Tampere University

Valtteri Vuorio

FINNISH DRIVERS AND SPEEDING

An Application of the Theory of Planned Behavior

Master's Thesis
Faculty of Engineering and Natural Sciences
Steve O'Hern
Markus Pöllänen
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ABSTRACT

Valtteri Vuorio:
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Many countries have set a goal of having zero traffic fatalities and zero serious injuries in the future. Reaching this goal will require a wide array of methods. Focusing on one avenue, such as improving the safety of just streets or vehicles will not be enough to eliminate all traffic fatalities and serious injuries. Finding and utilizing new methods for improving traffic safety will be at the heart of the drive to a safer future.

The main goal of this thesis was to find out if the theory of planned behavior was an effective model for designing further traffic safety improvements and public safety campaigns in the Finnish environment. The thesis attempted to answer this by analyzing results from ESRA (e-survey of road user attitudes). The conclusion was that the theory of planned behavior showed encouraging potential for traffic safety work. Especially focusing on changing drivers' attitudes and subjective norms about speeding in safety campaigns was supported by both the survey data and the success of previous safety campaigns.

The results from ESRA were also explored to find other relevant and interesting findings relating to the attitudes and beliefs of Finnish drivers. A wide variety of statistical methods were used and supporting evidence was gathered from literature to answer multiple research questions. The analysis found that Finnish drivers were much more likely to drive over the speed limit inside built-up areas when compared to other Nordic countries. The analysis also found that drivers that had higher confidence in their driving ability were especially likely to speed on rural roads. In general, the thesis found that speeders held much more positive attitudes and subjective norms toward speeding. Non-speeders were much more likely to think of speeding as completely unacceptable and to think others agreed with them.

Keywords: Theory of planned behavior, ESRA, Speeding, Attitudes, Road Safety

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TIIVISTELMÄ

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Usea maa on asettanut tavoitteekseen saavuttaa liikennejärjestelmän, joka ei tuota yhtäkään kuolemaa tai vakavaa loukkaantumista tulevaisuudessa. Tähän tilanteeseen pääsemiseen ei riitä yksittäisten asioiden, kuten teiden ja ajoneuvojen, turvallisuuden parantaminen. Uusien menetelmien ja lähestymistapojen löytäminen ja käyttäminen tulee olemaan keskiössä pykiessämme kohti turvallisempaa huomista.

Tämän diplomityön keskeisimpänä tavoitteena on tutkia, onko perustellun käyttäytymisen malli soveltuvainen liikenneturvallisuuden parantamiseen ja siihen tähtäävän viestintätyön suunnittelemiseen suomalaisessa kontekstissa. Tähän pyrittiin vastaamaan analysoimalla ESRA-kyselyn tuloksia. Analyysin lopputuloksena todettiin, että perustellun käyttäytymisen malli vaikuttaa lupaavalta tavalta suunnitella liikenneturvallisuustyötä ja sen lähestymistapoja. Erityisesti ihmisten asenteisiin ja subjektiivisiin normeihin keskittyvä lähestymistapa sai tukea sekä data-analyysistä että kirjallisuuskatsauksesta.

ESRA-kyselyn tuloksia tutkittiin myös muista näkökulmista relevanttien ja kiinnostavien tulosten löytämiseksi. Kyselytutkimuksen tulosten tutkimiseen käytettiin laajaa valikoimaa data-analyysimenetelmiä ja tueksi haettiin tietoa muista tutkimuksista polttavien kysymysten vastaamiseksi. Analyysissä todettiin, että suomalaiset kuljettajat ajoivat muita pohjoismaisia kuljettajia enemmän ylinopeutta erityisesti taajamissa. Analyyseissä tunnistettiin myös, että kuljettajat, jotka uskoivat omiin ajotaitoihinsa, ajoivat paljon ylinopeutta erityisesti taajamien ulkopuolella. Tutkimuksessa nousi myös, että ylinopeuden ajajilla oli odotetusti huomattavasti positiivisempia asenteita ja subjektiivisia normeja ylinopeudesta, kuin nopeusrajoitusten sisällä pysyvillä kuljettajilla. Kuljettajat, jotka eivät ajaneet koskaan ylinopeutta, ajattelivat ylinopeuden ajamista täysin hyväksymättömänä ja ajattelivat että muutkin ajattelivat samoin.

Avainsanat: Perustellun käyttäytymisen malli, ESRA, Ylinopeus, Asenteet, Liikenneturvallisuus

PREFACE

This thesis was started in May of 2022 and after a year of unsteady progress the project is finally done. A lot ended up happening in between the start and the end of the work and I could not be happier while writing the last few words 160 km away from where I wrote the first words so long ago. During the first courses of my university journey, we joked that some of us might graduate before the completion of the Olkiluoto nuclear plant that was already six years behind schedule at that point. As I was finishing this final draft the news of the completion of the plant came out. It only seems fitting to celebrate the finishing of one of the most expensive buildings in the world by turning in my thesis on the same day.

I would like to thank Liikenneturva for providing the opportunity and the data for the thesis and for being so patient while I worked on it. I would also like to thank the Nordic Road forum for providing funding for this thesis and for waiting for the results. I would like to thank my instructor Steve O'Hern from the Transport Research Centre VERNE for guiding me and keeping me somewhat on schedule during the thesis. Special thanks to the staff from the regional council of South Ostrobothnia for supporting the thesis project and contributing valuable input during the process. And finally, I would like to thank my family for cheering me on and pushing me to reach greater heights during this project and all throughout my life.

Seinäjoki, 16 April 2019

Valtteri Vuorio

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LIST OF SYMBOLS AND ABBREVIATIONS

AASHTO	The American Association of State Highway and Transportation Officials
ECMT	The European Conference of Ministers of Transport
ESRA	E-Survey of Road Users Attitudes
OECD	The Organization of Economic Cooperation and Development
OTI	The Finnish Crash Data Institute (Finnish: Onnettomuustieto-instituutti)
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action

1. INTRODUCTION

As many countries, regions, and cities have dedicated themselves to Vision Zero, it has become clear that reaching zero fatalities and zero seriously injured on our roads will require great effort. Reducing the frequency of traffic crashes and the severity of them remains one of the main objectives for the development of the transportation system. Reaching this goal will require tackling the problem from all sides. Measures such as lowering speed limits and adding more safety features to our cars and roads will only go so far in reducing traffic crashes. This means that it is also required to turn our heads toward people's attitudes of risky behaviors.

One of these risky behaviors, speeding, remains one of the main contributing factors in traffic crashes. Exceeding the speed limit is one of the most frequently broken rules on our roads and the behavior remains common regardless of countless interventions by multiple parties and agencies. Finding effective measures for affecting people's speeding behavior is key for reaching traffic safety goals in the future. This is why this thesis will analyze the theory of planned behavior and whether it can be used in the Finnish environment to reduce speeding behavior.

This thesis includes a chapter focusing on the use of the theory of planned behavior and other theories that are useful in its application. The second chapter focuses on speed, speeding, and their effect on traffic safety. The third chapter will analyze data from ESRA (E-Survey of Road users' Attitudes) to find out if the survey data supports the use of the theory of planned behavior in traffic safety work. At the same time the survey results will be examined for interesting and useful findings.

2. RESEARCH METHODS

This chapter aims to give the necessary background information on the utilized methods and the main source materials for understanding the rest of the thesis. The chapter starts out with the presentation of the main research questions and discussion on the delimitations of the study. Then the main source materials of the thesis are presented and the thinking behind the methods used in the thesis are explained. Finally, the structure of the thesis is laid out in the final part of this chapter.

2.1 Research questions

The thesis has two main goals. The first goal is to analyze the theory of planned behavior in conjunction with a survey of Finnish drivers' attitudes to see whether they form a valid basis for further action for bettering traffic safety. The second goal is to analyze the connections that the Finnish drivers' beliefs have on speeding behavior. These goals have been formulated into the following main research questions:

- Does the theory of planned behavior form a valid basis for actions aimed at limiting speeding behavior?
- Which beliefs about speeding are the best predictors of future speeding behavior?

The research questions were delimited to focus on the beliefs of drivers instead of all people since the focus of the thesis was partly on the connection these beliefs have on speeding behavior. Although the beliefs of the population at large have an impact on the beliefs and behavior of individuals, the beliefs of the drivers have a more direct impact on behavior. The study was originally meant to analyze both speeding and distracted driving, but it was limited to focus only on speeding to gain greater focus.

As the two main research questions were already relatively pointed, it was decided to aim the additional research questions toward expanding the scope of the thesis into specific directions. The main area of interest was the differences between Finnish drivers' beliefs and other Nordic drivers' beliefs and the differences in behavior between different driving environments. The supplemental research questions were formed as follows:

- How do Finnish driver's beliefs compare with other Nordic countries' drivers' beliefs?
- Which beliefs about speeding explain the differences in behavior between different driving environments?

The second supplemental research question about different driving environments was formed in the early research phases. It was noticed that Finnish drivers were much more likely to speed inside built-up areas when compared to their Nordic counterparts. This observation was deemed interesting enough to require its own supplemental research question.

2.2 Main source material

The thesis relies heavily on the theory of planned behavior by Ajzen (2005). Most of chapter 3 was written based on his original work building the theory and many of the analysis methods in chapter 5 were constructed based on the theory of planned behavior.

The chapter on speeding relies on a more varied list of sources. The base of the chapter follows a similar structure to the OECD and European Conference of Ministers of Transport (2006) publication on speed management. Specifically focusing first on the effects of speed. Other key sources for the chapter were the writings of Nilsson (2004) and Elvik et al. (2019). The history of speed limit trials in Finland was written mostly based on Salusjärvi's (1981) work on the subject.

2.3 Methods

This thesis started in perhaps an irregular way when compared to other research papers. Other pieces of research usually start with a question and find a way to answer it by collecting or consolidating data. This thesis started with the data and wanted to find what revelations can be acquired by analyzing the data. The data analyzed was a survey on people's attitudes and behavior about driving. This survey was designed by the VIAS institute, which meant that this paper had to be designed around the survey, the phrasing of the question, and the scope of the survey.

The data first approach of this research project forced the research philosophy to be very grounded and positivist. The usual approach to research design would first contemplate such things as what kind of ontological theory does the researcher or the thesis follow or which side of the interpretivist-realist spectrum are they located on (Saunders et al., 2019). This thesis had to adapt to the assumptions that the phrasing of the survey questions and their design implied.

The research adapted to a deductive approach that was natural to an analysis of survey results. The goal became to analyze how the theory of planned behavior fits the data gathered in the survey and at the same time explore what other interesting findings could be uncovered in the data. This mix of theory fit and data exploration became the method of the thesis almost consequentially.

The thesis uses a mix of a literature review and data analysis to attempt to reach the goals stated above. The literature review formed the basis for the data analysis and the data analysis became the core of the thesis. The literature review chapters did not attempt to answer any of the research questions but aimed to give context to the data analysis. A more detailed description of the structure of the thesis is presented in the next chapter.

2.4 Structure

The main body of this thesis consists of two research review chapters and one data analysis chapter. The first research review chapter covers the theory of planned behavior. The chapter explains the basics of the theory, presents some advantages of the theory, and explores how the theory has been applied in practice. The chapter also analyzes the concept of reactance and its interaction with theory of planned behavior.

The second research review chapter focuses on speeding. This chapter attempts to lay out how increased travel speeds affect traffic safety using previous studies. The relevant laws of physics and natural limitations are discussed as well as the aggregate level of how increased travel speeds are related to the number of crashes and the severity of them. The chapter also includes a short version of the history of speed limits, and their implementation in Finland. The development of average driving speeds and percentage of people driving over the speed limit will be discussed as well.

Following the speeding chapter, the thesis moves on to the data analysis chapter. This chapter analyses the ESRA survey data using multiple statistical methods including binary regression analysis as an example. The chapter also presents some previous research on the ESRA data and discusses the differences between the different Nordic countries. Finally, the results of the analysis are presented in their own chapter and the consequences of the study are discussed in the conclusions chapter. At the very end, as an appendix, will be a research paper that the results of this paper were submitted for.

3. DRIVER BEHAVIOR AND TRAFFIC SAFETY

Driver behavior is one of the main contributing factors in the causation of traffic crashes (Rothengatter, 1997). This has led to an increased interest in the application of psychological methods to understand and to change driver behavior. The field of traffic psychology aims to develop effective traffic crash countermeasures by better understanding the underlying processes behind driver behavior (Rothengatter, 1997). However, human behavior is complex and predicting it is difficult (Ajzen, 2005). To the joy of many researchers, people do behave somewhat consistently and coherently which makes the behavior also somewhat predictable (Ajzen, 2005). This chapter will focus on the theory of planned behavior as well as other theories that will help to better understand people's behavior in traffic and how that can be changed.

3.1 Theory of planned behavior

The theory of planned behavior (TPB) is a social psychological model developed by Ajzen (2005) that has been successfully used to model a wide range of behavioral change (Zhou et al., 2016; Ajzen, 2011; Stead et al., 2005). The core idea of TPB is that a person's behavioral intention is the most important variable for predicting a person's social behavior in advance (Ajzen, 2005). The theory also states that behavioral intention is created by three core components: attitude toward the behavior, subjective norms about the behavior, and perceived behavioral control of the behavior (Ajzen, 2005). TPB was developed by Ajzen based on his older theory of reasoned action (TRA). The main difference between these two theories is that TPB includes the aspect of perceived behavioral control, which makes it better at modeling behavior that might not be in the total volitional control of the person (Ajzen, 2005). The theory of planned behavior is presented in figure 1 below.

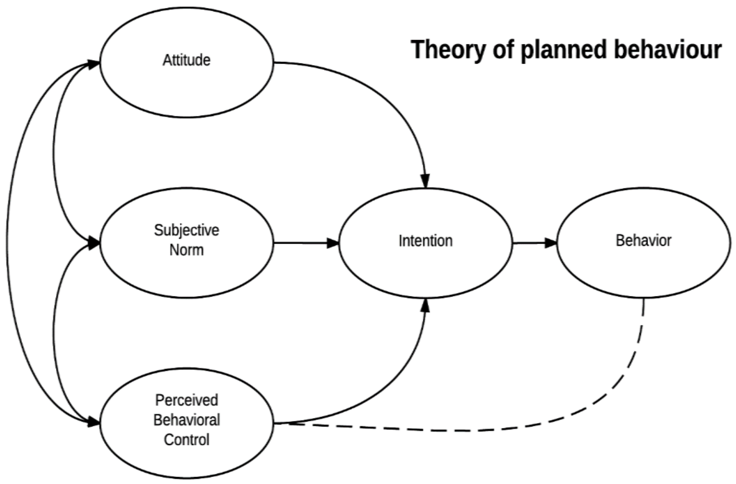

Figure 1. *Theory of planned behavior (Ajzen, 2005, p.118)*

Attitude is the first core component that affects behavioral intention. Ajzen (2005, p.3) defines attitude as a disposition to respond favorably or unfavorably to an object, person, institution, or an event. He bases this definition on the observation that if people are given questions about a topic, their answers will show a tendency to answer consistently in either positive or negative manner (Ajzen, 2005). In the context of this thesis, attitude describes the individual's positive or negative evaluation of performing a certain behavior.

Attitudes are inaccessible to direct measurement, so they must be inferred from indirect responses (Ajzen, 2005). Attitudes have been measured using self-reporting, direct observation of behavior, and by collecting them from friends or acquaintances (Ajzen, 2005). Ajzen (2005) describes that attitudes can be measured from verbal or non-verbal responses that represent beliefs, feelings, and action tendencies.

Attitudes are expressions of beliefs about a subject (Ajzen, 2005). Beliefs are connections between objects and outcomes (Ajzen, 2005). For example, "Speeding causes crashes." is a belief about speeding. People's beliefs about subjects vary in strength and in the subjective evaluations of the outcomes (Ajzen, 2005). The strength of a belief corresponds to how certain the person thinks it is that this connection between the outcome and the object is. The subjective evaluation of the outcome corresponds to whether they find the outcome in question positive or negative. As an example, I might hold the belief of “Speeding causes crashes”, I might be very certain about the connection between speeding and crashes, and I probably think that causing crashes is a negative attribute. This means that my attitude towards speeding would be affected negatively by my belief of “Speeding causes crashes”. Other people might not be as certain that speeding causes crashes, or some might not put the same amount of negative weight on the concept of causing crashes, and so their attitude towards speeding might not be affected as negatively by this belief as mine would be. I think it is important to note that beliefs do not have to be factual (Ajzen, 2005). They are based on people’s personal experiences and the information they have about the action (Ajzen, 2005). For example, a person can hold a belief that “Speeding doesn’t cause crashes” if their own personal experience and the information they have about speeding line up with that belief.

Every person has a collection of beliefs about each topic. Some beliefs have a positive connotation, others have negative ones. and some beliefs are more certain than others. The overall attitude of the person toward the topic is formed as an interaction between these beliefs. In mathematical terms, a person’s attitude about a behavior is formed by going through every belief a person holds about the behavior and summing the multiplications of the strengths and the subjective evaluations of the outcomes of the beliefs as in the equation

$$A_B \propto \sum b_i e_i,$$

where A_B is the attitude towards the behavior, $\propto$ means the relationship is directly proportional, b_i is the subjective likelihood that a behavior leads to outcome i, and e_i is the evaluation of the outcome i (Ajzen, 2005).

The second core component of the formation of behavioral intentions are subjective norms. Subjective norms describe the individual's perception of social pressure to perform or not to perform a certain behavior (Ajzen, 2005). Subjective norms can be formed through two different avenues. They can be formed through the persons belief that specific important individuals in their life approve or disapprove of performing the behavior, or they can be formed by the persons observations of whether these important individuals themselves engage in the behavior or not (Ajzen, 2005). Generally, people who believe that most important people in their lives approve of, or perform, a certain behavior, feel social pressure to perform the behavior themselves (Ajzen, 2005). The creation of social norms can be presented in mathematical form by the equation

$$SN \propto \sum n_i m_i,$$

where SN is the subjective norm about a behavior, n_i is a normative belief of an important person to the individual, and m_i is the motivation to comply with the normative belief of the important person in question. Subjective norms can also be assessed by asking the respondent directly to judge how likely it is that most people in their life that are important to them would approve of them performing a behavior (Ajzen, 2005).

The third component that affects the formation of behavioral intention is perceived behavioral control. Perceived behavioral control reflects the perceived ease or difficulty of performing or refraining from performing a behavior (Ajzen, 2005). It is affected by past experiences and anticipated obstacles (Ajzen, 2005). Perceived behavioral control also includes the subjective considerations for weather the person has the resources or the opportunity to perform the activity (Ajzen, 2005). Perceived behavioral control can be presented mathematically with the equation

$$PBC \propto \sum c_i p_i$$

where PBC is the perceived behavioral control of the behavior, c_i is a control belief and p_i is the control frequency (Ajzen, 2005). Control beliefs represent factors that help or hinder the person's ability to perform the behavior in question (Ajzen, 2005; Stead et al., 2005). Control frequency represents the frequency that the person is in the circumstances that they must face the control belief in question (Ajzen, 2005; Stead et al., 2005). Like social norms, perceived behavioral control can be measured by asking participants directly weather they thinks they are capable of performing, or refraining from performing, the behavior of interest (Ajzen, 2005; Stead et al., 2005).

All three components that affect the creation of behavioral intentions presented above are based on beliefs. Beliefs about the outcomes of the behavior in the case of attitude, beliefs about the opinions, and the behavior, of people around the person in the case of social norms, and beliefs about the presence or absence of obstacles in the case of perceived behavioral control (Ajzen, 2005). And as discussed above, beliefs are based on the information the person has, and the personal experiences of the person, but they are also affected by large number of personal and social factors (Ajzen, 2005). Figure 2 below represents the role that beliefs and background factors play in the creation of behavioral intentions.

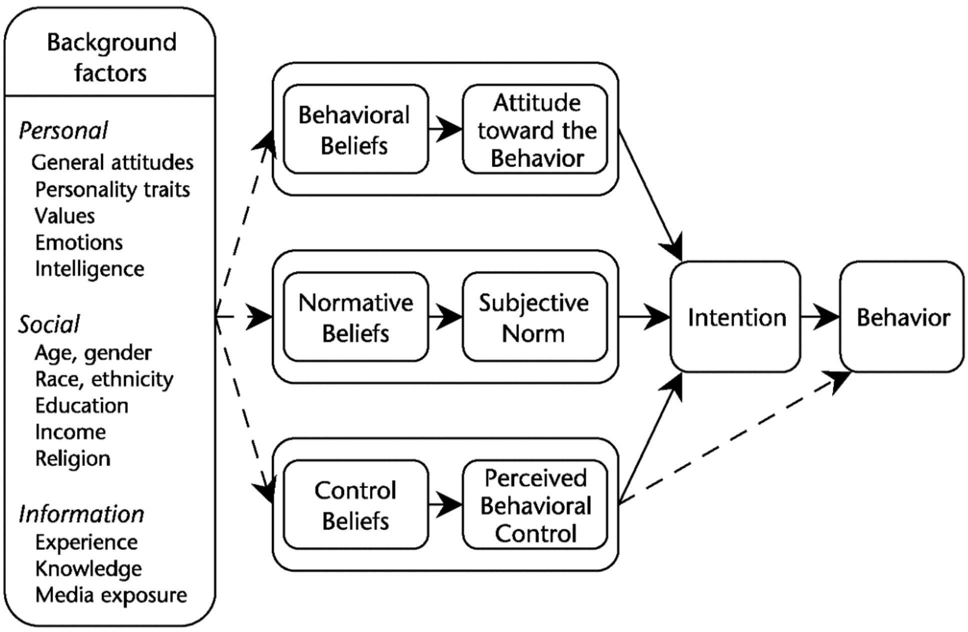

Figure 2. *Theory of planned behavior with the addition of beliefs and background factors (Ajzen, 2005, p.126)*

The two mathematical equations that form the rest of the theory of planned behavior model the formations of behavioral intention and behavior itself. Behavioral intentions are formed by the three components discussed above and weights derived from empirical studies following the equation

$$BI = w_A A + w_{SN} SN + w_{PBC} PBC,$$

where BI represents behavioral intention and w the empirically derived weights. As discussed at the beginning of this chapter, the central hypothesis of the theory of planned behavior is that intention to perform an activity is the best predictor for the performance of that activity (Ajzen, 2005). The intention-behavior relationship isn't perfectly linear, but it often has a strong correlation (Ajzen, 2005). In addition to behavioral intention, behavior is also affected by perceived behavioral control as in the equation

$$B = w_{BI} BI + w_{PBC} PBC$$

Where B is behavior. These five equations form the model of the theory of planned behavior.

3.2 The advantages of the theory of planned behavior

One of the main advantages of the theory of planned behavior is that it creates a basis for changing people's behavior for the better (Goldenbeld et al., 1998). As an example, the TPB has been successfully used to encourage people to go to the gym more often and to encourage them to stop smoking (Stead et al., 2005). In the field of traffic psychology, the theory has also been successfully adapted for example (Stead et al., 2005; Goldenbeld et al., 1998). Most studies using TPB to change behavior focus on the three core components of the formation behavioral intention: attitude, social norms, and perceived behavioral control.

One of the first campaigns aimed at reducing speeding that was based on the theory of planned behavior was the "Foolsspeed" campaign designed by the Scottish Road Safety Campaign in 1998 (Stead et al., 2005). The campaign was three years long and it was aimed at the three core components of the theory of planned behavior. The campaign was paired up with a four-year cohort study which found empirical evidence for using TPB as the underpinning of the advertisement (Stead et al., 2005). The advertisements were associated with significant changes in the attitudes and affective beliefs about speeding (Stead et al., 2005).

Ajzen (2005) notes that even though the theory of planned behavior represents a reasoned approach to predicting behavior, it does not mean that people consciously review every step in the chain whenever they engage in a behavior. Once a set of beliefs is founded, they form a cognitive foundation that serve as the building blocks that affect attitudes, social norms, perceived behavioral control, behavioral intention, and ultimately behavior (Ajzen, 2005).

Analyzing driver behavior requires the observation of the fact that driver behavior is not always reasoned (Goldenbeld et al., 1998; Summala, 1996). Driving is often an everyday task that people do in a particular way, without thinking about it beforehand, and justifying their behavior only in retrospect (Goldenbeld et al., 1998). This can make driving a habitual behavior. Habitual behaviors are defined as behaviors that occur without conscious information processing (Goldenbeld et al., 1998; Summala, 1996). Traffic psychology has also classified certain traffic safety behaviors, such as seat belt usage, as habitual (Goldenbeld et al., 1998). It should be noted that habitual behavior is not irrational. Habitual behaviors can be based on well-reasoned decisions made in the past and they can be judged as rational with hindsight (Goldenbeld et al., 1998).

3.3 Reactance and its effect on attitudes and behavioral intentions

There are other aspects that need to be considered when trying to influence people’s behavior. The first is the psychological theory of reactance that was first presented by Brehm (1966). This theory attempts to answer questions such as “Why does a child sometimes do the opposite of what they are told?” and “Why is propaganda frequently ineffective at persuading people?" (Brehm, 1966). According to Brehm (1966) the answer is reactance, as in the motivation to regain freedom after it has been lost or after it has been threatened, which leads people to not follow the social influence of others.

Reactance is an important concept to understand when creating messages that are aimed at changing or affecting people's behaviors. According to Dillard and Shen (2005) any persuasive message can be analyzed using reactance by looking at it as a threat to the personal freedoms of the receiver. If a message tries to convince a person to change their behavior, that poses a threat to their freedom to choose how to act and so it will create a motivation to gain back that freedom in the listener (Dillard & Shen, 2005). That motivation can cause the listener to do the exact opposite of the message, start to like the forbidden act more, or lose trust in the source of the threat (Dillard & Shen, 2005; Steindl et al., 2015).

Persuasive messages should be designed in a way that produces minimal reactance (Dillard & Shen, 2005). A badly worded message can cause the listener to counterargue and it can create a feeling of anger in them (Steindl et al., 2015). Messages that use words like "should", "ought", "must", and "need" have been shown to create stronger reactance in the listener (Steindl et al., 2015; Dillard & Shen, 2005). Messages that are framed through loss, for example "When you speed on this road, you are more likely cause an accident", have been shown to create more reactance than messages that are framed through gain, for example "If you follow the speed limit on this road, you are less likely to cause an accident" (Steindl et al., 2015).

People experience reactance differently and with different strengths (Steindl et al., 2015). For example, studies have shown that people with more collectivistic personality traits experience less reactance when the threat to their freedom comes from their ingroup instead of their outgroup (Steindl et al., 2015). On the other hand, people with more individualistic personality traits have indicated that the eliminated freedom seemed more attractive when the threat came from their ingroup instead of the outgroup (Steindl et al., 2015). Researchers speculate that this reaction is based on the individualistic persons willingness to protect their own personal freedoms and differentiate themselves from their own ingroup (Steindl et al., 2015).

The paper written by Steindl et al. (2015) also looked at how reactance effects attitudes and behavioral intentions. They designed an experiment where participants were shown a persuasive message that combined a threat-to-health component and a recommendation component. As an example, in one of the messages they would first discuss the negative consequences of not flossing and then recommend flossing. The researchers would present each participant with a list of questions that measured their reaction to a certain message. Multiple versions of the first part of the message were used and they were classified as either high threat or low threat. The researchers wanted to see how the person's level of reactance changed when the threat was more severe. The questionnaire also measured the participants' attitudes and behavioral intentions toward the behavior in question and estimated their proneness to reactance. Their findings produced figure 3 below.

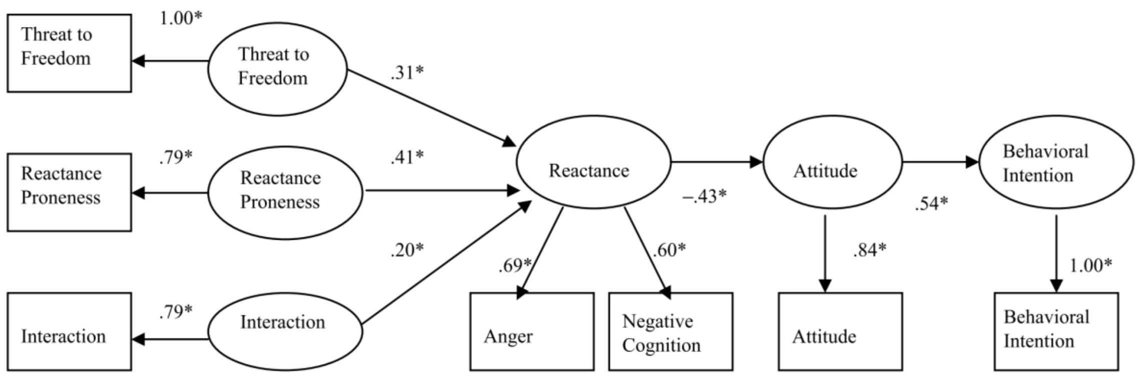

Figure 3. *How reactance affected attitude and behavioral intention in a flossing related study (Dillard & Shen, 2005)*

The figure describes that the amount of reactance a person experienced was affected by three things. The first was the level of threat the message posed to the freedom of the person. The study found that messages with a higher threat level produced more reactance. The second was the person’s proneness to reactance. People with higher proneness were found to have higher levels of reactance to the messages overall. The third was the interaction between the threat level of the message and the proneness of the person to reactance. The study found that depending on the topic of the message people with higher proneness would have stronger reactance to messages with higher level threats than expected. Interaction represented this effect. Overall, the study found that stronger reactance would negatively affect the persons attitude toward the behavior and the intention to perform that behavior (Steindl et al., 2015).

4. SPEEDING

Speeding is a behavior that can have serious consequences. The Finnish Motor Insurers' Centre (OTI) found in their 2020 report on fatal crashes that 32% of all drivers involved in fatal crashes were driving more than 10 km/h above the speed limit at the time of the crash (OTI, 2020). In the same report, it was found that from the people found liable for the crash 47% were driving above the speed limit (OTI, 2020). Generally, researchers estimate that speeding is a key contributing factor in 10-15% of all traffic crashes and in 30% of all fatal crashes (European Comission, 2021; OECD; ECMT, 2006).

Despite the dangers of driving over the speed limit, speeding is still common. Observations made between the years 2007 and 2017 in Finland on rural non-motorway roads with a speed limit of 80 km/h found that 63% of all vehicles travel above the legal speed limit (Adminaité-Fodor & Jost, 2019; Kiiskilä et al., 2020). Observations in other European countries have found similar results (Adminaité-Fodor & Jost, 2019; European Comission, 2021).

Speeding is a term that can refer to a few specific behaviors. In common use, speeding means driving over the speed limit, but many researchers like to differentiate between excessive speed and inappropriate speed. Excessive speed means driving at a speed higher than the maximum allowed and inappropriate speed means driving at too high a speed for a traffic situation. Both behaviors are considered under the umbrella term of speeding. (European Comission, 2021; OECD; ECMT, 2006)

But as we can see from the definition above, speeding is a relative term. A person can speed relative to the speed limit or relative to the prevailing conditions. This is why this thesis will first analyze the effects of speed to establish why limiting speeds is a worthwhile effort in general. Then the thesis moves on to look at speed limits and how the implementation of them has been used to limit the negative effects of speed. At the end of this chapter, the thesis will examine speeding as a social phenomenon and what that entails.

4.1 Effects of speed

Speed allows for a reduction in journey times and thus increases mobility (OECD; ECMT, 2006; European Comission, 2021; International Transport Forum, 2018; Kallberg et al., 2014). Increased average travel speed allows people to access opportunities and services from farther away and this often contributes to a general increase in the overall quality of life. People value faster movement as it allows them to do more in the same amount of time. Studies on people's transportation habits have found that people use between 60 and 90 minutes for transportation in a single day no matter what the infrastructure looks like (Zahavi & Ryan, 1980). This suggests that as travelling speeds increase, people travel for longer distances instead of using that time for something other than travelling.

However, speed also has many downsides. First, increasing speed of motor traffic increases the frequency and the severity of crashes (Nilsson, 2004; Jurewicz et al., 2016). Drivers have less time to notice and react to threats when the speed of the vehicle increases (Green, 2000; Hooper & McGee, 1983). High speed also increases breaking distances and reduces drivers' field of vision (Greibe, 2007; AASHTO, 2018). Secondly, adding speed also increases the amount of pollutants that are emitted by the vehicle (Kallberg et al., 2014; Malin et al., 2023). As speed increases, atmospheric drag and the rolling friction of the tires increase significantly. This means it takes more power, and so fuel, to overcome these forces and maintain a higher speed. Third, noise pollution also increases significantly as the speed of the traffic increases (Robertson et al., 1998). Noise pollution and other emissions have a serious effect on human health, especially in urban areas. Lastly, fast moving traffic can severe communities and discourage walking and cycling in communities with large amounts of traffic (OECD; ECMT, 2006). This can lead to a less active lifestyle that can have other negative health effects (OECD; ECMT, 2006). Increasing the average travel speed encourages people to move farther away from city centers contributing to urban sprawl (OECD; ECMT, 2006). In the next chapters we will look at these effects that increasing speed has in more detail.

4.2 Speed, Reaction Time, and Braking Distance

Speed has a significant effect on road safety through multiple mechanisms. One of these mechanisms is the interaction speed has with human reaction time. Reaction time is a product of human biology, and it varies greatly between people. In traffic engineering, reaction time includes the time it takes for a driver to notice a possible threat, identify the threat, decide on a suitable reaction to the threat and move their body to respond to the threat (Green, 2000). Green (2000) analyzed multiple studies on reaction time and found that expected reaction time varies from 0,7 seconds in ideal conditions all the way to 1,5 seconds in unexpected and unusual cases. These were average reaction times, and it would be expected to see some drivers react to similar situations significantly slower. In their study Hooper and McGee (1983) found that the 95^{th} percentile for perception-break-reaction time was 2,16 seconds. The green book by American Association of State Highway and Transportation Officials (AASHTO) (2018) also points out that some situations require more complex processing that might extend the reaction time to 2,7 seconds. Using the 95^{th} percentile for reaction time means that a car travelling at 100 km/h can move up to 60 meters before breaking is initiated by some drivers, whereas a car travelling at 80 km/h would move 48 meters in the same amount of time.

Speed also affects the breaking distance of the car. Breaking distance is the distance that it takes to stop the car from the moment that the driver starts to brake. The breaking distance can be calculated using two commonly used methods. The first one calculates the distance by using friction and the equations

$$E_k = \frac{1}{2} m {V_0}^2, \qquad and \qquad W_f = \mu m g d, \qquad to\ arrive\ at \qquad d = \frac{{V_0}^2}{2\mu g} \quad (1)$$

where E_k is kinetic energy, W_f is work done by friction, d is the breaking distance, V_0 is the initial speed, μ is the mean coefficient of friction, g is the gravitational constant, and m is mass of the vehicle. This method uses measurements of the mean coefficients of friction in different conditions and road types to produce estimates of the breaking distance by velocity. The coefficient of friction varies greatly, but commonly a value of 0,7 is used for dry roads and 0,4 is used for wet roads. The other, slightly newer, method uses the equation

$$d = \frac{{V_0}^2}{2a} \qquad (2)$$

where a is the deceleration. This method uses information from studies that measure the deceleration that people break with to estimate the breaking distances. According to the AASHTO (2018) most people break using a deceleration rate of $4{,}5\ \mathrm{m/s^2}$ and 90 % break with a deceleration rate of at least $3{,}4\ \mathrm{m/s^2}$. In Geibe's (2007) study an average professional driver broke with a deceleration rate of $8{,}4\ \mathrm{m/s^2}$ and non-professional drivers broke with a deceleration rate of $7{,}4\ \mathrm{m/s^2}$ in dry conditions. With the equations (1) and (2) and estimates of coefficients of friction and deceleration rates, estimates of breaking distance using initial vehicle speed can be calculated as in figure 4 below. It should be noted that these estimates vary greatly partly because breaking distances are a product of many variables. These include tire condition, possible breaking assistance systems, the mass of the car and its breaking systems effectiveness, weather conditions and the pressure put on the breaking pedal (Greibe, 2007).

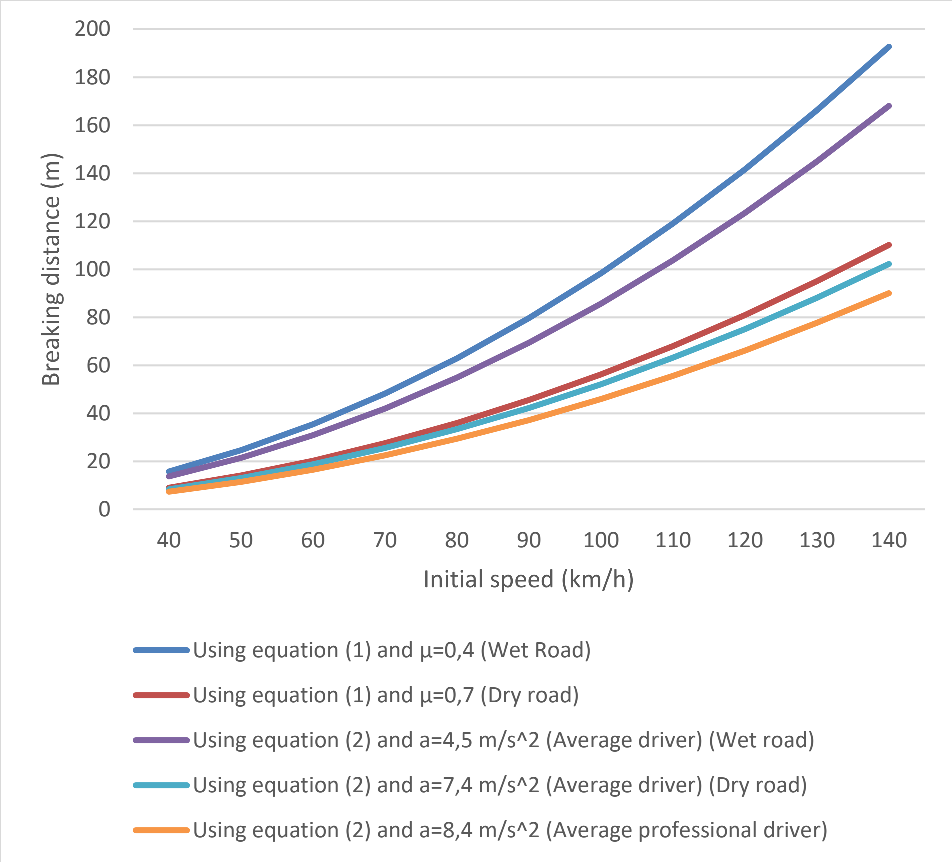

Figure 4. *Estimations of breaking distance by initial vehicle speed using different calculation methods and variables*

As we can see in figure 4, estimates of breaking distance based on initial speed vary significantly, but the trend is clear. As initial speed increases, breaking distance increases at a faster rate. When we compare these estimates to real world results from Greibe's (2007) study, we can see the same upwards trend, but the breaking distances are at the lower end of the calculated estimates. To sum up, initial speed has a large impact on the breaking distance.

The interaction between reaction time, breaking distance, and initial speed means that as driving speeds increase the time that the driver has for reacting to dangerous situations decreases and the tolerance for mistakes is limited. And if the driver can't stop the vehicle in time, a higher initial speed means that the speed at the time of the crash is also higher. Reaction time is rooted in human biology and breaking distance is dependent on many environmental factors. More effective braking systems and assistive or automatic computer systems can reduce the effect of these physiological limitations, but they form the basis of what the built environment must be designed around.

4.3 Speed, Crash Frequency, and Crash Severity

Increased vehicle speed has been shown to increase both the severity of traffic crashes and the frequency of them (Aarts & van Schagen, 2006; OECD; ECMT, 2006; Elvik et al., 2019; Nilsson, 2004). The connection between speed and crash severity is relatively straight forward (Aarts & van Schagen, 2006). In the event of a crash, the occupants of a vehicle and the people outside of the vehicle must endure dramatically increased amount of force as the speed of the vehicle increases. Kinetic energy E_k follows the commonly known formula of $E_k = \frac{1}{2}mv^2$. As the travel speed of a vehicle doubles, its kinetic energy quadruples. When looking at collisions, the kinetic energy of the car provides an accurate estimate of the severity of the crash (Jurewicz et al., 2016; Aarts & van Schagen, 2006).

However, estimating the increase in the frequency of crashes is much more difficult. There are many factors that affect the number of crashes. For example, as outlined in chapter 4.2., reaction time and breaking distance increase as speed increases which leaves less room for mistakes. On the other hand, these factors can be, and have been, considered when designing roads. Researchers have tried to estimate the relationship between speed and crash frequency using multiple methods. Some researchers have decided to examine how individual vehicle speed effects the likelihood of a crash, whereas some others have decided to examine the issue at an aggregate level (Aarts & van Schagen, 2006).

The studies examining individual drivers usually employ a self-reporting method. For example, in a study by Fildes et al. (1991) drivers' speeds were measured on an urban 60 km/h road and a rural 100 km/h road. Of these drivers, the ones that drove fastest (above

85th percentile) and slowest (below 15th percentile) were stopped and asked about their history of road crashes in the past 5 years. The researchers found that the faster drivers were more likely to have been in a crash in the last 5 years. The finding followed an exponential curve and the curve for urban roads was much steeper. These curves can be seen in figure 5 below. (Fildes et al., 1991; Aarts & van Schagen, 2006)

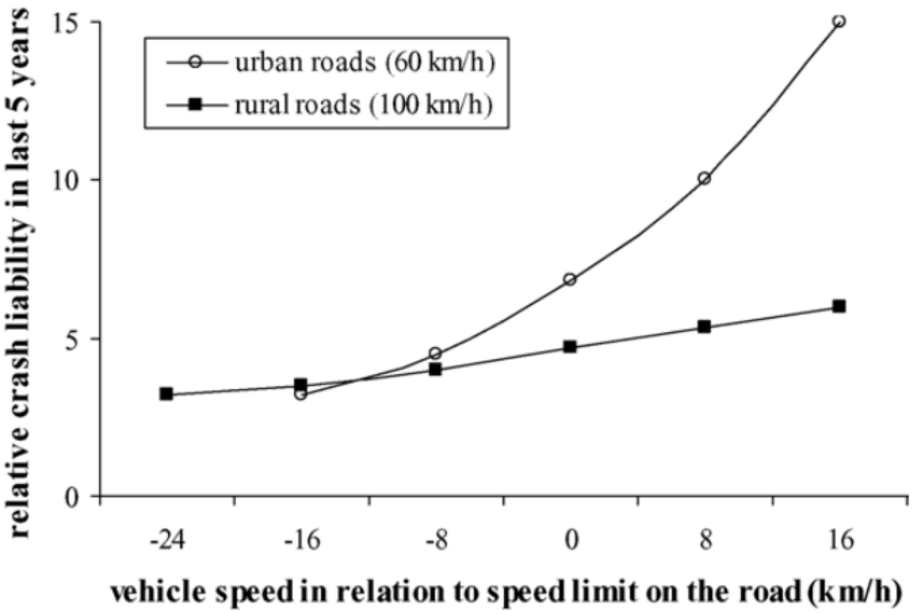

Figure 5. *Connection between vehicle speed and relative crash liability in the last 5 years (Fildes et al., 1991)*

Other self-report studies have found similar exponential relationships between speed and crash liability in the past. These results vary from a 7,75% increase in crash liability as speed is increased by 1% in a study by Quimby et al. (1999) to a 13,1% liability increase with 1% speed increase in a study by Maycock et al. (1999) (Aarts & van Schagen, 2006).

The other method of estimating speeds effect on crash frequency utilizes data from roads that have changed speed limits. Perhaps the most widely cited study using this method is Nilsson's (2004) paper on his Power model. Nilsson (2004) wanted to estimate how the change in the mean speed on a road effects the number of injuries and the number of fatalities on that road. Based on data from multiple countries and equations from Newtonian physics he created the Power Model. Nilsson's (2004) power model can be represented with six equations:

$$Number\ of\ fatal\ accidents = Y_1 = \left(\frac{V_1}{V_0}\right)^4 \cdot Y_0\ ,$$

$$Number\ of\ fatalities\ = Z_1 = \left(\frac{V_1}{V_0}\right)^4 \cdot Y_0 + \left(\frac{V_1}{V_0}\right)^8 \cdot (Z_0 - Y_0)\ ,$$

$$Number\ of\ fatal\ and\ serious\ injury\ accidents = Y_1 = \left(\frac{V_1}{V_0}\right)^3 \cdot Y_0\ ,$$

$$Number\ of\ fatalities\ or\ serious\ injuries = Z_1 = \left(\frac{V_1}{V_0}\right)^3 \cdot Y_0 + \left(\frac{V_1}{V_0}\right)^6 \cdot (Z_0 - Y_0)\ ,$$

$$Number\ of\ injury\ accidents\ (all) = Y_1 = \left(\frac{V_1}{V_0}\right)^2 \cdot Y_0\ , \qquad and$$

$$Number\ of\ all\ injured\ road\ users\ (all) = Z_1 = \left(\frac{V_1}{V_0}\right)^2 \cdot Y_0 + \left(\frac{V_1}{V_0}\right)^4 \cdot (Z_0 - Y_0)\ .$$

In the equations above Y_0 and Y_1 represent the number of accidents before and after respectively on the road, Z_0 and Z_1 are the number of injured in accidents before and after on the road, and V_0 and V_1 are the mean vehicle speeds before and after on the road. This model estimates that as mean driving speed on a road decrease by 5%, the number of injurious crashes will decrease by 9,8% and fatal crashes will decrease by 18,5% (Nilsson, 2004). It should be noted that Nilsson's Power model was first introduced in 1981 and that he used mainly data from rural 2-lane roads to verify his model (Nilsson, 2004). However, other studies have found that the Power model produces accurate results even with new crash data and modern safety equipment (Elvik et al., 2019). The findings also illustrate how lowering mean speed by small amounts has an outsized impact on the number of accidents and injured people. Figure 6 below presents how a change in mean speed impacts the relative number of accidents based on Nilsson's (2004) Power model.

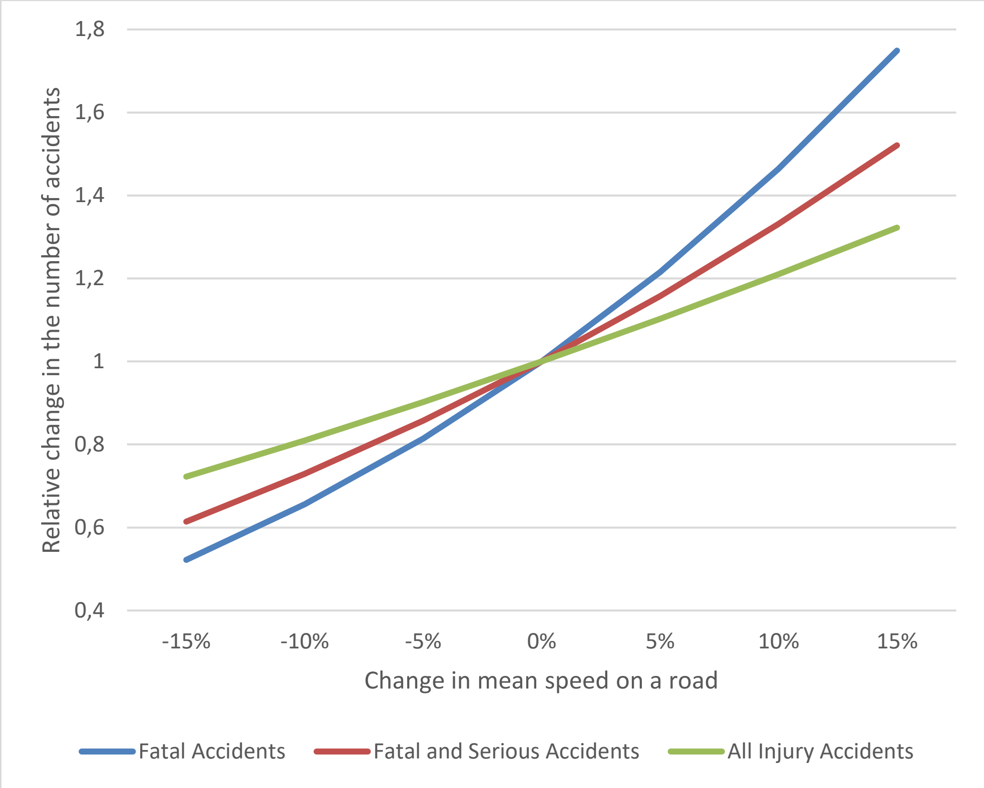

Figure 6. *Change in the number of fatalities and injuries as mean speed changes (Nilsson, 2004)*

To sum up, researchers studying speeding's effect on crash frequency on an individual level as well as those examining it on an aggregate level have found that speed has an exponential relationship with the frequency of crashes. Their findings disagree on the strength of this relationship, but the overall trend seems to be clear. A similar relationship has been found between crash severity and speed.

4.4 Speed limits

The first national law setting a maximum allowed speed for motorized vehicles was introduced in the United Kingdom in the year 1861 (The National Archives, 1861). Earlier legislation to limit reckless driving of horse-drawn carriages did exist in many places, for example in the city of New Amsterdam it was forbidden to drive a wagon at a gallop inside of the city limits (Nodarse, 2019). Section 11 of the locomotive act of 1861 from the UK goes as follows:

“It shall not be lawful to drive any Locomotive along any Turnpike Road or public Highway at a greater Speed than Ten Miles an Hour, or through any City, Town, or Village at a greater Speed than Five Miles an Hour; …” (The National Archives, 1861).

The law also sets a maximum penalty of ten pounds for exceeding the speed limit which is equivalent to 915 pounds in 2022 when adjusted for inflation (The National Archives, 1861). Interestingly, the speed limits were found to be too high, so in the Locomotive Act 1865 a lower speed limit of four miles an hour (6,4 km/h) was set for outside of built-up areas and a speed limit of 2 miles per hour (3,2 km/h) was set for cities and villages with an additional requirement for a red flag to be carried ahead of the vehicle on foot (The National Archive, 1865). Over time, these limits were raised and eventually revoked in the UK and the wider enactment of such speed limits around the world was delayed partly by the lack of speedometers until the middle of the 20th century.

In Finland, the first speed limits were implemented after a set of experiments were conducted in the 1960’s (Salusjärvi, 1981). The first experiment of 1962 set a general speed limit of 90 km/h in three provinces of Finland for four months, where there was no previous speed limit (Salusjärvi, 1981). The limit of 90 km/h was chosen because only 15 % of drivers exceeded it when there was no speed limit (Salusjärvi, 1981). The number of accidents decreased by 6%, the number of injuries decreased by 8% and the number of fatal accidents decreased by 10% because of this speed limit trial (Salusjärvi, 1981). Speed limits were found to have reduced the average driving speeds and the differences between driving speeds of different drivers (Salusjärvi, 1981). Experiments continued throughout the 60’s in different forms. In the meantime, measurements showed that the average driving speed had continued to increase linearly from 69 km/h in 1962 to 82 km/h in 1968 (Salusjärvi, 1981). Because of this increase in average driving speeds, a committee proposed that the implementation of general speed limits should be abandoned because of their overly limiting effect on the free selection of speed and alternative solutions such as road-section speed limits should be trialed instead (Salusjärvi, 1981).

The second set of trials between 1970 and 1973 focused on road-sectional maximum speed recommendations (Salusjärvi, 1981). These recommended maximum speeds were based on road geometry and were found to be effective at reducing the fastest speeds by 3-4 km/h and the number of serious accidents significantly (Salusjärvi, 1981). Based on these trials and other studies done on the previous trials a committee proposed nationwide speed limits and a parliamentary group started work on a new proposal in 1972. New interest in implementing speed limits was sparked by the new year's speech of President Kekkonen in 1973 (Salusjärvi, 1981). A large portion of his speech was dedicated to this issue and urged decision makers to follow Sweden's example in implementing speed limits (Kekkonen, 1973). Sweden had implemented speed limits based on road standards in 1968, but Sweden had had a 50 km/h speed limit inside built-up areas since 1955 (Nilsson, 1982). It should be noted that some Finnish towns and cities had also set their own speed limits before national limits. At the time Finland's roads were regarded as some of the most dangerous in the world with an accident rate of 12,2 accidents per 10 000 vehicles, more than double Sweden's 4,6 accidents per 10 000 vehicles (Salusjärvi, 1981).

The implementation of speed limits was done in three phases starting from Southern Finland and expanding North (Salusjärvi, 1981). The speed limits were set at 60, 80, 100, or 120 km/h based on road quality, sight distances, traffic volume, and road geometry (Salusjärvi, 1981). The goal of the new speed limits was to find a good middle ground between the increased number of accidents of higher speeds and increased time cost of lower speeds (Salusjärvi, 1981). In addition to the three phases, the oil crisis forced the government to implement a general 80 km/h speed limit for 6 months in 1974 (Salusjärvi, 1981).

The basic logic of speed limits has remained mostly unchanged since the 1970's. Some small changes have been made to accommodate specific circumstances better. In 1973 a maximum speed of 80 km/h was set for buses, trucks, and vans. In 1988, a default speed limit of 80 km/h was set for outside of built-up areas and 50 km/h for inside of built-up areas. In 1991 lower speed limits were introduced during winter. Additionally, temporary measures such as the 80 km/h speed limit for new drivers have been in place but have been removed since. Currently busses and vans can also have an increased 100 km/h limit if specific safety requirements are met. (kirjastot.fi, 2007)

This approach to introducing speed limits was successful at reducing the number of fatalities greatly. In Finland the number of fatalities on roads reduced from more than 1100 in 1973 to below 600 in 1978 when the speed limit system was introduced (Tilastokeskus, 2007). The full development of the number of fatalities can be seen in figure 7 below.

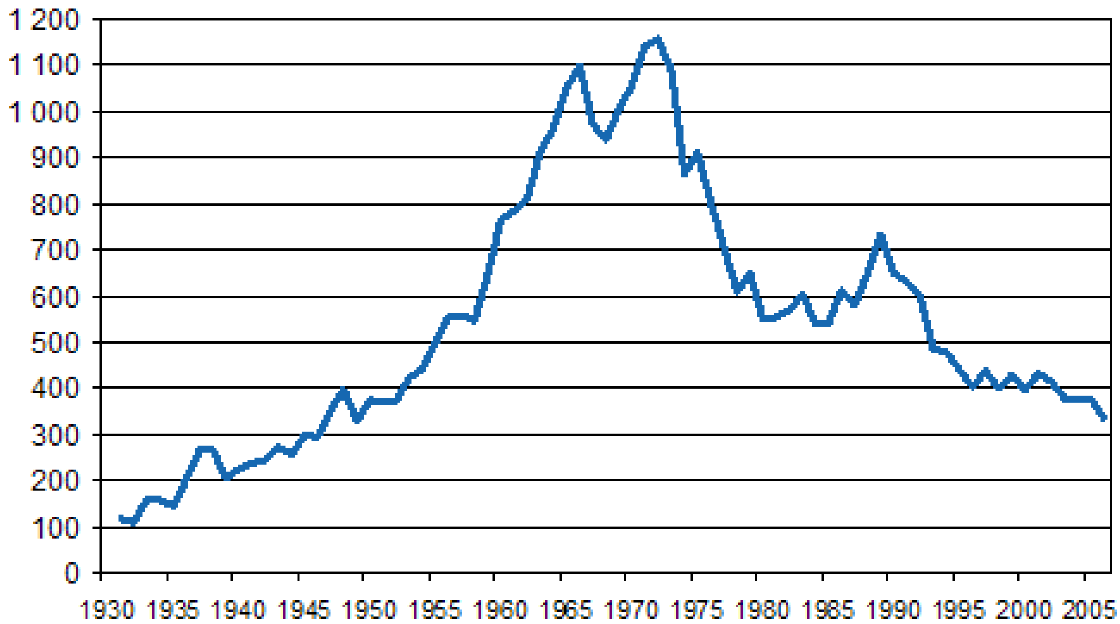

Figure 7. *Number of fatalities on Finnish roads from 1931 to 2005 (Tilastokeskus, 2007)*

As can be seen from figure 7 above, the implementation of speed limits started a dramatic fall in the number of fatalities on Finnish roads over time. This is even more significant than it seems on the surface, since the number of kilometers driven on Finnish roads has continued to increase from 24,4 billion kilometers in 1975 to 52,2 billion in 2005 (Tilastokeskus, 2007). As expected, the average driving speed also fell after the implementation of national speed limits. The development of average driving speeds throughout this period and up to modern day can be seen in figure 8 below.

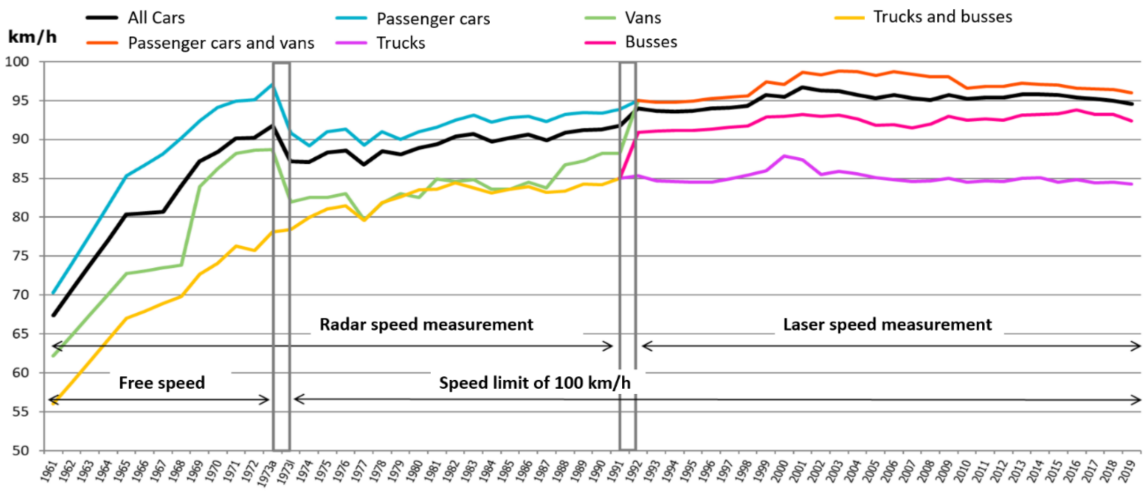

Figure 8. *Development of average driving speeds on Finnish roads from 1961 to 2019 (Kiiskilä et al., 2020)*

As figure 8 shows, the implementation of national speed limits stopped the increase of average driving speeds that had been quite drastic and linear until that point. The average driving speed declined sharply after the implementation of speed limits. However, the average driving speed continued to increase slowly up until the turn of the century when the incremental increase turned to plateau and eventually event to a very slow decline. The Finnish transport and infrastructure agency has continued to track average speeds on Finnish roads. Table 1 below shows the most recent results for average speeds and the share of vehicles driving over the speed limit in both the summer and the winter seasons.

Table 1. *Average driving speeds, shares of vehicles driving over the speed limit and share of vehicles driving more than 10 km/h over the speed limit on Finnish rural roads depending on the speed limits in 2019 (Kiiskilä et al., 2020)*

Road type	Speed limit (km/h)	Average speed of all vehicles (km/h)		Share of vehicles driving over the speed limit		Share of vehicles driving more than 10 km/h over the speed limit	
		Summer	Winter	Summer	Winter	Summer	Winter
Two lane roads	Persistent 60	62,3	61,5	62,1 %	56,2 %	9,7 %	7,5 %
	Persistent 80	81,9	79,7	59,5 %	48,4 %	13,3 %	7,0 %
	Summer 100, winter 80	93,4	83,6	28,1 %	68,2 %	4,8 %	15,7 %
	Persistent 100	95,9	91,6	38,1 %	22,9 %	8,7 %	3,8 %
Motorway	Summer 100, winter 80	91,0	82,9	21,6 %	67,8 %	2,0 %	12,6 %
Four lane roads	Persistent 60	66,4	-	70,5 %	-	34,0 %	-
	Persistent 70	67,1	65,8	33,3 %	26,6 %	3,5 %	2,3 %
	Persistent 80	80,8	79,3	53,5 %	45,9 %	11,0 %	8,1 %
	Persistent 100	98,6	95,3	48,1 %	35,2 %	11,1 %	6,1 %
Four lane motorway	Persistent 80	82,9	81,5	63,2 %	56,1 %	14,8 %	12,3 %
	Persistent 100	98,9	95,3	50,0 %	37,9 %	13,5 %	7,5 %
	Summer 120, winter 100	112,9	102,0	37,9 %	61,9 %	7,7 %	20,8 %
Average of all roads		92,8	87,0	43,5 %	53,4 %	9,4 %	12,0 %

These measurements indicate that speed limits have been an effective tool for limiting the average speed of vehicles to the indicated level. The only clear exemption to this are four lane roads with a persistent 60 km/h speed limit where the speed limit was exceeded by 6,4 km/h on average. On other roads the average speed stayed below the speed limit or exceeded the limit by less than 4 km/h. However, it should be pointed out that speed limits are set based on road geometry which also guides people's own speed choice. That makes establishing a causal link between the two very difficult.

The second notable statistic from these measurements is that the average driving speed decreased during the winter, but the share of people driving over the speed limit increased. Also, the roads with the largest share of vehicles driving over the speed limit during the winter were the roads where the speed limit changed to a lower speed when compared to the summer season. On winter speed limits, it has been estimated that reducing speed limits by 20 km/h on certain road sections for a little over three months a year, a reduction of 15 fatalities is achieved and a reduction of 50 injuries is achieved (Kallberg et al., 2014). This change is achieved with just a 3,8 km/h reduction in average driving speeds (Kallberg et al., 2014).

In addition to traffic safety and average driving speeds, speed limits can also affect fuel consumption and emissions. Cars are at their most efficient when driving between the speeds of 60 km/h and 80 km/h (Malin et al., 2023). This means that limiting driving speeds can reduce fuel consumption, overall emissions, and electric car electricity use. Figure 9 below exemplifies how the amount of emissions increases as the speed of the traffic flow increases.

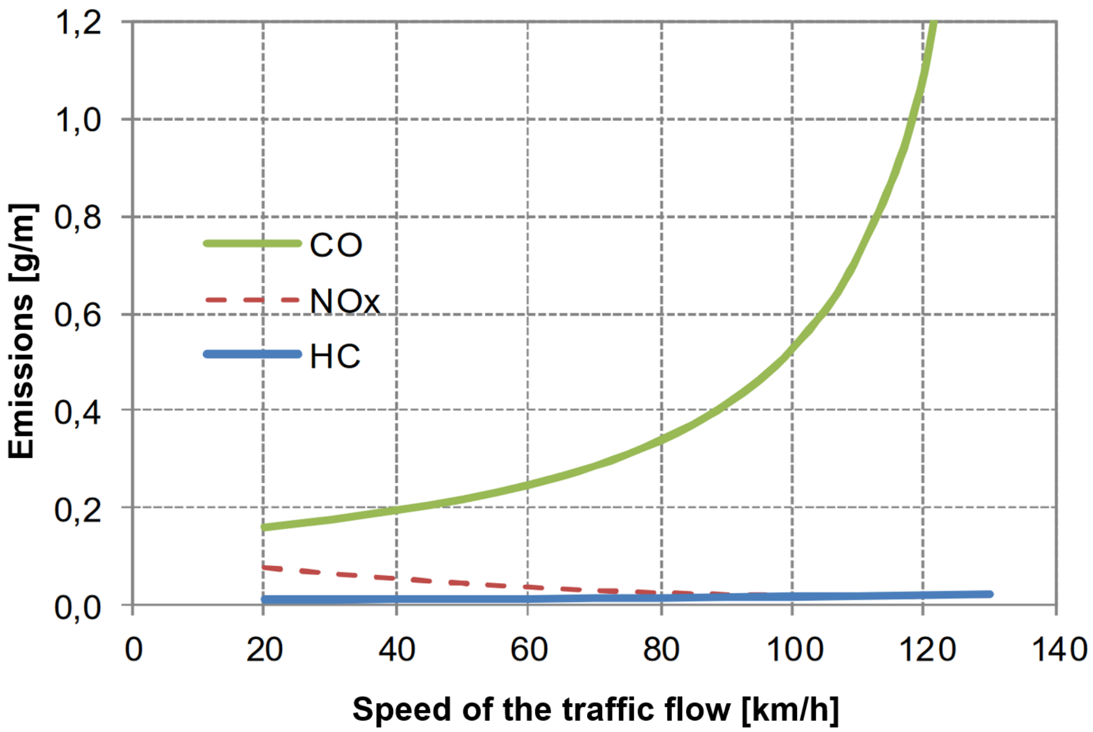

Figure 9. *Emissions of gas-powered cars as the speed of traffic flow increases (Ntziachristos et al., 2013)*

Travelling speed also affects the noise pollution levels emitted by the car. The total noise emitted by the vehicle is a product of two main factors. The first is the engine. The engine is the main source of noise pollution at low speeds. The second factor is the wheels. The noise emitted by the wheels of the vehicle is the main source of noise at higher speeds. The relationship between these two factors is represented in figure 10 below.

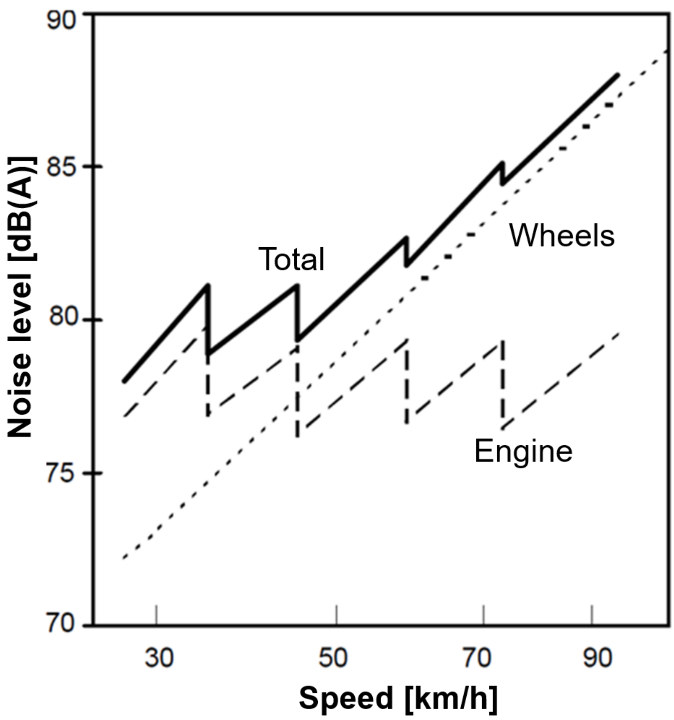

Figure 10. *Total noise levels and their producers at different speeds (Robertson et al., 1998)*

Based on the effects of speed presented above, officials have tried to calculate optimal speed limits. These calculations consider time saved by the increased speeds, the increased vehicle costs, the increase in traffic crashes, the increase in noise pollution, and the increase in emissions. In Finland these calculations concluded that the optimal speed limit on rural roads falls somewhere between 80 km/h and 95 km/h (Kallberg et al., 2014). It should be noted that these results varied significantly based on the values and costs given to each variable and the road type the calculations were done on.

4.5 Speeding as a social phenomenon

Multiple observational studies have found that, if the speed limit on a road is lowered and nothing else about the road's design is changed, the average driving speed on that road does not change immediately. The average driving speed starts to go down slowly over time, and it will reach a new equilibrium after multiple years. This suggests that the average driving speed on a road is affected by the speed limit, but it is not necessarily determined by it. The gradual change also suggests that the average driving speed is negotiated between drivers. Some drivers might start driving according to the speed limit immediately, some might continue driving according to the old speed limit, but the gradual change indicates that there is a large population of drivers who set their speed according to social norms. If the cars around a person are speeding, they will drive faster, because they don’t want to be the ones “holding up traffic”. But after a while when more and more drivers start driving according to the new speed limit, the social norm on that road changes gradually.

In traffic research, safety is usually seen as a product of the interaction between the driver, the vehicle, and the environment. That means the reasons why people exceed the speed limit are complex and varied. The speed selection of the driver is not exclusively affected by the speed limit. Factors such as weather, level of enforcement, lane width, the safety equipment of the car, and the attitudes of the driver are all considered when making decisions on travelling speed.

5. ANALYSIS OF THE DATA

This chapter begins with a short introduction to the ESRA survey, and some previous studies undertaken using the survey results. ESRA, or the E-Survey of Road users' Attitudes, is a joint initiative between various road safety institutes, research centers, and private actors from all over the world that aims to collect and analyze road safety data with a specific focus on behavior and culture. The survey has been conducted twice so far in 2015 and 2018. The third iteration of the survey has started collecting data in 2023. The 2018 survey covered 48 countries on six different continents.

After a short introduction to the ESRA survey, the chapter will continue with a short overview of the Finnish survey results. Starting from chapter 5.3, some data analytic methods will be engaged. First correlation analysis is applied to analyze the connections between the participants' answers to the survey questions. Then simple linear regression analysis is used to build models inspired by the TPB based on the results of the correlation analysis. After that, binary logistic regression is used to build models for predicting whether a participant is a speeder or a non-speeder. Finally, the differences between the attitudes of speeders and non-speeders will be analyzed in more detail.

5.1 Previous research on the ESRA data

The coordinators of ESRA, the Vias Institute, compile a country fact sheet for each of the participating countries. The country fact sheet of Finland gives a good overview of the core set of variables gained from the survey. Relating to speeding, Finnish participants found speeding more acceptable both personally and socially than the wider European average (Vias institute, 2021). Also, a larger percentage of the participants from Finland engaged in speeding than the European average (Vias institute, 2021). Interestingly, a larger proportion of Finnish participants thought they were likely to be checked by the police for respecting the speed limits on a typical journey when compared to other European participants (Vias institute, 2021).

Other researchers have analyzed the ESRA survey results. For example, a study by Holló, Henézi and Berta (2018) compared the self-reported behavioral results of the ESRA survey to findings of studies observing seat belt usage and child safety seat usage on Hungarian roads. Their conclusion was that the ESRA survey results conformed relatively well to the observed data and that ESRA findings could be used as a proxy of real values for traffic safety indicators. (Holló et al., 2018)

5.2 Overview of the data

The analysis is based on the Finnish datasets from the ESRA surveys from 2015 and 2018. The focus will mainly be on the 2018 dataset. The 2018 survey results include answers from 994 people. A breakdown of the genders and the age groups of the participants can be seen below in table 2.

Table 2. *Sample size of the survey and a breakdown of the gender and age of the participants*

Sample size	Gender			Age Group					
	Male	Female	Other	18-24	25-34	35-44	45-54	55-64	65-
994	48,8 %	51,2 %	0 %	10,4 %	15,7 %	15,0 %	16,4 %	16,9 %	25,7 %

The gender percentages are slightly skewed to the female side when compared to the overall Finnish gender distribution and the older age groups have more representation than the younger side. Regardless, the survey has representative samples of each age group and gender. It should be noted that analyzing individual age groups might introduce increased error rates because of the smaller sample sizes of the subgroups. The participants were also asked to report their level of education and the results can be seen below in table 3.

Table 3. *Self-reported level of education of the participants*

	None	Primary Education	Secondary Education	Batchelor's Degree	Master's degree or higher
Education level	0,4 %	13,2 %	53,8 %	18,9 %	13,7 %

The education level of the participants was slightly higher than the overall Finnish average. For example, of the entire Finnish population, 10,6 % have a master's degree or higher and 12,5 % have a bachelor's degree (Tilastokeskus, 2022). The bias toward higher educated participants should be kept in mind when analyzing results. When it comes to living environment, 39% of the respondents lived in urban areas and 61% lived in semi urban and rural areas. The survey did not ask whether the participants lived in urban areas but inferred it using the distance to the closest public transportation stop and the frequency of service of that stop. This approach does have some problems especially in the Finnish environment and the approach makes it difficult to compare this number to other measures of urbanization. Of the participants 82,8% had driving licenses whereas 17,2 % did not. This number is very close to the percentage of overall population that has a driving license. The use of other transportation modes is represented in table 4.

Table 4. *Self-reported transport mode use of the participants*

	Pedestrian	Cyclist	Motorcyclist	Car Driver	Car Passenger	Public Transport
Percentage that used each transport mode at least few days a month	95,6 %	48,6 %	7,3 %	70,7 %	70,5 %	47,7 %

Almost all participants reported that they had walked in the last month. Roughly 70% reported driving a car and being a passenger in a car. Approximately 50% reported having cycled and taking public transport. A little over 7% reported riding a motorcycle. It should be noted that the survey was conducted in the winter months, which might have influenced the answers the participants gave to this question.

In the survey the participants were presented with a list of questions regarding typical behaviors while driving, attitudes towards speeding, perceived behavioral control, and subjective norms. Some of these questions presented the participant with a statement and asked them to indicate their view on the statement on a scale from 5 (agree) to 1 (disagree). Some of the questions asked the participants to indicate how often they participated in a particular activity on a scale of 5 (almost always) to 1 (never). However, some questions were measured on a scale from 7 to 1. A list of speeding related questions and the means and standard deviations are presented in table 5 below.

Table 5. *List of speeding related questions and the means and standard deviations of the answers*

Question	Mean	Std. Dev.
Over the last 12 months, how often did you as a CAR DRIVER drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	2,65	1,03
Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit inside built-up areas?	2,23	1,04
Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	2,45	1,09
Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit on motorways/freeways?	2,55	1,18
Where you live, how acceptable would most other people say it is for a CAR DRIVER to drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	2,63	1,02
How acceptable do you, personally, feel it is for a CAR DRIVER to drive faster than the speed limit inside built-up areas?	2,04	1,01
How acceptable do you, personally, feel it is for a CAR DRIVER to drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	2,48	1,11
How acceptable do you, personally, feel it is for a CAR DRIVER to drive faster than the speed limit on motorways/freeways?	2,67	1,17
To what extent do you agree with each of the following statements? I have to drive fast; otherwise, I have the impression of losing time.	1,46	0,82
To what extent do you agree with each of the following statements? Most of my friends would drive 20 km/h over the speed limit in a residential area.	1,82	1,09
To what extent do you agree with each of the following statements? Respecting speed limits is boring or dull.	2,04	1,20
To what extent do you agree with each of the following statements? I trust myself when I drive significantly faster than the speed limit.	2,07	1,20
To what extent do you agree with each of the following statements? I am able to drive fast through a sharp curve.	1,90	1,12

To what extent do you agree with each of the following statements? I often drive faster than the speed limit.	2,15	1,18
To what extent do you agree with each of the following statements? I like to drive in a sporty fast manner through a sharp curve.	1,52	0,91
To what extent do you agree with each of the following statements? I will do my best to respect speed limits in the next 30 days.	4,12	1,20
How often do you think each of the following factors is the cause of a road crash involving a car? driving faster than the speed limit	4,24	1,23
Do you support or oppose a legal obligation to install Intelligent Speed Assistance (ISA) in new cars (which automatically limits the maximum speed of the vehicle and can be turned off manually)?	3,38	1,37
Do you support or oppose a legal obligation to install Dynamic Speed Warning signs (traffic control devices that are programmed to provide a message to drivers exceeding a certain speed threshold)?	3,88	1,10
What do you think about the current traffic rules and penalties in your country for driving or riding faster than the speed limit? The traffic rules should be stricter.	0,45	0,50
What do you think about the current traffic rules and penalties in your country for driving or riding faster than the speed limit? The traffic rules are not being checked sufficiently.	0,63	0,48
What do you think about the current traffic rules and penalties in your country for driving or riding faster than the speed limit? The penalties are too severe.	0,34	0,47
On a typical journey, how likely is it that you (as a CAR DRIVER) will be checked by the police for respecting the speed limits?	4,40*	1,76

*Answered on a scale from 1 to 7

The answers indicated that most participants had driven over the speed limit and have done so on a semi regular basis. Just 13,2 % of the participants reported that they had not driven over the speed limit in the last 12 months. Roughly 20% also saw speeding as a relatively acceptable behavior both personally and socially. Speeding inside built-up areas was seen as less acceptable than outside of them or on the motorway. Most participants disagreed with statements linking speeding to gaining time and excitement. Similarly, most participants indicated that they did not trust their own driving ability enough to exceed the speed limit. Almost all participants agreed that speeding was a contributing factor to traffic crashes and promised to respect the speed limits in the following 30 days. Most participants supported the implementation of intelligent speed assistance systems and dynamic speed warning signs and thought that the current traffic rules and penalties were already strict enough.

5.3 Correlation analysis

Next, correlation analysis was conducted on the survey data. The focus of the analysis was specifically on the answers of Finnish drivers, so the data was filtered so that only people that had a driving license and had driven in the last 30 days were included. People that did not answer the questions about speeding in the last 30 days were also filtered out. That resulted in a sample size of 695. The results of the first correlation analysis of background characteristics with self-reported speeding can be seen below in table 6.

Table 6. *Correlations of background characteristics with self-reported speeding in the last 30 days*

	Self-re-ported speeding inside built-up areas	Self-re-ported speeding outside built-up areas	Self-re-ported speeding on mo-torways
Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit inside built-up areas?	1,000	0,761**	0,655**
Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit outside built-up areas?	0,761**	1,000	0,788**
Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit on motorways/freeways?	0,655**	0,788**	1,000
Are you...? (1 = male; 2 = female)	-0,106**	-0,143**	-0,109**
Age	-0,098**	-0,044	-0,093*
What is the highest qualification or educational certificate that you have obtained?	0,077*	0,099**	0,113**
Level of urbanization	-0,002	0,056	0,014
During the past 12 months, ... How often did you walk mini-mum 100m?	0,060	0,023	-0,030
During the past 12 months, … How often did you cycle (non-electric)?	0,049	0,019	0,017
During the past 12 months, ... How often did you drive a car (non-electric or non-hybrid)?	-0,199**	-0,197**	-0,214**
During the past 12 months, ... How often did you drive a hy-brid or electric car?	-0,030	0,001	-0,043
During the past 12 months, … How often did you take the train?	0,006	0,011	-0,029
During the past 12 months, ... How often did you take the bus?	0,046	0,078*	0,050
During the past 12 months, ... How often did you take the tram/streetcar?	0,058	0,032	-0,006
During the past 12 months, ... How often did you take the subway?	0,038	0,051	-0,001

During the past 12 months, ... How often did you take the aeroplane?	-0,040	-0,074	-0,098**
During the past 12 months, ... How often did you be a passenger in a car?	-0,038	0,009	-0,049

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

This analysis produced some predictable results but also some less predictable ones. First, speeding in one environment was strongly correlated with speeding in other environments. This was expected and makes intuitive sense. Secondly, speeding was correlated with age and gender. Males were more likely to speed in all environments and especially outside of built-up areas. When it comes to age, older people were less likely to speed which was expected, but interestingly the correlation between age and self-reported speeding was found to be statistically significant only inside built-up areas and on motorways. Outside of built-up areas age was not found to be a significant correlative factor with self-reported speeding. Having a higher education was also found to be correlated with self-reported speeding. Interestingly, the correlation between education level and self-reported speeding was more significant outside of built-up areas than inside of them.

One expected result was that driving more often was correlated with more self-reported speeding in all environments. On the other hand, having to drive to work or having to drive a vehicle for work was not found to correlate with speeding. For the most part, using different transportation modes was not found to correlate with self-reported speeding. There were two exceptions. Using the bus more in the last 12 months was found to be correlated with less speeding outside of built-up areas, but not inside of them or on the motorway. The second correlation was between flying more often and speeding on the motorway.

Next, correlation analysis was conducted to investigate how answers on other speeding related questions correlated with self-reported speeding. The goal was to find the best questions to select for further analysis. The correlations between the answers to these questions can be seen in table 7 below.

Table 7. *Correlations of speeding related questions and self-reported speeding*

	Self-reported speeding inside built-up areas	Self-reported speeding outside built-up areas	Self-reported speeding on motorways
Where you live, how acceptable would most other people say it is for a CAR DRIVER to drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	0,381**	0,443**	0,415**
How acceptable do you, personally, feel it is for a CAR DRIVER to drive faster than the speed limit inside built-up areas?	0,600**	0,530**	0,446**
How acceptable do you, personally, feel it is for a CAR DRIVER to drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	0,500**	0,575**	0,505**
How acceptable do you, personally, feel it is for a CAR DRIVER to drive faster than the speed limit on motorways/freeways?	0,495**	0,578**	0,584**
To what extent do you agree with each of the following statements? Most of my friends would drive 20 km/h over the speed limit in a residential area.	0,348**	0,264**	0,199**
To what extent do you agree with each of the following statements? I have to drive fast; otherwise, I have the impression of losing time.	0,366**	0,361**	0,368**
To what extent do you agree with each of the following statements? Respecting speed limits is boring or dull.	0,487**	0,519**	0,460**
To what extent do you agree with each of the following statements? I trust myself when I drive significantly faster than the speed limit.	0,420**	0,486**	0,424**
To what extent do you agree with each of the following statements? I am able to drive fast through a sharp curve.	0,327**	0,363**	0,330**
To what extent do you agree with each of the following statements? I often drive faster than the speed limit.	0,618**	0,675**	0,607**
To what extent do you agree with each of the following statements? I like to drive in a sporty fast manner through a sharp curve.	0,281**	0,303**	0,288**
To what extent do you agree with each of the following statements? I will do my best to respect speed limits in the next 30 days.	-0,319**	-0,322**	-0,317**
How often do you think each of the following factors is the cause of a road crash involving a car? driving faster than the speed limit	-0,149**	-0,170**	-0,166**

**. Correlation is significant at the 0,01 level (2-tailed).

Predictably, most of the answers to the speeding related questions showed statistically significant correlations with self-reported speeding. However, some correlated more strongly than others. The question “To what extent do you agree with each of the following statements? I often drive faster than the speed limit.” correlated very strongly (over 0,5) with 5 of the other 12 questions relating to speeding. It also correlated strongly (over 0,6) with the self-reported speeding. This suggests that participants interpreted it as a rephrasing of some of the other questions as such it was excluded from further analysis.

In addition to the previously mentioned question, there were other ones that correlated strongly with self-reported speeding. Social acceptability and personal acceptability indicated with the four first questions of table 7 were found to be strongly correlated with increased speeding. Especially, personal acceptability of speeding inside built up areas was found to be one of the strongest correlations with speeding inside built-up areas. From the questions indicating different attitudes toward speeding, finding that respecting the speed limits was dull and having the impression of losing time when not speeding, were found to correlate the strongest with self-reported speeding. Also, thinking that most of your friends would drive significantly over the speed limit in residential areas was correlated with speeding especially in built-up areas.

Questions relating to the participants’ trust in their own driving ability were also correlated with increased speeding. The two questions that had a negative correlation with speeding were related to personal promise of not speeding in the next 30 days and a question inquiring whether the participant thought speeding was a contributing factor in traffic crashes.

5.4 Regression analysis

The next step was to employ regression analysis based on the findings of the correlation analysis. The goal was to create a model that followed the basic logic laid out in the theory of planned behavior. The TPB was presented in chapter 3.1 of this thesis and condensed in picture 2 of the same chapter. The simple core of the theory is that best predictor of behavior is behavioral intention, and that behavioral intention can be modeled using the equation

$$BI = w_A A + w_{SN} SN + w_{PBC} PBC,$$

where BI is behavioral intention, A is attitude, SN is subjective norms, PBC is perceived behavioral control, and w represents the weight derived from experiments. The factors of BI, A, SN, and PBC were approximated by selecting specific questions that were estimated to create an accurate, yet understandable, constructs for each of the four factors.

The best question for behavioral intention was somewhat difficult to choose, since there were two possible choices. The first option was to use the answers from the question "To what extent do you agree with each of the following statements? I will do my best to respect speed limits in the next 30 days." as it gives a direct indication of an intention not to speed. The second option was to use the question "Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit inside built-up areas?", or the equivalent question for other environments depending on the analysis. The second one represents more of an indication of past behavior rather than behavioral intention, but it had the upside that there were separate questions for each of the different road environments. The different upsides were significant enough so that using both questions was justified. The first question will be used for general analysis and the second option will be used for road environment specific analysis.

The factor of attitude was estimated by taking answers from "I have to drive fast; otherwise, I have the impression of losing time" and "Respecting speed limits is boring or dull." and by calculating a construct. These two questions were selected because they had a strong correlation with self-reported speeding and represented two common attitudes toward speeding. Negative attitudes toward speeding were not included since that would have complicated the analysis unnecessarily. Because of this the attitude variable should be seen as more of an estimation of the effect of positive attitudes for speeding.

The estimation of Subjective Norm was formed with a similar method but using answers to questions: “Where you live, how acceptable would most other people say it is for a CAR DRIVER to drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?” and “How acceptable do you, personally, feel it is for a CAR DRIVER to drive faster than the speed limit …?” using the appropriate environment for each analysis. These two questions were chosen since they encapsulate both the social and the personal acceptability of speeding. These two questions also had strong correlations with self-reported speeding. Considerations were made, whether including personal acceptability into the subjective norms’ calculation would bring it too close to the attitude factor, but since the answer to the question regarding personal acceptability did not correlate too strongly with the questions selected to the attitude category, it was included in the subjective norms’ indicator.

The estimation of perceived behavioral control was calculated with answers from questions: “I trust myself when I drive significantly faster than the speed limit.” and “I am able to drive fast through a sharp curve.”. These two questions were chosen into the analysis since they covered both the perceived ability to exceed the speed limit and the perceived ability to drive fast in difficult circumstances.

The first analytical model was a simple linear regression model to see if attitudes, subjective norms, and perceived behavioral control predicted behavioral intention to speed. The constructs described above were used for each of the factors. Specifically, the indicator of behavioral intention was based on the intention to follow the speed limit in the next 30 days. The results can be seen in table 8 below.

Table 8. *Factors influencing behavioral intention to speed*

	B	Std. Error	t	Sig.
Constant	0,360	0,145	2,477	0,014
Attitude	0,326	0,065	4,999	<0,001
Subjective Norms	0,213	0,062	3,446	<0,001
Perceived Behavioral Control	0,220	0,056	3,916	<0,001

$R^2 = 0{,}255, \quad Adjusted\ R^2 = 0{,}250, \quad F = 57{,}225$

All the three factors of the TPB were found to statistically predict the behavioral intention of speeding. Attitude was found to be the strongest predictive indicator of the three. The indicators of subjective norms and perceived behavioral control were found to be at a similar strength in predictive ability. The model explained 25 percent of the variation in behavioral intention.

Next, linear regression analysis was used to analyze attitudes, subjective norms and percieved behavioral control statistically predicted speeding behavior in different environments. Table 9 below has the results from three different linear regression models for speeding inside built up areas B_{in}, speeding outside built-up areas B_{out}, and speeding on motorways B_m.

Table 9. *Factors influencing the amount of speeding behavior in different environments*

	B_{in}	B_{out}	B_m
Constant	0,078**	0,106**	0,106**
Attitude	0,331**	0,352**	0,357**
Subjective Norms	0,456**	0,406**	0,476**
Perceived behavioral control	0,062	0,138**	0,072
R^2	0,385	0,413	0,381
Adjusted R^2	0,382	0,411	0,376

* Indicates significance at level >0,05

** Indicates significance at level >0,01

The three models ended up being expectedly similar. Attitudes were a statistically significant predictor of speeding in all environments. Attitudes affected speeding behavior relatively more outside of built-up areas and on motorways when compared to speeding inside built-up areas. Interestingly subjective norms were the most impactful factor in predicting speeding in all environments. Subjective norms were relatively larger factors for predicting speeding inside built up areas and on motorways, but a little bit less so outside built-up areas. Perceived behavioral control was found to be a statistically significant factor only outside of built-up areas, but not inside of them or on motorways. PBC was still the least impactful factor out of the three even outside built-up areas.

Background factors such as age, gender and education were not included in the linear regression models above as the theory of planned behavior asserts that these background factors affect attitudes, subjective norms, and perceived behavioral control, which create behavioral intentions. The next step in the analysis was to model how these background factors affected the three main factors of the TPB. The results of the five linear regression models can be seen below in table 10.

Table 10. *Factors influencing attitudes, subjective norms and perceived behavioral control*

	A	SN_{in}	SN_{out}	SN_m	PBC
Constant	0,241**	0,472**	0,511**	0,560**	0,416**
Gender	-0,061**	-0,049*	-0,070**	-0,074**	-0,164**
Age	-0,153**	-0,295**	-0,269**	-0,309**	-0,194**
Education	0,107*	0,094	0,112	0,112	0,034
R^2	0,050	0,090	0,078	0,092	0,126
Adjusted R^2	0,046	0,086	0,074	0,088	0,123

** indicates significance at level >0,01
* indicates significance at level >0,05

The main finding of these models was that gender and age were statistically significant predictors of all the three factors of the TPB. Being a male or a younger person were statistically significant predictors of more positive attitudes, more accepting subjective norms, and higher perceived behavioral control toward speeding. Even though being more highly educated was correlated with more speeding, being more highly educated was not a statistically significant predictor of subjective norms or perceived behavioral control. However, being more highly educated was a statistically significant predictor of more positive attitudes toward speeding.

5.5 Binary logistic regression analysis

The previous analysis on speeding analyzed how attitudes, subjective norms and perceived behavioral control affected the amount of speeding the participant reported. To analyze how different aspects affected whether the participants speeded in general binary logistic regression was used. For this, the answers to the question "Over the last 30 days, how often did you as a CAR DRIVER drive faster than the speed limit…?" for each of the three environments were reclassified into binary variables. The variables were divided so that people that reported that answered "1 – never" were classified as non-speeders and everyone else was classified as a speeder. Then binary logistic regression was used to analyze if attitudes, subjective norms, and perceived behavioral control could statistically significantly predict whether someone was a speeder or a non-speeder. The same constructs for the approximations for attitude, subjective norms and perceived behavioral control were used as earlier. The constructs are a sum of two answers ranging from 1 to 5 so the constructs ranged in value between 1 and 10. The results for speeding inside built-up areas can be seen below in table 11.

Table 11. *Factors influencing speeding inside built-up areas*

	B	Std. Error	Sig	OR	95% CI for OR	
					Lower	Upper
Constant	-2,556	0,347	<0,001	0,078		
Attitude	0,412	0,094	<0,001	1,509	1,254	1,816
Subjective Norms	0,484	0,073	<0,001	1,622	1,405	1,873
Perceived Behavioral Control	0,063	0,069	0,361	1,065	0,931	1,218

Nagelkerke R^2= 0,277

The analysis found that the odds of the participant being a speeder inside built-up areas increased by 50,9% (95% CI [1,254; 1,816]) for every additional point in the attitude indicator. The analysis also found that every additional point in the subjective norm indicator increased the odds of the participant being a speeder by 62,2% (95% CI [1,405; 1,873]). Increases in the perceived behavioral control indicator was not found to statistically increase the likelihood of someone being a speeder inside built-up areas. Next, the same analysis was conducted for speeding outside built-up areas. The results can be seen in table 12 below.

Table 12. *Factors influencing speeding outside built-up areas*

	B	Std. Error	Sig	OR	95% CI for OR	
					Lower	Upper
Constant	-1,976	0,362	<0,001	0,139		
Attitude	0,327	0,101	0,001	1,387	1,138	1,690
Subjective Norms	0,360	0,069	<0,001	1,433	1,253	1,639
Perceived Behavioral Control	0,192	0,080	0,016	1,211	1,036	1,416

Nagelkerke R^2= 0,231

In contrast to speeding inside built-up areas, the likelihood of speeding outside built up areas was increased less by attitudes (38,7%, 95% CI [1,138; 1,690]) and subjective norms (43,3%, 95% CI [1,253; 1,639]). However, increasing the indicator for perceived behavioral control was found to increase the likelihood of being a speeder outside built up areas by 21,1% (95% CI [1,036; 1,416]). Finally, the same analysis was performed for speeding on motorways. The results can be seen in table 13 below.

Table 13. *Factors influencing speeding on motorways*

	B	Std. Error	Sig	OR	95% CI for OR	
					Lower	Upper
Constant	-1,862	0,348	<0,001	0,155		
Attitude	0,374	0,099	<0,001	1,454	1,198	1,765
Subjective Norms	0,363	0,065	<0,001	1,437	1,265	1,633
Perceived Behavioral Control	0,069	0,074	0,351	1,071	0,927	1,237

Nagelkerke R^2= 0,219

The likelihood of speeding on motorways was increased statistically significantly by attitudes (45,4%, 95% CI [1,198; 1,765]) and subjective norms (43,7%, 95% CI [1,265; 1,633]). Increasing the indicator for perceived behavioral control was not found to increase the likelihood of being a speeder on motorways (95% CI [0,927; 1,237]).

5.6 Differences in attitudes between speeders and non-speeders

The goal of the next analysis was to drill down to the differences between answers given by speeders and non-speeders. As previous analysis found that attitudes and subjective norms were statistically significant predictors of speeding behavior the goal was to understand better how attitudes differed between these two groups. The four questions that were used in the analysis to create the constructs for attitudes and subjective norms were selected for further analysis. Figure 11 below displays how the distributions of answers differed between speeders and non-speeders in these questions.

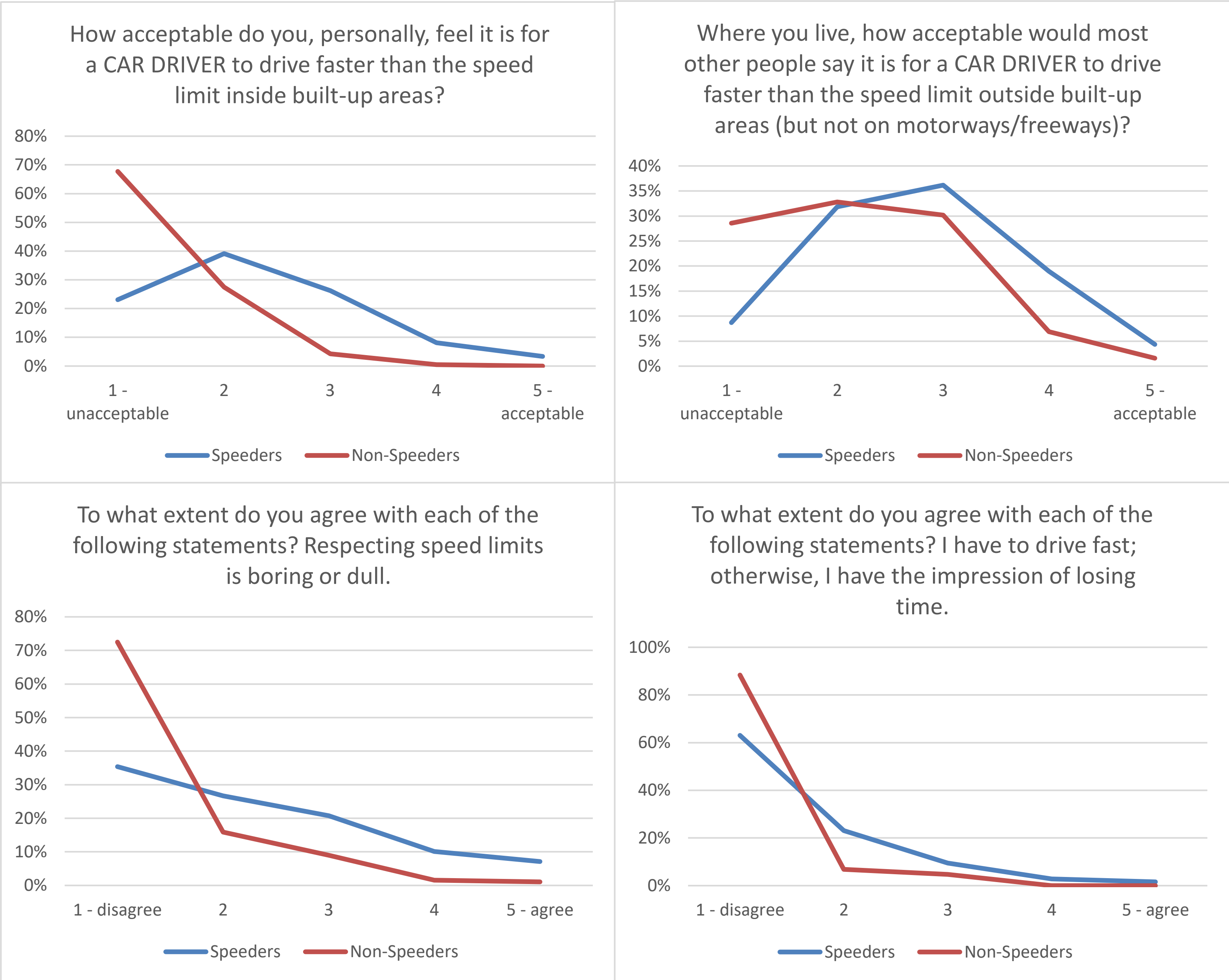

Figure 11. *Answer distributions of speeders and non-speeders to speeding related questions*

The difference between speeders and non-speeders is clear. Non-speeders reported having more negative attitudes and perceptions of subjective norms toward speeding than speeders. A large majority of non-speeders found speeding personally unacceptable, they also had very different perception of how other people view speeding when compared to speeders, and non-speeders found that respecting speed limits wasn't boring.

5.7 Finnish and Nordic attitudes toward speeding in urban areas

When comparing the ESRA-survey results from the Nordic countries, one statistic differentiates Finland from the rest. Finnish people were much more likely to have driven over the speed limit inside of urban areas. From the Finnish participants 72,8% admitted having driven over the speed limit in an urban area in the last 30 days. The same figure is much lower in most other Nordic countries. In Denmark [61,8%], Norway [54,1%], and Sweden [53,8%] a significantly lower proportion of participants admitted to having driven over the speed limit in urban areas in the last 30 days. The only Nordic country that had similar results to Finland was Iceland at 73,5%. This same pattern is not present when looking at speeding outside of urban areas. When asked, 81,8% of Danes, 81,4% of Icelanders, 78,9% of Finns, 78,5% of Swedes, and 78,4% of Norwegians reported that they had driven over the speed limit outside of urban areas.

The previous analysis shown in this thesis shines some light on the differences between speeding outside and inside built-up areas. Speeding behavior in both environments was predicted by the attitudes and subjective norms of the driver. Perceived behavioral control was not found to be a predictive factor for speeding inside built-up areas. Since speeding was about equally common outside of built-up areas in all countries, that would suggest that subjective norms were one of the main differentiating factors between the countries. This would mean that Finnish people speed inside built-up areas more than other Nordic countries, because they find speeding inside built up areas more acceptable personally and they think most other people found it acceptable as well.

When analyzing the background factors affecting subjective norms of speeding inside built up areas, it was found that age was a significant factor. Younger people were much more likely to report that they found speeding inside built-up areas acceptable than older people. Men were also more likely to find speeding inside built-up areas acceptable than women. This leaves room for future studies looking at how subjective norms of speeding inside built-up areas differ between the Nordic countries.

6. RESULTS

The analysis of the survey results found that the three factors of the theory of planned behavior were statistically significant predictors of the intention to speed. The indicator for attitude toward speeding was found to be the strongest predictor of the intention to speed. The indicators for subjective norms and perceived behavioral control were also found to be statistically significant predictors of the intention to speed. A model with these three factors could explain 25,5 percent of the variation in the intention to speed. This result validates that the framework laid out by the theory of planned behavior is an effective lens for analyzing the data gathered from the survey of Finnish drivers' attitudes and for further traffic safety work in the Finnish environment.

Further analysis found that the amount of self-reported speeding in different environments had differing statistically significant predictors. Indicators for attitudes and subjective norms were significant predictors for the amount of speeding in all environments, but perceived behavioral control was a statistically significant predictor for the amount of speeding only on rural, non-motorway, roads. This suggests that the imagined level of control over speeding behavior and its consequences is not the main limiter speeding behavior of people inside of built-up areas or on motorways, but on rural roads people who feel like they are able to drive faster, do so more liberally. One might speculate that the environment of a rural road makes it socially and personally acceptable enough for people to speed, but only people that are confident in their driving abilities end up speeding consistently.

The analysis also found that only attitudes and subjective norms are statistically significant predictors of someone being a speeder or a non-speeder. Perceived behavioral control was not found to be a statistically significant factor in predicting whether someone was a speeder or not. The fact that subjective norms were the strongest separator between speeders and non-speeders in built-up areas and rural roads is telling. People's perception of other people's views of them seems to be a significant intensive to follow common rules. Attitudes about speeding were also a strong separator between speeders and non-speeders.

The effect of background characteristics of the driver on the attitudes, subjective norms and perceived behavioral control of the driver were analyzed. Being a male or younger were both statistically significant predictors of more positive attitudes, more accepting subjective norms, and higher perceived behavioral control toward speeding. Being more highly educated was a statistically significant predictor of having more positive attitudes toward speeding, but not more accepting subjective norms or perceived behavioral control. Other background characteristics were not found to be statistically significant predictors of differing attitudes, subjective norms, or perceived behavioral control.

It should be noted that the indicators for attitude, subjective norms, and perceived behavioral control, as referred to above, were constructed based on multiple questions that were selected by the researcher. The selection was done with the aim of producing the most accurate indicators for the factors at hand, but there were no scientifically robust criteria for the selection. Certain rules, such as the question should not correlate too strongly with self-reported speeding and the selected questions should not correlate too strongly with each other, were followed when choosing questions for the indicators. In conclusion, the indicators should not be seen as literal measures of attitudes, subjective norms, or perceived behavioral control.

The thesis also analyzed the differences between the answers of speeders and non-speeders to the survey questions. The result was that speeders had significantly more positive attitudes toward speeding. As examples, speeders were more likely to think that speeding saved them time and that not speeding was boring. The analysis also found that the perception of other people's opinions about speeding differed between speeders and non-speeders. Non-speeders were much more likely to say that they thought most other people would find speeding completely unacceptable. It should be noted that the non-speeder group was small. Only less than a hundred participants reported that they never drove over the speed limit. This should be considered when interpreting the results.

The survey results also uncovered that Finnish people's speeding behavior differed from other Nordic countries. Especially notable was the fact that Finnish drivers were much more likely to speed inside built-up areas. As previously mentioned, speeding inside built-up areas was predicted with more positive attitudes and subjective norms, which implies that Finnish drivers have more accepting attitudes toward speeding inside built-up areas when compared to other Nordic countries. This difference could not be explained using only the Finnish survey results, so further research should be done to examine the difference in speeding behavior of Finnish and Nordic drivers and the reasons behind it.

Some researchers have speculated that speeding might be a habitual behavior and not under volitional control. The theory of planned behavior does not work as well on behaviors that are not under volitional control. This is a major asterisk over this whole thesis. The incorporation of perceived behavioral control does mitigate this problem with the model somewhat, but it should be kept in mind when reading the results. Furter research should be done on the habitual nature of some driving behaviors.

Researchers have also found that driver's speeding behavior can be classified based on their frequency and magnitude. Some people might speed often but only slightly over the speed limit and others might speed infrequently but significantly over the speed limit. This thesis only analyzed the differences between speeders and non-speeders and the determinants of the frequency of the behavior. Further research could be done into the different speeder "types".

7. CONCLUSIONS

The thesis found that the theory of planned behavior is an effective framework for analyzing the connections between speeding attitudes and speeding behavior in the Finnish environment. This is a positive result in the sense that the theory of planned behavior can be applied to create actionable plans for changing people's behavior. One example of the theory of planned behavior being applied to speeding is the Foolsspeed campaign by the Scottish Road Safety Campaign. Based on this research and the success of the Foolsspeed campaign, public awareness campaigns designed with the theory of planned behavior in mind show potential in the Finnish context.

The thesis also found that attitudes about speeding and subjective norms about speeding were statistically significant predictors of both the amount of self-reported speeding and whether the driver had driven over the speed limit at all in all driving environments. This reinforces the validity of the approach of focusing on changing the attitudes and the subjective norms of drivers when designing public safety campaigns.

Perceived behavioral control was found to be a less significant factor in the prediction of speeding behavior. On the other hand, it ended up being indicative of a difference in the driving environments and how some people behave in them. In built-up areas and on motorways perceived behavioral control was not found to be a statistically significant predictor of speeding behavior. On rural roads however people who believed in their ability to speed were more likely to speed in general and speed more often when compared to people who were not as confident drivers. Rural roads seem to encourage confident drivers to speed as an environment in some way. More research should be done to understand the reasons behind this relationship.

Finnish and Nordic driver behavior and the differences between them were analyzed and they were found to differ in one crucial way. Finnish drivers were much more likely to speed inside built-up areas. The best predictors for speeding inside built-up areas for Finnish drivers were attitudes about speeding and subjective norms of speeding. Finding the source of this difference between the countries might help close the safety gap between Finland and the other Nordic countries. More research should be done to investigate this trend specifically.

The thesis also looked at the differences between the answers of the speeders and the non-speeders. This analysis found that speeders held much more positive beliefs about speeding and thought that other people thought of speeding as a more acceptable behavior than non-speeders. Non-speeders were also much more likely to think that speeding was a completely unacceptable behavior and to think that others thought the same.

The results of this thesis were submitted for the writing of a research publication. The resulting paper titled "Kaahaajat: Finnish Attitudes towards Speeding" was published in the International Journal Environmental Research and Public Health. The paper has been added to the end of this thesis as an appendix. The paper includes further discussion on the significance of the results.

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APPENDIX A

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Article

Kaahaajat: Finnish Attitudes towards Speeding

Steve O'Hern [1,2,*], Valtteri Vuorio [1] and Amanda N. Stephens [2]

1 Transport Research Centre Verne, Tampere University, 33014 Tampere, Finland
2 Accident Research Centre, Monash University, Clayton, VIC 3800, Australia
* Correspondence: steve.ohern@tuni.fi

Abstract: People driving in excess of the posted speed limit (referred to as speeding in English or Kaahaajat in Finnish) is a common road user behaviour. In Finland, between 2000 and 2020, speeding was identified as the key contributing factor in 41% of fatal motor vehicle collisions. This may be because disregarding speed limits on motorways and on residential roads are the most common violations performed by Finnish drivers. This study identifies factors influencing speeding while driving in Finland. In particular, 703 responses from Finnish drivers of the ESRA2 (E-Survey of Road users' Attitudes) were analysed to understand the theory of planned behaviour (TPB) factors underpinning speeding behaviours in three road environments: inside built-up areas; outside of built-up areas; and on motorways and freeways. Three binary logistic regression analyses were used to understand which elements of TPB were associated with self-reported speeding in each of these environments. Approximately two thirds of participants reported speeding in each of the three road environments. Attitudes and subjective norms were associated with speeding in built-up areas and on motorways or freeways. In addition, perceived behavioural control and age were significantly associated with speeding outside of built-up areas. The findings highlight how a systematic approach is needed to address speeding considering enforcement, engineering, legislation, and education.

Keywords: driver behaviour; speeding; theory of planned behaviour; Finland; road safety

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1. Introduction

People driving in excess of the posted speed limit (Kaahaajat in Finnish), is a common road user behaviour [1,2]. The European Transport Safety Council estimates that between 35% and 75% of vehicle speed observations are higher than the legal speed limit [1]. Excessive and inappropriate speeds are a major road safety problem. Yet even relatively small increases above the posted limit can increase the risk of crash involvement [3,4]. Indeed, speeding is a contributing factor in approximately one third of fatal collisions throughout Europe [1] and a significant number of serious injury crashes [5]. Furthermore, the contribution of speeding in casualty crashes may be underestimated, with the role of speeding in fatal crashes estimated to be as high as 60% when combining data from multiple sources [6].

Vehicle travel speed ("speed") influences road safety in two ways. First, speed is a direct contributor to kinetic energy, which is converted into the deformation of vehicles, heat, and biomechanical energy in a collision. The more kinetic energy, the more destructive the crash. Speed, therefore, directly influences crash and injury severity [5]. Speed also influences safety by giving road users less time to process information, react, and smaller margins for error when a critical situation occurs. It is widely accepted that excessive and inappropriate speeds for the driving conditions are risk factors for crashes and injury and ceteris paribus, higher speeds are associated with a higher number of crashes [5].

To achieve the United Nations (UN) goal of halving traffic deaths and injuries by 2030 [7], meeting the objectives of Vision Zero, there is a need to address behaviours such as speeding. These objectives are also central to the Finnish road safety strategy.

In Finland, statistics from in-depth investigations of fatal road crashes reported by the Finnish Crash Data Institute "Onnettomuustietoinstituutti" (OTI), show that between 2000 and 2020, speeding was identified as the key contributing factor in 41% of fatal motor vehicle collisions [8], with almost a quarter of drivers involved in these crashes estimated to be exceeding the speed limit by over 30 km/h [8]. When investigating self-reported driver behaviours in Finland, Mesken et al. (2002) [2] found that disregarding the speed limits on motorways and on residential roads were the most common violations performed by Finnish drivers. Mesken et al. identified that speeding violations were committed because drivers want to get to their destinations on time, maintain speed, or because driving fast can be enjoyable for the driver [2]. More recently, when investigating young drivers in Finland, Mattsson replicated the findings of Mesken with a unique sample, while identifying speeding-related items as having the strongest loadings for their rule violation factor [9]. However, these studies focused on the Driver Behaviour Questionnaire and did not consider the underlying reasons as to why some drivers choose to speed. Developing a deeper understanding of the factors that influence a driver's decisions to speed is imperative to addressing road safety issues. This is particularly important in Finland given both the high prevalence of speeding and the high proportion of crashes where speeding is a contributing factor.

A number of studies have used the theory of planned behaviour to better understand speeding behaviour [10–12]. Developed by Ajzen (1991) [13], the TPB is a social psychological model which describes the relationship between socio-cognitive factors and self-reported behaviour. The model stipulates that behaviour can be predicted by a combination of positive attitudes towards the behaviour, perceived behavioural control (PBC) over engaging in the behaviour, and favourable views of the behaviour from others. These factors increase the intention and ultimately engagement in the behaviour. In each case, intention to speed was predicted by more positive attitudes toward the behaviour and greater subjective norms towards it [10,11]. Conner et al. also showed that past behaviour was an important predictor of speeding, thus drivers in Finland who commonly commit speeding violations are more likely to commit these again [12].

Studies using the TPB therefore highlight areas for intervention. Indeed, Stead et al. and Poulter et al. showed that speeding was successfully reduced after interventions targeted the TPB factors [11,14]. These studies, conducted in the UK, indicate that similar interventions would be beneficial to support road safety in Finland. The first step in designing these is to therefore understand whether the TPB model is similarly predictive of speeding behaviour in Finland.

In 2015, the Vias Institute established and conducted the E-Survey of Road Users' Attitudes (ESRA) [15]. The ESRA aims to collect an international sample of road safety performance data, focusing on road safety culture and self-reported behaviours of road users, including self-reported engagement in speeding while driving and underlying reasons for this behaviour [16]. To this end, the ESRA measures motivation for behaviour using the theory of planned behaviour framework (TPB) [13].

In 2018, the ESRA ran for the second time in 32 countries, with an additional 16 countries surveyed in 2019. Amongst the European nations to participate in ESRA2, over half of the drivers surveyed reported exceeding the speed limit while driving in the 30 days prior to completing the survey [17]. Finnish drivers reported some of the highest prevalence of speeding on motorways, in built up areas, and outside of built-up areas, with the Finnish rates exceeding the averages reported in Europe, Asia, Oceania, North America, and Africa. Similarly, in the 2015 version of the ESRA, Finnish drivers reported the highest rates of speeding with 84% of drivers reporting that they exceeded the speed limit at some stage when driving on motorways in the past 12 months [18].

It is apparent that speeding represents a major road safety issue in Finland with both a high prevalence of self-reported speeding amongst the population and a high proportion of crashes reporting speeding as a key contributing factor. Research conducted elsewhere has shown that the TPB is a promising framework to understand why drivers speed, and design appropriate interventions. However, to date, the TPB has not been applied on a cohort of Finnish drivers. The aim of this research was to use the ESRA2 for the Finnish sample to understand the TPB factors underpinning speeding behaviours reported in the questionnaire.

2. Materials and Methods

2.1. Procedure

Each country that participates in the ESRA collects a sample of roughly 1000 responses [16]. In Finland, the survey was facilitated by the Finnish Road Safety Council (Liikenneturva). To be eligible for the study, respondents had to be aged 18 or older and reside in Finland. Quotas for the sample were set for age and gender distributions based on the UN statistical division. The geographic location of respondents was also monitored [16].

The online survey took approximately 20 min to complete. The Vias Institute's protocol was followed for data cleaning and processing [16]. Deidentified data were provided for the analysis. The Finnish National Board on Research Integrity does not require a review by an ethics committee for research based on public and published data, registry and documentary data, or archive data. Notwithstanding, institutional ethics procedures were followed for this research.

A detailed explanation of the ESRA2 methodology is available on the ESRA website (https://www.esranet.eu/, accessed on 7 November 2022) [16].

2.2. Materials

The ESRA2 uses the TPB framework to understand motivations behind behaviours of different road users including car drivers [16]. Within the ESRA2, there are a sub-set of questions related to self-declared speeding while driving in built up areas, on motorways and freeways, and outside of built-up areas. Participants were asked; over the last 30 days, how often did they as a car driver speed in each of the three road environments. Responses were recorded on a five-point scale where 1 was "never" and 5 was "almost always".

The questionnaire also asked respondents about their attitudes towards speeding, their views regarding the acceptability of speeding from a social and personal perspective, opinions of speed enforcement, and their views regarding the risk of speeding while driving.

2.3. Participants

The Finnish sample for the ESRA2 included 994 responses. However, only respondents who held a valid driver's licence and had driven a car in the 30 days prior to the survey were included in the analysis. This reduced the sample to 703 responses. The remaining 291 responses were excluded from the analysis. Table 1 presents a summary of the respondents' demographics. Of the included responses, 46.8% were female, and 53.2% were male. Participants' age was from 18 to 83 (M = 49.9; SD = 17.1). About one-third of the sample lived in urban areas (33.6%) while the remainder lived in semi-urban or rural areas (66.4%).

Table 1. ESRA2 Finland: Characteristics or car drivers.

Variable		*n* (%)
Gender	Female	329 (46.8)
	Male	374 (53.2)
Age group	18–24	67 (9.5)
	25–34	97 (13.8)
	35–44	106 (15.1)
	45–54	126 (17.9)
	55–64	114 (16.2)
	65+	193 (27.5)
Urbanisation	Urban	236 (33.6)
	Semi-urban or Rural	467 (66.4)

2.4. Analysis

Summary statistics are presented for speeding in the three different road environments. Comparisons are made to the international responses of the ESRA2 survey. Mean and standard deviations are presented for item scores for each TPB factor related to speeding while driving as well as factors related to risk perception, and perceptions of enforcement.

Bivariate associations between age, gender, urbanisation, factors of the TPB, risk perception, and enforcement were measured using Pearson's and point biserial correlations. Relationship strength followed Cohen's interpretation of <0.3 weak, 0.30 to 0.50 medium and >0.50 strong relationship [19]. Finally, binary logistic regression was utilised to investigate the dichotomous relationship between drivers that self-reported speeding in each road environment and the associated factors. The analysis was performed using IBM SPSS version 28.

3. Results

Participants self-reported speeding in three road environments in ESRA2. Participants were asked 'Over the last 30 days, how often did you as a car driver . . . ?; drive faster than the speed limit inside built-up areas?, drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?, and drive faster than the speed limit on motorways/freeways?' Finnish drivers reported some of the highest rates of speeding in the three road environments. Table 2 includes a summary of the Finnish results for the three road environments compared to other Nordic countries and the European, American, Asia/Oceanic, and African averages based on the sample of 1000 responses collected in each country.

Table 2. Proportion of drivers who exceeded the speed limit while driving in the past 30 days.

Country	Inside Built-Up Areas	On Motorways/Freeways	Outside Built-Up Areas
Finland	72.80%	77.80%	78.90%
Denmark	61.80%	74.10%	81.80%
Iceland	73.50%	*	81.40%
Norway	54.10%	79.00%	78.40%
Sweden	53.80%	80.50%	78.50%
America (3)	57.30%	69.90%	64.60%
Europe (24)	56.30%	61.50%	67.50%
Asia Oceania (9)	44.00%	47.90%	47.50%
Africa (12)	41.70%	49.30%	48.80%

* not reported for Iceland, brackets show number of countries in each region, details of the included countries can be found at (https://www.esranet.eu/ accessed on 7 November 2022).

Summary statistics for each item related to the TPB (attitudes, subjective norms, and perceived behaviour control), perceptions of enforcement, and risk perception are presented in Table 3. Overall, roughly two-thirds of participants reported speeding in each of the three road environments measured in the questionnaire. However, the rate of engagement was low, with the most common road environment to speed in being motorways and freeways. Generally, drivers had respectful attitudes towards the speed limit, and they did not perceive that obeying the speed limit would cost them time. Participants were neutral regarding how socially acceptable the public found speeding. Similar personal views were held, albeit there was a slightly more positive view towards speeding on motorways, which corresponds with the higher rates of speeding reported in this road environment. Participants tended to not perceive that they had the behavioural control to drive significantly faster than the speed limit or drive fast around sharp corners. There was a slight perception that police may be enforcing speed on a typical drive and there was a general agreement that speed is a contributing factor in crashes involving a car.

Table 3. ESRA speeding item scores and responses to TPB items.

Construct	Item	Mean	SD
Self-reported speeding (1 = never, 5 = almost always)	*Over the last 30 days, how often did you as a car driver*		
	drive faster than the speed limit inside built-up areas?	2.23	1.035
	drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	2.45	1.090
	drive faster than the speed limit on motorways/freeways?	2.54	1.173
Attitudes (1 = disagree, 5 = agree)	*To what extent do you agree with each of the following statements?*		
	I have to drive fast; otherwise, I have the impression of losing time.	1.46	.822
	Respecting speed limits is boring or dull.	2.04	1.196
Subjective Norms (1 = unacceptable, 5 = acceptable)	*Where you live, how acceptable would most other people say it is for a car driver to*		
	drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	2.63	1.025
	How acceptable do you, personally, feel it is for a car driver to		
	drive faster than the speed limit inside built-up areas?	2.05	1.008
	drive faster than the speed limit outside built-up areas (but not on motorways/freeways)?	2.48	1.109
	drive faster than the speed limit on motorways/freeways?	2.67	1.169
Perceived Behavioural Control (PBC) (1 = disagree, 5 = agree)	*To what extent do you agree with each of the following statements?*		
	I trust myself when I drive significantly faster than the speed limit.	2.07	1.193
	I am able to drive fast through a sharp curve.	1.90	1.117
Risk Perception (1 = never, 6 = almost always)	How often do you think driving faster than the speed limit is the cause of a road crash involving a car?	4.24	1.230
Enforcement (1 = very unlikely, 7 = very likely)	On a typical journey, how likely is it that you as a car driver will be checked by the police for respecting the speed limits?	4.40	1.765

Dimension reduction was performed for each factor by averaging scores across the items presented in Table 3. Correlation analysis was performed for each TPB factor, enforcement, risk perception, and participants demographics (Table 4). Overall, relationships between the TPB factors tended to be moderate (ranging from 0.49 to 0.63). Age shared weak negative relationships with self-reported speeding, attitudes, subjective norms, and PBC, indicating that younger drivers tended to also report increased likelihoods of engaging in speeding, more positive attitudes towards speeding, more normalised behaviour in the community and greater perceptions of behavioural control to engage in speeding. There was also a weak relationship between gender, attitudes, and self-reported behaviour. Male drivers tended to report having engaged more in speeding and had more negative attitudes, higher PBC, and higher subjective norms regarding speeding compared to females. Female drivers tended to report a greater perception of risk associated with speeding. Interestingly, there were no relationships between speeding behaviours and geographic location; however, those living in semi-urban and rural areas also tended to feel they were less likely to be checked by police for speeding on a typical journey, albeit this relationship was weak. Moderate to strong relationships were identified between the TPB factors and self-reported speeding. Those who engaged more in speeding also reported a reduced risk perception, and an increased perception of encountering speeding enforcement while driving.

Binary logistic regressions were conducted using self-reported speeding in the three road environments as the dependent variables. The original speeding variables were dichotomized to investigate the differences between participants who reported that they had not engaged in speeding in the past 30 days (i.e., responded 1 to the question) and those that had (i.e., responded 2–5 to the question, as reported in Table 2).

Table 4. Bivariate (Pearson/point biserial) correlations.

Factor	1	2	3	4	5	6	7	8
Age (1)	1							
Gender (2)	0.02	1						
Urbanisation (3)	0.05	0.02	1					
Self-reported speeding (4)	−0.09 *	−0.13 **	0.03	1				
Attitudes (5)	−0.15 **	−0.13 **	0.01	0.55 **	1			
Subjective Norms (6)	−0.26 **	−0.16 **	−0.01	0.63 **	0.56 **	1		
Perceived Behavioural Control (7)	−0.16 **	−0.32 **	0.00	0.49 **	0.61 **	0.54 **	1	
Risk Perception (8)	−0.01	0.22 **	−0.03	−0.19 **	−0.23 **	−0.24 **	−0.27 **	1
Enforcement (9)	−0.02	0.02	−0.11 **	0.12 **	0.05	0.13 **	0.05	−0.03

* = $p < 0.05$; ** = $p < 0.001$.

Attitudes (OR = 1.446; 95% CI: 1.203–1.737) and subjective norms (OR = 1.311; 95% CI: 1.219–1.410) were positively associated with speeding in built-up areas, with participants who held positive views towards speeding and felt that the behaviour was accepted amongst the community having higher odds of speeding in built up areas. (Table 5).

Table 5. Factors influencing speeding in built-up areas.

Parameter	B	Std. Error	Sig.	OR	95% CI for OR	
					Lower	Upper
Age	0.010	0.006	0.067	1.010	0.999	1.022
Gender (male)	0.123	0.202	0.543	1.131	0.761	1.680
Urbanisation (urban)	−0.130	0.206	0.527	0.878	0.587	1.314
Attitudes	0.368	0.094	0.000	1.446	1.203	1.737
Subjective Norms	0.271	0.037	0.000	1.311	1.219	1.410
Perceived Behavioural Control	0.040	0.073	0.586	1.040	0.902	1.199
Risk Perception	−0.059	0.084	0.479	0.942	0.799	1.111
Enforcement	−0.018	0.056	0.746	0.982	0.881	1.095
(Constant)	−2.849	0.728	0.000	0.058		

When considering speeding on freeways and motorways, attitudes (OR = 1.392, 95%CI 1.152–1.683) and subjective norms (OR = 1.255; 95%CI:1.140–1.317) were again significantly associated with the increased odds of speeding (Table 6).

Table 6. Factors influencing speeding on freeways and motorways.

Parameter	B	Std. Error	Sig.	OR	95% CI for OR	
					Lower	Upper
Age	0.009	0.006	0.139	1.009	0.997	1.020
Gender (male)	−0.164	0.206	0.427	0.849	0.566	1.272
Urbanisation (urban)	0.131	0.209	0.532	1.139	0.757	1.716
Attitudes	0.331	0.097	0.001	1.392	1.152	1.683
Subjective Norms	0.203	0.037	0.000	1.225	1.140	1.317
Perceived Behavioural Control	0.054	0.076	0.476	1.056	0.910	1.225
Risk Perception	0.040	0.085	0.636	1.041	0.881	1.230
Enforcement	0.038	0.057	0.498	1.039	0.930	1.161
(Constant)	−2.531	0.735	0.001	0.080		

When driving outside of built-up areas, attitudes (OR = 1.297; 95%CI: 1.062–1.585), and subjective norms (OR = 1.341; 95%CI: 1.237–1.453) were again positive predictors of the behaviour as well as perceived behaviour control (OR = 1.188; 95%CI: 1.007–1.402). Age was also significantly associated with the increased odds of having driven over the speed limit (Table 7).

Table 7. Factors influencing speeding outside of built-up areas.

Parameter	B	Std. Error	Sig.	OR	95% CI for OR	
					Lower	Upper
Age	0.020	0.006	0.001	1.020	1.008	1.032
Gender (male)	0.009	0.218	0.966	1.009	0.658	1.547
Urbanisation (urban)	0.380	0.219	0.083	1.462	0.951	2.246
Attitudes	0.260	0.102	0.011	1.297	1.062	1.585
Subjective Norms	0.293	0.041	0.000	1.341	1.237	1.453
Perceived Behavioural Control	0.173	0.084	0.041	1.188	1.007	1.402
Risk Perception	0.019	0.090	0.829	1.020	0.855	1.216
Enforcement	−0.013	0.060	0.836	0.988	0.878	1.111
(Constant)	−3.871	0.793	0.000	0.021		

4. Discussion

In Finland, speeding has been identified as the key contributing factor in 41% of fatal motor vehicle collisions [8]. This study investigated the Finnish sample of responses from the ESRA2 survey focusing on self-reported speeding in the three road environments reported in the questionnaire.

Finnish drivers were found to have some of the highest rates of speeding amongst ESRA2 countries. Amongst the three road environments considered in the survey, 78.9% of drivers reported speeding when driving outside of built-up areas, 77.8% of drivers reported speeding on motorways or on freeways, and 72.8% of drivers reported speeding inside built-up areas. The high rates of speeding align with previous research from Finland when investigating self-reported driver behaviours where disregarding the speed limits on motorways and on residential roads were identified as the most common violations performed by Finnish drivers [2].

Compared to other Nordic countries, self-reported rates of speeding were similar on motorways and outside built-up areas; however, the rate of speeding in built-up areas was considerably higher. Finland has one of the better track records for road safety amongst OECD nations [20]. However, Finland has the highest rates of fatalities per population amongst Nordic countries [20]. As such, road safety efforts to target speeding in built-up environments may represent an important intervention. Research by Kloeden et al. [3] found that in 60 km/h urban speed zones, the relative risk of a crash doubles for every additional 5 km/h that vehicles travel over the speed limit. Similarly, Elvik (2008) identified that the number of fatal and serious injury crashes in 60 to 80 km/h speed zones could be reduced by 22% with the elimination of speeding [21]. As such, interventions to reduce speeding in built-up environments could result in significant road safety improvements in Finland.

For interventions to be effective, an understanding of the road users engaging in speeding is required. The findings of this research align with previous studies when comparing bivariate relationships between overall speeding and demographics, and found that young drivers [4,22,23], and males [23,24] were more likely to report engaging in speeding. However, when considering the three specific road environments, no gender differences were identified, and age was only associated with having exceeded the speed limit outside of built-up areas. More surprisingly, older adults were increasingly likely to speed in these environments with each year of age associated with a 2% increase in the odds of having driven over the speed limit outside of built-up environments. The finding suggest that more nuanced classifications of drivers are needed beyond demographics to identify drivers that are at risk of engaging in speeding.

Watson and colleagues proposed that drivers should be classified according to the magnitude and frequency of their speeding. In their study, they found differences in the profile of high- and low-level speeding, both in terms of their age and gender profiles and recommended specific targeted safety strategies related to speed enforcement accordingly [25]. Likewise, Stephens et al. (2017) found that in a representative sample of drivers from Australia, drivers could be classified into different speed behaviour categories [4]. These categories reflected the magnitude of the speed behaviour, from compliant, small exceedances up to 5 km/h over the limit, between 6 and 10 kilometres over the limit, between 11 to 15 kms over the limit, and 16 km over the limit. In line with Watson et al., the demographics in Stephens' speed categories differed, with younger and male drivers over-represented in the higher speed categories [4]. In addition, those in the higher speed categories were also more likely to have positive attitudes towards speeding behaviour, have friends or family that also speed, and underestimate the risk. Thus, these findings not only align with the data from Finland, demonstrating motivations underlying behaviour, but suggest that different groups of speeders may need to be targeted with different interventions.

Using the TPB, our results build on this by showing that the underlying determinants for speeding differed depending on the road environment. Within each road environment, driver attitudes and subjective norms were associated with self-reported speeding. This provides evidence for potential countermeasures to reduce dangerous behaviour. For example, in their study targeting speeding behaviour using the TPB in the UK, Stead et al. found that advertising campaigns can be effectively used to influence attitudes towards speeding; however, in the same study, they did not identify significant changes amongst subjective norms [11]. Stead suggests that attitudes may be more susceptible to change, compared to subjective norms and PBC when using communication means as they only comprise internal dimensions. As such, interventions could be developed to address attitudes through educational and public awareness campaigns targeting speeding across the three road environments, particularly in built-up environments where Finland falls behind other Nordic countries in terms of driver behaviour. These campaigns could also highlight the risks associated with speeding, which helps raise drivers' awareness of its contribution to crashes.

When considering speeding outside of built-up environments, the significant factors also included PBC and driver age. In line with Stead's research, these constructs may be more difficult to influence through public awareness campaigns [11]. To address speeding in these environments, it may be necessary to utilise enforcement strategies. The bivariate analysis identified that there was a generally neutral perception amongst drivers that there was a risk of encountering police enforcement when driving and previous research has shown that speeding is often underpinned by perceptions of enforcement and crash risk [4]. Mackay et al. found that drivers who frequently speed are less likely to perceive that speeding contributes to crashes and are also more likely to hold negative views of enforcement [26]. Finland is one of the few countries in the world to have a "day fine"-based system where fines for speeding over 20 km/h are based on the offender's personal income. While this system has resulted in some very large speeding fines being issued [27], the findings suggest that Finns do not perceive enforcement as a strong deterrent and that potentially there needs to be an increased effort towards enforcing low-level speeding. This aligns with previous studies which have found that enforcement alone is not an effective measure in reducing aberrant driving behaviours [28,29] and as such, complimentary strategies should also be considered. Notwithstanding, there is scope for further exploration of the issues of enforcement beyond what is covered in the ESRA. The question used in the ESRA asks how likely it is that a car driver would be checked by police; however, it would also be interesting to understand how likely drivers thought it would be that they would be caught speeding and/or receive a fine. This highlights the need for more targeted research looking into the speeding behaviours of drivers beyond what is included in the ESRA questionnaire.

Advanced Driver Assistance Systems (ADAS), such as Intelligent Speed Assist (ISA), may increasingly mitigate speeding behaviours [4]. ISA alerts drivers when they are travelling above the speed limit and has been found to be effective in reducing speed on compliance in car drivers [4]. ISA alongside other ADAS features became compulsory in new vehicles in the EU in 2022 (Regulation (EU) No. 2019/2144) [30]. However, when asked about ISA in the ESRA survey, Finnish drivers held neutral views regarding ISA being installed in new cars, and their mean results were lower than the European average reported in the study [17]. Higher levels of automation may further reduce the risks associated with speeding by reducing the contribution of human errors in crashes [31]. However, these systems rely on drivers adopting the technology and using it correctly. Until the fleet is fully autonomous, other approaches are required to address speeding.

While the ESRA survey offers an understanding into self-reported speeding, there is a need to develop a stronger understanding of the prevalence of drivers who are engaging in speeding, the extent that they are exceeding the speed limit, and the road environments where speeding is most prevalent. Previous research has shown that drivers most often engage in low-level speeding where they exceed the speed limit by up to 5 or 10 km/h [4]. Quantification of the extent of speeding would provide greater insight into the risks associated with the behaviour, beyond what is capable from a self-reported questionnaire and there is a need for complimentary research that quantifies the extent of speeding and the ranges in which speeding is engaged throughout Finland.

There is also a need to develop a comprehensive set of items for assessing the TPB constructs to provide confidence in the construct reliability. There is also a need to further understand the context in which speeding occurs. The ESRA2 data collection was performed in winter, a time when fewer drivers are likely to speed due to the increased workload associated with driving in dark, snowy, and icy conditions which are typical of Finnish roads [32]. Research considering seasonal variation could provide the available insight into enforcement and public awareness campaigns.

Finally, the research is susceptible to biases of self-reported data. Participants may experience recall error when reporting their engagement in speeding. Furthermore, there is the potential that not all participants interpret the Likert scales in the same way. There may also be a desirability bias amongst participants; however, given that the survey was anonymous, this bias should have been minimised.

Notwithstanding, the study increases the understanding of the factors that influence speeding in Finland. The study demonstrates that speeding is a complex issue. A systematic approach is needed to address speeding that uses enforcement, engineering, legislation, and education.

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