ Anders

Wanneer anders, graag specificeren hoe

Relevantie van overwegingen

Wanneer u besluit of iets goed of slecht is, in welke mate zijn de volgende overwegingen dan van belang voor uw oordeel? Van "Helemaal niet relevant" (Deze overweging heeft niets te maken met mijn besluit over goed en slecht), tot "Heel erg relevant" (Dit is een van de belangrijkste factoren wanneer ik oordeel over goed en slecht)

	Helemaal niet relevant	Niet erg relevant	Enigszins relevant	Redelijk relevant	Erg relevant	Heel erg relevant
Of iemand emotioneel heeft geleden	○	○	○	○	○	○
Of sommige mensen anders behandeld werden dan anderen	○	○	○	○	○	○
Of iemands daden liefde toonden voor zijn of haar land	○	○	○	○	○	○
Of iemand te weinig respect voor autoriteit heeft getoond	○	○	○	○	○	○
Of iemand standaarden van puurheid en fatsoenlijkheid geschonden heeft	○	○	○	○	○	○
Of iemand goed was in wiskunde	○	○	○	○	○	○
Of iemand zorgde voor een zwak of kwetsbaar iemand	○	○	○	○	○	○
Of iemand oneerlijk heeft gehandeld	○	○	○	○	○	○
Of iemand zijn of haar groep verraden heeft	○	○	○	○	○	○
Of iemand zich conformeerde aan de tradities van de maatschappij	○	○	○	○	○	○
Of iemand iets walgelijks heeft gedaan	○	○	○	○	○	○
Of iemand wreed was	○	○	○	○	○	○
Of iemands rechten zijn ontzegd	○	○	○	○	○	○
Of iemand te weinig loyaliteit heeft getoond	○	○	○	○	○	○
Of iemands actie chaos of wanorde veroorzaakte	○	○	○	○	○	○
Of iemand zich gedroeg op een wijze die God zou goedkeuren	○	○	○	○	○	○

Eens/oneens met stellingen

Zou u voor de volgende stellingen aan willen geven in welke mate u het ermee eens of oneens bent.

	Zeer mee oneens	Redelijk mee oneens	Enigszins mee oneens	Enigszins mee eens	Redelijk mee eens	Zeer mee eens
Medeleven met degenen die lijden, is de belangrijkste deugd.	○	○	○	○	○	○

Wanneer de overheid wetten maakt, dan moet de garantie dat iedereen eerlijk behandeld wordt het belangrijkste principe zijn.	○	○	○	○	○	○
Ik ben trots op de geschiedenis van mijn land.	○	○	○	○	○	○
Respect voor autoriteit is iets dat alle kinderen moeten leren.	○	○	○	○	○	○
Mensen behoren geen walgelijke dingen te doen, zelfs wanneer er niemand schade berokkend wordt.	○	○	○	○	○	○
Het is beter iets goeds te doen dan iets slechts.	○	○	○	○	○	○
Een van de ergste dingen die een mens kan doen is een weerloos dier pijn doen.	○	○	○	○	○	○
Rechtvaardigheid is de belangrijkste behoefte voor een maatschappij.	○	○	○	○	○	○
Mensen behoren loyaal te zijn aan hun familieleden, zelfs wanneer zij iets slechts hebben gedaan	○	○	○	○	○	○
Mannen en vrouwen hebben elk verschillende rollen in de maatschappij.	○	○	○	○	○	○
Ik vind sommige daden slecht, omdat zij onnatuurlijk zijn.	○	○	○	○	○	○
Het kan nooit goed zijn om een mens te doden.	○	○	○	○	○	○
Ik vind dat het moreel onjuist is dat rijke kinderen een heleboel geld erven, terwijl arme kinderen niets erven.	○	○	○	○	○	○
Het is belangrijker om een teamspeler te zijn dan om jezelf te uiten.	○	○	○	○	○	○
Als ik een soldaat was en ik was het oneens met de orders van mijn leidinggevende, dan zou ik toch gehoorzamen omdat dit mijn plicht is.	○	○	○	○	○	○
Kuisheid is een belangrijke en waardevolle deugd.	○	○	○	○	○	○

Persoonlijke vragen

Als laatste krijgt u een aantal vragen over uw persoonlijke kenmerken en autogebruik.

Bent u man of vrouw?

○ Man

○ Vrouw

In welk jaar bent u geboren?

[ ]

Wat is uw hoogst genoten opleiding?

- Lagere school
- Middelbare school
- MBO
- HBO
- WO
- Anders

Wanneer anders, graag specificeren welke

Wat is uw bruto jaarlijkse inkomen?

- 0-10.000 euro
- 10.000-20.000 euro
- 20.000-30.000 euro
- 30.000-40.000 euro
- 40.000-50.000 euro
- 50.000-60.000 euro
- 70.000-80.000 euro
- 90.000-100.000 euro
- > 100.000 euro

Heeft u momenteel een auto?

- Ja, private lease
- Ja, business lease
- Ja, prive bezit
- Nee, ik leen of huur een auto wanneer nodig

Hoe vaak rijdt u auto?

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

Heeft u kinderen?

- [ ] Ja, thuiswonend
- [ ] Ja, uitwonend
- [ ] Nee

F.3. Variables

Table F.1: Variables

Code	Source	Explanation
PANEL_ID ID	Panelclix	ID generated by panelclix
START	Panelclix	Starttime of interview
END	Panelclix	Endtime of interview
TIME	Panelclix	Duration of interview
BLOCK		Whether the respondent answered ratings- and choice questions from Block 1 or Block 2
SET		Number of Choiceset of this block (1, 2 or 3)
BOOST	Q6	Whether the respondent knew (1), or does not knew about the booster (2), or did not see the booster in the survey (0)
GENDER	Panelclix	Whether the respondent is Male (0) or Female (1)
AGE	Panelclix	Age of the respondent
EDU	Q45	Highest level of education of the respondent; High school (1), MBO (2), HBO (3), or WO (4)
INC	Q46	Bruto yearly income of the respondent; ranging from 0-10.000 euro (0), till >100.000 euro (8)
CAR	Q47	Whether the respondent owns a private lease car (3), business lease car (2), private car (3), or does not own a car (0)
CARUSE	Q48	How often the respondent drives car; ranging from less than 1 day a year (0), till (almost) every day (7)
CHILD	Q49	Whether the respondent has children still living at home (2), children not living at home (1) or does not have children (0)
LDW	Q1	Whether the respondent has/uses/would like to have a Lane Departure Warning system (introductory question)
EBP	Q2	Whether the respondent has/uses/would like to have Emergency Braking for Pedestrians/Cyclists (introductory question)
EBC	Q3	Whether the respondent has/uses/would like to have Emergency Braking for cars (introductory question)
SL	Q4	Whether the respondent has/uses/would like to have an Intelligent Speed Limiting system (introductory question)
ACC	Q5	Whether the respondent has/uses/would like to have Adaptive Cruise Control (introductory question)
ACCID0	Q38d	0 if the respondent has been involved in a car accident in the past 2 years
ACCID1	Q38a	1 if the respondent has been involved in a car accident while driving in the past 2 years
ACCID2	Q38b	2 if the respondent has been involved in a car accident while someone else was driving in the past 2 years
ACCID3	Q38c	3 if the respondent has been involved in a car accident while walking or cycling in the past 2 years
ACCID_O0	Q39c	0 if the respondent does not have close relatives involved in a car accident in the past 2 years
ACCID_O1	Q39b	1 if the respondent has a close relative involved in a car accident while in a car in the past 2 years
ACCID_O2	Q39a	1 if the respondent has a close relative involved in a car accident while walking/cycling in the past 2 years

G

Moral Foundations Constructs

The moral foundations theory states that the mean of the following MFQ questions should be taken, to arrive at the score for each moral foundation stated above.

Harm:

- EMOTIONALLY - Whether or not someone suffered emotionally
- WEAK - Whether or not someone cared for someone weak or vulnerable
- CRUEL - Whether or not someone was cruel
- COMPASSION - Compassion for those who are suffering is the most crucial virtue.
- ANIMAL - One of the worst things a person could do is hurt a defenseless animal.
- KILL - It can never be right to kill a human being.

Fairness:

- TREATED - Whether or not some people were treated differently than others
- UNFAIRLY - Whether or not someone acted unfairly
- RIGHTS - Whether or not someone was denied his or her rights
- FAIRLY - When the government makes laws, the number one principle should be ensuring that everyone is treated fairly.
- JUSTICE – Justice is the most important requirement for a society.
- RICH - I think it's morally wrong that rich children inherit a lot of money while poor children inherit nothing.

Ingroup:

- LOVECOUNTRY - Whether or not someone's action showed love for his or her country
- BETRAY - Whether or not someone did something to betray his or her group
- LOYALTY - Whether or not someone showed a lack of loyalty
- HISTORY - I am proud of my country's history.
- FAMILY - People should be loyal to their family members, even when they have done something wrong.
- TEAM - It is more important to be a team player than to express oneself.

Authority:

- RESPECT - Whether or not someone showed a lack of respect for authority
- TRADITIONS - Whether or not someone conformed to the traditions of society
- CHAOS - Whether or not an action caused chaos or disorder
- KIDRESPECT - Respect for authority is something all children need to learn.
- SEXROLES - Men and women each have different roles to play in society.
- SOLDIER - If I were a soldier and disagreed with my commanding officer's orders, I would obey anyway because that is my duty.

Purity

- DECENCY - Whether or not someone violated standards of purity and decency
- DISGUSTING - Whether or not someone did something disgusting
- GOD - Whether or not someone acted in a way that God would approve of
- HARMLESSDG - People should not do things that are disgusting, even if no one is harmed.
- UNNATURAL - I would call some acts wrong on the grounds that they are unnatural.
- CHASTITY - Chastity is an important and valuable virtue.

H

Exploratory Factor Analysis

To research which of the moral foundation questionnaire indicators cohere enough to combine as a factor, exploratory factor analysis (EFA) is conducted. EFA aims at exploring the relationships among the variables (indicators), and finds factors that represent the commonality in the indicators. The goal of EFA is to reach a simple structure, in which each indicator loads high (>0.50) on only one factor, and low (<0.30) on all the other factors. Indicators that don't (almost) apply to this are removed. Also, at least 2 variables should load high on each factor. If not, the model is constrained to less factors.

- First, an oblique (Oblimin) rotation with all indicators (the 30 morality questions) is conducted in SPSS. An oblique rotation is used, as this comes closest to a "simple structure". SOLDIER is removed as its commonality is below 0.25, and it loads below 0.3 on all of the factors.
- Then, one by one, RESPECT, COMPASSION, DECENSY, WEAK and TRADITIONS are removed as these scored below 0.5 on two factors.
- Then, the indicators loading on the factors are checked for interpretability. RESPECT (.316), HISTORY(.379) and RICH(.439) are removed due their low factor-loadings, and as these were different than the high-loading indicators of this factor.
- Finally, is checked if the VARIMAX-rotation does not result in a too different outcome. The resulting (simple) structure is shown in Table H.1.

However, Interpreting the underlying constructs is a bit hard. The first factor contains indicators from all foundations. The second factor is more interpretative, as it contains mainly factors from Ingroup and Purity, representing mostly religious (catholic) values. Factor 4 contains emotional indicators. The Cronbachs alphas are calculated for these self-made scales. All factors now have an alpha over 0.7, and are therefore thrustworthy. Factors 1 and 4 are even highly trust-worthy as they are above 0.8. These factors can be used as latent variables in the hybrid choice model.

Table H.1: Exploratory Factor Analysis MFQ

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**
DISGUSTING	**.887**	-.070	.084	-.044
CRUEL	**.800**	-.120	.096	.041
UNFAIRLY	**.676**	-.144	.123	.142
CHAOS	**.659**	-.059	.168	.084
BETRAY	**.639**	.267	-.028	-.054
LOYALTY	**.587**	**.300**	-.084	.155
RIGHTS	**.551**	-.123	.106	**.305**
CHASTITY	-.001	**.668**	.049	-.080
GOD	.157	**.610**	-.148	.124
FAMILY	-.200	**.544**	.128	.064
TEAM	-.015	**.528**	.109	-.104
SEXROLES	.005	**.508**	-.045	-.040
UNNATURAL	-.002	**.499**	.130	-.045
LOVECOUNTRY	.124	**.477**	-.060	.240
JUSTICE	.074	-.041	**.686**	.056
HARMLESSDG	.122	.097	**.672**	-.158
ANIMAL	.011	-.011	**.662**	.048
KIDRESPECT	.044	.046	**.604**	-.048
FAIRLY	.115	-.129	**.567**	.146
KILL	-.073	.122	**.375**	.097
TREATED	.135	-.056	.043	**.784**
EMOTIONALLY	.027	.037	.107	**.747**

Table H.2: Cronbach alpha scores for new constructs

	α
Factor 1	.901
Factor 2	.774
Factor 3	.752
Factor 4	.811

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