2021:00482- Unrestricted

Report

Phantom braking in Advanced Driver Assistance Systems

Driver experience and Car manufacturer warnings in Owner manuals

Authors
Claudia Moscoso
Trond Foss
Gunnar D. Jenssen

SINTEF Community
Digitalization in Transport
2021-05-27

SINTEF Community
Digitalization in Transport
2021-05-27

SINTEF Community
SINTEF Community

Address:
Postboks 4760 Torgarden
NO-7465 Trondheim
NORWAY
Switchboard: +47 40005100

info@sintef.no

Enterprise /VAT No:
NO 919 303 808 MVA

KEYWORDS:
Phantom braking
Driver Assistance Systems
Driver experience
Private transport

Report

Phantom braking in Advanced Driver Assistance Systems

Driver experience and Car manufacturer warnings in Owner manuals

VERSION
2.0

DATE
2021-05-27

AUTHOR(S)
Claudia Moscoso
Trond Foss
Gunnar D. Jenssen

CLIENT(S)
Norwegian Public Roads Administration

CLIENT'S REF.
Stein-Helge Mundal

PROJECT NO.
102024157

NUMBER OF PAGES/APPENDICES:
38 + Appendix

ABSTRACT
The present report describes the work carried out with the main goal to map and identify the occurrence of phantom braking, to identify under which special conditions these episodes happen more often, and to reveal the level of trust, attitudes, and interest towards Advanced Driver Assistance Systems among Norwegian drivers. A prior analysis of the user manuals of 8 car models from 2019 and onwards revealed that different names and descriptions of Automatic Emergency Braking (AEB) are interchangeably used in the manuals. The review shows that information about unexpected braking and AEB limitations is available in the manuals to the car drivers/owners. In addition, a web-survey was distributed to nearly 25 thousand drivers across Norway, yielding a final sample size of 3,415 respondents. The results of the web-survey indicated that over 70% of the respondents reported to have experienced phantom braking at least once in their lives, under different driving speeds and different conditions. Three conditions in particular were most associated with phantom braking: road/street geometry, oncoming traffic, and constructions next to and across the roads. Other conditions were provided by the respondents as possible triggers for phantom braking, including conflicts between outdated map data in the vehicles and the real traffic regulations. Finally, the results also revealed that despite having experienced phantom braking, the majority of respondents are still positive towards ADAS, and these continue to be activated in their vehicles.

PREPARED BY
Claudia Moscoso

SIGNATURE
Claudia Moscoso

CHECKED BY
Dagfinn Moe

SIGNATURE
Dagfinn Moe

APPROVED BY
Terje Reitaas

SIGNATURE
Terje Reitaas

REPORT NO.
2021:00482

ISBN
978-82-14-07667-7

CLASSIFICATION
Unrestricted

CLASSIFICATION THIS PAGE
Unrestricted

Document history

VERSION	DATE	VERSION DESCRIPTION
1.0	2021-05-21	1st version for project group - intern use
1.5	2021-05-25	2nd version for quality assurance
2.0	2021-05-27	Final version

Table of contents

APPENDICES

Preface

The present report documents work performed with the aim to map the occurrence and identify special conditions in which phantom braking takes place. The report describes first the warnings and limitations that can be encountered in Owner manuals of vehicles with Advanced Driver Assistance Systems. A second part of the report is dedicated to present the results obtained via a web-survey which served to map the prevalence of phantom braking at a national level among the owners of eight car types with Advanced Driver Assistance Systems in Norway.

SINTEF Community - Department of Mobility and Economics has carried out the present study as an assignment from the Norwegian Public Roads Administration (Statens Vegvesen). The report has been prepared by Research Scientist Claudia Moscoso, Senior Adviser Trond Foss (PL), and Senior Research Scientist Gunnar D. Jenssen. Senior Research Scientist Dagfinn Moe has quality assured the report.

The Norwegian Public Roads Administration has been represented by Chief Engineer Stein-Helge Mundal who has also contributed to the web survey questions.

Trondheim, 27 of May 2021

Terje Reitaas

Terje Reitaas
Research Manager

Summary

Although the advanced driver assistance systems (ADAS) are designed to support drivers in normal and critical situations (e.g. adaptive cruise control, adaptive headlights, reduce speed and prevent collisions with other vehicles or objects that appear in a vehicle's predicted driving lane), it has been reported that the speed reducing systems have been activated without the driver experiencing a real critical situation. Such experiences are referred to as "phantom braking". There can be many causes and situations that cause phantom braking. Some are mentioned in the vehicles' user manuals. Nevertheless, it can be perceived as frightening for the driver and in the worst case cause a rear-end collision. To obtain data that can reveal the frequency of how often this occurs in Norway, the Norwegian Public Roads Administration wished to gather information from owners of newer relevant vehicles that are equipped with such extra sensors and applications. To this end, a research study was carried out among the Norwegian population. Owners of 8 different car models were contacted and invited to answer a web-survey.

A prior analysis of the user manuals of 8 car models from 2019 and onwards revealed that different names and descriptions of Automatic Emergency Braking (AEB) are interchangeably used in the manuals. The review shows that information about unexpected braking and the limitations of the AEB is available in the manuals to the car drivers/owners.

The survey was distributed via short message service (SMS) to be responded online to nearly 25 thousand drivers across Norway, distributed among the 8 car models. The car model with the largest subsample was Tesla Model 3, representing 22% of the sample frame. A total of 3,415 individuals responded the web-survey. The results of the study show that almost 28% of the respondents reported to have never experienced phantom braking, indicating that over 70% of them have experienced phantom braking at least once in their lives. Despite this high percentage, only 10 individuals (0.3% of the sample) indicated that phantom braking led to traffic accidents. Phantom braking is reported to occur under different driving speeds, with a slightly higher tendency to happen under driving speeds between 70 and 90 km/h. Regarding the frequency of phantom braking episodes under special conditions, the results suggest that most of these episodes have happened mainly due to three conditions: *i.* road/street geometry, *ii.* oncoming traffic, and *iii.* constructions next to or across the roads. However, other special conditions such as level and distribution of lighting, weather, and roadside terrain have been also reported by the respondents to be associated with phantom braking.

The study also explored the opinions and attitudes of the respondents towards ADAS after experienced phantom braking. The results show that despite having experienced these episodes, the respondents reported to be still positive towards ADAS indicating that only 2.7% of the respondents have deactivated ADAS in their cars. Moreover, the results show a slightly increase in interest towards ADAS after buying a vehicle with these systems. Although the results suggest an increase in interest, the data also showed that around 77% of the respondents reported to not have read more about ADAS in their user manuals.

Findings from the qualitative analyses revealed that other conditions were identified as possible phantom braking triggers, such as: driving speed signals presented in specific lighting materials might not be read by the ADAS, distance between traffic signs not registered by the vehicles, and the ability to register road elements by different ADAS technologies. Finally, a very common condition associated with phantom braking was a conflict between the outdated map data present in a vehicle and the actual regulations present in the roads, such as driving speed signs. The results presented in this report offer useful insights and shed a light on the prevalence of phantom braking in Norway. Further research is recommended to explore several factors that might contribute to the challenge of phantom braking.

Sammendrag

Selv om de avanserte førerstøttesystemene (ADAS for akronymet på engelsk) er designet for å hjelpe sjåfører i både normale og kritiske situasjoner (f.eks. adaptiv cruise control, adaptive fjernlys, redusere hastigheten og forhindre kollisjoner med andre kjøretøyer eller gjenstander som vises i kjøretøyets predikerte bane), er det rapportert at systemene for å redusere hastighetene har blitt aktivert uten at førere opplever en reell kritisk situasjon. Slike opplevelser blir referert til som "fantombremsing". Det kan være mange årsaker og situasjoner som forårsaker fantombremsing. Noen er nevnt i kjøretøyenes brukerhåndbøker. Likevel kan det oppfattes som skremmende for sjåføren og i verste fall forårsake en kollisjon. For å samle data som kan avsløre hyppigheten av hvor ofte dette skjer i Norge, ønsket Statens Vegvesen å samle inn informasjon fra eiere av nyere relevante kjøretøy som er utstyrt med slike sensorer og applikasjoner. For å oppnå dette ble det gjennomført en forskningsstudie blant den norske befolkningen. Eiere av 8 ulike bilmodeller ble kontaktet og invitert til å svare på en web-undersøkelse.

En gjennomgang av brukerhåndbøkene til 8 bilmodeller fra 2019 og fremover avslørte at forskjellige navn og beskrivelser av automatisk nødbremsing (AEB) brukes om hverandre i håndbøkene. Gjennomgangen viser at informasjon om uventet bremsing og nødbremsingens begrensninger er tilgjengelig i manualene til bilførere/eiere.

Undersøkelsen ble distribuert via SMS for å bli besvart online til omtrent 25 tusen førere over hele Norge fordelt på de 8 bilmodellene. Bilmodellen med den største svarprosenten var Tesla Model 3 som representerer 22% av hele utvalget. Totalt svarte 3.415 personer på nettundersøkelsen. Resultatene av studien viser at nesten 28% av respondentene rapporterte at de aldri hadde opplevd fantombremsing, noe som indikerer at over 70% av dem har opplevd fantombremsing minst en gang. Til tross for denne høye prosentandelen indikerte bare 10 personer (0,3% av utvalget) at fantombremsing førte til trafikkulykker. Fantombremsing er rapportert å forekomme under forskjellige kjørehastigheter, med en litt høyere tendens til å skje under kjørehastigheter mellom 70 og 90 km/t. Når det gjelder hyppigheten av episoder med fantombremsing under spesielle forhold, antyder resultatene at de fleste av disse episodene hovedsakelig har skjedd på grunn av tre forhold: *i.* veg/gate geometri, *ii.* motgående trafikk, og *iii.* konstruksjoner ved siden av eller over vegene. Imidlertid har andre spesielle forhold som nivå og distribusjon av belysning, vær og føreforhold og vegens sideterreng blitt rapportert av respondentene til å være assosiert med fantombremsing.

Studien omhandlet også respondentenes meninger og holdninger til ADAS etter opplevd fantombremsing. Resultatene viser at til tross for at de har opplevd disse episodene, rapporterte respondentene at de fortsatt var positive overfor ADAS. Bare 2,7% av respondentene har deaktivert ADAS i bilene sine. Resultatene viser også en liten økning i interessen for ADAS etter å ha kjøpt et kjøretøy med disse systemene. Selv om resultatene antyder en økt interesse for ADAS, viste dataene også at rundt 77% av respondentene rapporterte å ikke ha lest mer om ADAS i brukerhåndbøkene sine.

Resultatene fra de kvalitative analysene viste at andre forhold ble identifisert som mulige fantombremsende utløsere, f.eks.: kjørehastighetssignaler presentert i spesifikke materialer kan ikke leses av ADAS, avstanden mellom trafikkskilt som ikke ser ut til å være registrert av kjøretøyene, og muligheten til å registrere veg elementer ved hjelp av forskjellige ADAS-teknologier. En veldig vanlig tilstand forbundet med fantombremsing er en konflikt mellom de utdaterte kartdataene i et kjøretøy og de reelle trafikkbestemmelser, f.eks. fartsgrenseskilt. Resultatene som presenteres i denne rapporten gir nyttig innsikt og beskriver forekomsten av fantombremsing i Norge. Videre forskning anbefales for å utforske flere faktorer som kan bidra til utfordringen med fantombremsing.

1 Introduction

In the last 5 years, there have been reported traffic accidents in Norwegian roads which have caused 115 fatalities and 636 badly injured people. Car drivers or car passengers are involved in 61.7% of all traffic fatalities in the last years (SSB, 2021). Although there can be many causes for these traffic accidents (e.g. speed, intoxication, fatigue, illness), the lack of driving ability among the vehicle drivers made up for 55% of the fatal accidents in 2019 (Ringen, 2019).

Advanced Driver Assistance Systems (ADAS) are a response from the transport technology sector to contribute to road safety. According to the European Commission, the ADAS are defined as '*vehicle-based intelligent safety systems which could improve road safety in terms of crash avoidance, crash severity mitigation and protection and post-crash phases. ADAS can, indeed, be defined as integrated in-vehicle or infrastructure-based systems which contribute to more than one of these crash-phases. For example, intelligent speed adaptation and advanced braking systems have the potential to prevent the crash or mitigate the severity of a crash*' (European Commission, 2016). As such, ADAS are expected to contribute to drivers' ability and reduce traffic accidents and the possible fatalities that they entail. Indeed, a study across Europe identified that countries with higher deployment rates of ADAS presented a lower number of road fatalities compared to countries with lower deployment rates (Kyriakidis, 2015).

Many new vehicles are equipped with a number of ADAS to support the driver in critical situations. Some of these systems (e.g., Intelligent Speed Adaptation - ISA or Advanced Emergency Brake System - AEBS) can interfere with the vehicle's braking system so that the vehicle brakes unexpectedly. Sometimes this happens without the driver experiencing a real critical situation, or in situations that are not of a critical nature. Such inconvenient braking experiences are also referred to as 'phantom braking'.

There can be many causes and situations that cause phantom braking. Most are mentioned in the vehicle's user manuals. Other causes can be directly related to human factors, as stated in previous research: the ADAS are as safe as users handle them (Hagl & Kouabenan, 2020). Regardless of the cause, phantom braking can be perceived as frightening for the driver and in the worst case cause a rear-end collision or any other traffic accidents.

In order to obtain figures that can substantiate the frequency of how often this occurs in Norway, Statens Vegvesens (Norwegian Public Roads Administration) wished to conduct a survey with owners of newer relevant vehicles that are equipped with extra equipment, namely Advanced Driver Assistance systems (ADAS). This report presents the results of a research study with the following objectives:

- O1: Map and analyse the frequency of how often phantom braking occurs at different speeds.
- O2: Map and analyse in which situations such undesirable and / or unexpected decelerations occur.
- O3: Map and analyse how drivers who use vehicles with automatic driver assistance systems experience the systems' unexpected decelerations.
- O4: Map and analyse the extent to which the vehicle's manuals describe the possibility of unexpected decelerations and the extent to which the driver has familiarized himself with this.

Prior to the web-survey, and as a part of O4, a review of 8 different owner manuals was carried out in order to understand how these systems are presented to the drivers or car owners, and to form a basis for the development of the survey questionnaire.

2 Car manufacturer warning in Driver manuals

2.1 Introduction

Quoting of Owner manuals

This clause includes text from Owner manuals that are copyright protected. The Norwegian representatives of the car producers have been contacted and we appreciate that they have all been positive to our request to quote the exact text in the Owner manuals.

The permission to quote the exact text is only valid for the use in this report and does not imply that readers of this report can do the same quoting with reference to this report without the permission of the car producers or their respective national representatives.

Owner manual purpose

The Owner manual describes how the driver shall use the car and its supporting applications, e.g., Advanced Driver Assistance Systems (ADAS). The primary goal of the manual is to advice the owner/driver on how to use and utilise the supporting applications but also to warn the owner/driver about the application limitations. Examples are what happens in case the driver does not follow the driver guidelines and what are the reduced liability of the car manufacturer in such cases. The purpose seems two-fold: firstly, to inform the driver about the safety risks of ignoring the warnings and instructions, secondly to protect the car manufacturer from a legal action from the driver in those cases where the ignorance have caused unwanted events with injuries and damages.

The Owner manuals from 7 different car manufacturers were downloaded, see **Error! Reference source not found.** below. The car manufacturers have different policies regarding access to the Owner manuals without being owner of the relevant car make and model. The most usual policies are:

- The Owner manual can be downloaded in pdf format and free of charge from the home page of the car manufacturer
- The Owner manual can be downloaded in pdf format and free of charge from the home page of a user group (usually owners and/or persons interested in the car make and model). In some cases, you must be a member of the user group.
- The Owner manual can be downloaded in pdf format and free of charge from https://carmanuals2.com
- The Owner manual can only be downloaded from the car manufacturer homepage after having referenced the vehicle licence plate number or the Vehicle Identification Number (VIN).

Not all Owner manuals were available in Norwegian which is the version available for the persons responding to the survey reported in Section 3. In those cases, the English or American versions were used. Our assumption is that for the ADAS application Avoid collision (or the similar Automatic Emergency Braking, AEB) in speeds above 50 km/h, the warnings for a car make and model will be similar independent of the Owner manual language.

Table 1. Sites for downloading Owner manuals	
Car type and model	**Link to downloaded manual**
Audi e-tron	https://ownersmanuals2.com/audi/e-tron-2019-owners-manual-75020 There seems to be one common Owner manual for all versions of the Audi e-tron.
Hyundai Ioniq	https://owners.hyundaiusa.com/us/en/resources/manuals-warranties.html As no Norwegian version of the Owner manual was found on the Norwegian Hyundai home page or the Hyundai main home page, the American version was downloaded from HyundaiUSA.com.
Hyundai Kona	https://owners.hyundaiusa.com/us/en/resources/manuals-warranties.html As no Norwegian version of the Owner manual was found on the Norwegian Huyndai home page or the Huyndai main home page, the American version was downloaded from HyundaiUSA.com.
Jaguar I-pace	https://www.ownerinfo.jaguar.com/model/4K/2019/document/29953_no_NOR Web-based manual in Norwegian. Not found as a pdf-file that could be downloaded.
Mitsubishi Outlander PHEV	https://carmanuals2.com/get/mitsubishi-outlander-phev-2019-owner-s-manual-112982 Mitsubishi Outlander has three different variants: petrol, diesel and hybrid. It is assumed that the warnings related to ADAS are the same independent of variant. In this project the driver for hybrid variant was used (in English).
Nissan Leaf	https://wetransfer.com/downloads/d7ae35f2c4c2fb7d45d7846eefe4e28920210318112401/ce8ac251334b641508db629d281616e120210318112418/e68f7d European version. Nissan Leaf comes in different variants related to the battery capacity. It seems as it the same manual for all variants.
Tesla model 3	https://carmanuals2.com/get/tesla-model-3-2019-brukerhandbok-113474 The manual is in Norwegian and downloaded from Carmanuals.
Volkswagen Golf electric (E-Golf)	The web-based manual was downloaded from VW using a VIN provided by Harald A. Møller AS, Norway.

2.2 Audi e-tron warnings

The Audi e-tron Owner manual has three levels of important information to the driver: Warning, Note and Tips. Only the warnings are reported in this report unless there are major notes or tips that could be relevant for phantom braking.

The Audi e-tron has the following phantom braking related generic warnings for their Assist systems:

General information - Safety precautions - ⚠ Warning

- 'Unexpected steering or braking interventions may be initiated by the assist systems. Note the information on storing luggage.
- For the assist systems to be able to react correctly, the function of the sensors and cameras must not be restricted. Note the information on sensors and cameras.'

System limitations - ⚠ Warning

- 'The use of an assist system cannot overcome the natural laws of physics. A collision cannot be prevented in certain circumstances.
- Warnings, messages, or indicator lights may not be displayed or initiated on time or correctly, for example, if vehicles are approaching very fast.
- Corrective interventions by the assist system, such as steering or braking interventions, may not be sufficient or they may not occur. Always be ready to intervene'.

System limitations - ⓘ Tips

- 'Due to the system limitations when detecting the surrounding area, the system may warn or intervene unexpectedly or too late in certain situations. The assist system may also interpret a driving manoeuvre incorrectly and then warn the driver unexpectedly'.

Surrounding area detection – Sensor overview - ⚠ Warning

- 'There are areas around the vehicle that sensors cannot detect. Objects, animals, and people may only be detected with limitations or may not be detected at all. Always monitor the traffic and the vehicles surroundings directly and do not become distracted'.

The manual describes that the Audi Pre sense front application can detect an impending frontal impact and react with warnings, braking interventions, and pre-emptive safety measures for the vehicle occupants. The assist system warns the driver of an upcoming situation that could cause a collision. If the driver does not react, the Pre sense front can brake the vehicle to a full stop. This reduces the vehicle speed in the event of a collision. The assist system is only intended for a vehicle driving ahead that brakes suddenly, the vehicle with the driver subject to the assist system approaches a vehicle significantly slower speed or that a pedestrian or cyclist is standing in the lane or is moving into it. The assist system does not react on objects like animals, crossing or oncoming vehicles, bars, railings or railcars.

ⓘ Tips

- 'The tip (and not a warning) in this case is 'Keep in mind that Audi Pre sense front can apply the brakes unexpectedly. Always secure any cargo or objects that you are transporting to reduce the risk of damage or injury'.

2.3 Hyundai Ioniq warnings

The Autonomous (Automatic) Emergency Braking (AEB) system is designed to detect and monitor the vehicle ahead or detect a pedestrian in the road. The system uses radar signals and camera recognition to warn the driver that a collision is imminent. The system will, if necessary, apply emergency braking.

⚠ Warning

- 'This system is only a supplemental system and it is not intended to, nor does it replace the need for extreme care and attention of the driver. The sensing range and objects detectable by the sensors are limited. Pay attention to the road condition at all times.
- Never drive too fast in accordance with the road conditions or while cornering.
- Always drive cautiously to prevent unexpected and sudden situations from occurring. AEB does not stop the vehicle completely and is not a collision avoidance system.

- The AEB system logic operates within certain parameters, such as the distance from the vehicle or pedestrian ahead, the speed of the vehicle ahead, and the driver's vehicle speed. Certain conditions such as inclement weather and road conditions may affect the operations of the AEB system.

From the Owner manual it seems as if the assist system is focusing on pedestrians (driving speed between 8 and 70 km/h) and vehicles ahead (8 – 180 km/h). When the vehicle speed is above 80 km/h the AEBS only applies partial braking 'to prevent unintended full braking to stop in the middle of the highway'.

There are also warnings related to the malfunction of the system:

⚠ Warning

- 'In certain instances, and under certain driving conditions, the AEB system may activate prematurely. This initial warning message appears on the LCD display with a warning chime. Also, in certain instances the front radar sensor or camera recognition system may not detect the vehicle or pedestrian ahead. The AEB system may not activate, and the warning message will not be displayed.
- The AEB system may activate during braking and the vehicle may stop suddenly shifting loose objects towards the passengers. Always keep loose objects secured.
- The AEB system operates only to help detect vehicles or pedestrians in front of the vehicle.
- The AEB system is not designed to detect other objects on the road such as animals'.

In addition to the warnings above there are several much more detailed descriptions of scenarios and conditions when the sensors and/or logic system will not work properly, e.g., in heavy snow or rain, objects ahead of the vehicle are too small or when driving in curves.

2.4 Hyundai Kona warnings

The Forward Collision-Avoidance Assist (FCA) system is designed to detect and monitor the vehicle ahead. The system uses radar signals and camera recognition to warn the driver that a collision is imminent. The system will, if necessary, apply emergency braking.

⚠ Warning

- 'This system is only a supplemental system and it is not intended to, nor does it replace the need for extreme care and attention of the driver. The sensing range and objects detectable by the sensors are limited. Pay attention to the road conditions at all times.
- Always drive cautiously to prevent unexpected and sudden situations from occurring. FCA does not stop the vehicle completely and is not a collision avoidance system.
- The FCA system logic operates within certain parameters, such as the distance from the vehicle or pedestrian ahead, the speed of the vehicle ahead, and the driver's vehicle speed. Certain conditions such as inclement weather and road conditions may affect the operations of the FCA system.
- In certain instances, and under certain driving conditions, the FCA system may activate prematurely. This initial warning message appears on the LCD display with a warning chime. Also, in certain instances the camera recognition system may not detect the vehicle or pedestrian ahead. The FCA system may not activate and the warning message will not be displayed.
- The FCA system may activate during braking and the vehicle may stop suddenly shifting loose objects towards the passengers. Always keep loose objects secured.
- Occupants may get injured, if the vehicle abruptly stops by the activated FCA system. Pay extreme caution.
- The FCA system operates only to help detecting vehicles in front of the vehicle.

- The FCA system is not designed to detect other objects on the road such as animals'.

In addition to the warnings above there are several much more detailed descriptions of scenarios and conditions when the sensors and/or logic system will not work properly, e.g., in heavy snow or rain, objects ahead of the vehicle are too small or when driving in curves.

2.5 Jaguar I-pace warnings

Collision avoidance safety

⚠ Warning

- 'Collision avoidance systems are not a substitute for driving safely, with due care and attention. Staying alert, driving safely, and being in control of the vehicle at all times is the responsibility of the driver.
- The driver is responsible for driving with due care and attention, and in a safe manner for the vehicle, the occupants, and other road users. The driver is responsible for detecting obstacles, and estimating the vehicle's distance from them, when manoeuvring the vehicle. The driver should observe all road signs, road markings and any potential braking situations, and act appropriately'.

Autonomous emergency braking (AEB) Safety

The AEB system is based on information from the forward-facing camera in the wind screen. It supports the automatic emergency braking in case the AEB system identify an imminent risk of collision with another vehicle travelling in front or a crossing pedestrian. The system operates between 5 and 80 km/h.

⚠ Warning

- 'The AEB system uses forward-facing cameras to detect real vehicles and pedestrians, plus other certified target objects. AEB is not designed to detect any other objects, including non-industry approved targets.
- In order for AEB to operate, it must be able to detect a clear image of the object and be able to determine its movement. If either of these does not occur, the AEB system may not operate'.

Autonomous emergency braking (AEB) Limitations

Vehicle detection Autonomous Emergency Braking (AEB) does not operate if:

- 'The vehicle is negotiating a tight corner.
- Dynamic Stability Control (DSC) is switched off.
- The forward-facing cameras are dirty or obscured.
- The vehicle’s speed is below 5 km/h (3 mph), or above 80 km/h (50 mph).
- Visibility is impaired due to severe weather conditions, e.g., heavy rain, fog, or snow'.

In addition to the items listed for the vehicle detection AEB system, the Pedestrian detection AEB system does not operate if:

- 'The vehicles speed is above 60 km/h (37 mph).
- The detected object is not identified as a pedestrian.
- The height of the object is less than 1 m.
- The Pedestrian detection AEB system cannot determine that the target object is a pedestrian. For example, if the pedestrian is carrying a large object'.

High-speed emergency braking

The high-speed emergency braking feature attempts to slow the vehicle automatically if it detects that a collision with a slower vehicle ahead is unavoidable. The high-speed emergency braking feature operates at all speeds. The High-speed AEB has to be reset by a retailer or authorised repairer if it has been activated in a situation of imminent collision.

⚠ Warning

- 'The high-speed emergency braking feature may not react to slow-moving vehicles.
- The high-speed emergency braking feature does not react to stationary vehicles or vehicles travelling in the opposite direction'.

We have not found an explicit warning about phantom braking in the AEB part of the owner manual. However, such warning may be found in other parts of the manual. However, the driver/owner is clearly informed about the limitations of the AEB.

2.6 Mitsubishi Outlander PHEV warnings

Forward Collision Mitigation (FCM) System

The FCM system uses a sensor in the windscreen to determine the distance and relative speed to a vehicle and a pedestrian ahead the vehicle. The system operates in two levels like many other similar systems for other makes and models by 1) a warning to the driver and 2) initiating braking of the vehicle. The *warning* level operates between approximately 15 and 140 km/h against a vehicle and between approximately 7 and 65 km/h against a pedestrian. The *braking* level operates between approximately 5 and 80 km/h against a vehicle and between approximately 5 and 65 km/h against a pedestrian.

⚠ Warning

- 'A driver is responsible for driving safely. The FCM is the system to mitigate collision-caused damage or to avoid collisions as much as possible. The system is not intended to compensate for driver's loss of attention to the front during driving due to distraction of carelessness or supplement a drop in visibility due top rain and fog. It is never a substitute for your safe and careful driving. Always be ready to apply the brakes manually'.

The Owner manual has a list of 33 cases where the FCM may not operate properly detecting a vehicle and 12 cases where the FCM may not detect a pedestrian, e.g., in cases where the pedestrians are forming a group.

⚠ Caution

The Owner manual describes in a rather detailed way compared to other manuals when the FCM system is activated in situations where there is no need for activation. In the manual these situations are described as a Caution and not a Warning.

- 'The FCM control and alarm functions may be triggered in the following situations:
    - When there is a structure beside the entrance of a curve and intersection
    - When running on a narrow iron bridge
    - When passing through a gate with small head or side clearance
    - When there are metallic objects, steps or projections on the road surface
    - When quickly approaching a vehicle in front to overtake it
    - When passing an electronic toll collection gate
    - When running under an overpass, a pedestrian overpass or a small tunnel
    - When running into Multi-storey car park
    - When the road gradiently and suddenly changes while running

- When stopping very close a wall or a vehicle in front
- When passing close to a vehicle, pedestrian or object
- When driving on the road that the vehicle in front runs in offset position from your vehicle
- When passing through an area where objects may contact the vehicle, such as thick grass, tree branches or a banner
- When there are patterns on the road that may be mistaken for a vehicle or a pedestrian
- When a vehicle cuts into your path in the detecting range of the sensor
- When an oncoming vehicle is positioned straight ahead of your vehicle on a curved road
- When passing through a plastic curtain etc.
- When the FCM detects a long object carried on your vehicle, such as skies or a roof carrier
- When driving through fog, steam, smoke or dust
- When the windscreen of the sensor portion is covered with dirt, water droplets, snow and ice etc.'

2.7 Nissan Leaf warnings

According to the Owner manual the 'Automatic Emergency Braking (AEB) can assist the driver when there is a risk of a forward collision with the vehicle ahead in the traveling lane. The AEB system uses a radar sensor located on the front of the vehicle to measure the distance to the vehicle ahead in the same lane'. The system works at speeds above 5 km/h. It starts with a warning as in most other similar applications and continue with brake activation.

The manual includes a warning with several limitations of the AEB system:

⚠ Warning

'Listed below are the system limitations for the AEB system. Failure to operate the vehicle in accordance with these system limitations could result in serious injury or death.

- The AEB system cannot detect all vehicles under all conditions.
- The radar sensor does not detect the following objects:
  - Pedestrians, animals or obstacles in the roadway.
  - Oncoming vehicles.
  - Crossing vehicles.
- The radar sensor has some performance limitations. If a stationary vehicle is in the vehicles's path, the AEB system will not function when the vehicle is driven at speeds over approximately 50 mph (80 km/h).
- The radar sensor may not detect a vehicle ahead in the following conditions:
  - Dirt, ice, snow or other material covering the radar sensor.
  - Interference by other radar sources.
  - Snow or road spray from traveling vehicles.
  - If the vehicle ahead is narrow (e.g., motorcycle).
  - When driving on a steep downhill slope or roads with sharp curves.
- In some road or traffic conditions, the AEB system may unexpectedly apply partial braking. When acceleration is necessary, continue to depress the accelerator pedal to override the system.
- Braking distances increase on slippery surfaces.
- The system is designed to automatically check the sensor's functionality, within certain limitations. The system may not detect some forms of obstructions of the sensor area such as ice, snow, stickers,

etc. In these cases, the system may not be able to warn the driver properly. Be sure that you check, clean and clear the sensor area regularly.

- Excessive noise will interfere with the warning chime sound, and the chime may not be heard'.

2.8 Tesla Model 3 warnings

Tesla Model 3 has three different collision avoidance applications:

- **Forward Collisions Warning** that provides visual and audible warnings in situations when Model 3 detects that there is a high risk of a frontal collision. The forward-looking camera and radar monitors the area about 160 meter in front of the vehicle for objects like vehicles, motorcycles, bicycle or pedestrians. The speed range for the operation of the application is between 10 and 150 km/h. If the driver does not take immediate action the Automatic Emergency Braking may activate the brakes if a collision is imminent.
- **Automatic Emergency braking (AEB)** automatically applies braking to reduce the impact of a frontal collision. When a frontal collision seems unavoidable the AEB reduces the speed with 50 km/h if the vehicle speed is higher than 56 km/h. Example: The sensor system discovers an object in the road when the vehicle has a driving speed of 80 km/h. The AEB system will reduce the speed down to 30 km/h before it releases the brakes.
- **Obstacle-aware Acceleration** that reduces acceleration if Model 3 detects an object it its immediate driving path in cases where the driver presses the acceleration pedal. The application is designed to operate in speeds less than 16 km/h and when the vehicle is quite close to obstacles, e.g., walls or garage door.

⚠ Warning

'**Forward collision warning** is for guidance purposes only and is not a substitute for attentive driving and sound judgement. Keep your eye on the road when driving and never depend on Forward Collision Warning to warn you of a potential collision. Several factors can reduce or impair performance, casing either unnecessary, invalid, inaccurate, or missed warnings. Depending on the Forward Collision Warning to warn you of a potential collision can result in serious injury or death'.

⚠ Warning

'**Automatic Emergency Braking** is not designed to prevent all collisions. In certain situations, it can minimize the impact of a frontal collision by attempting to reduce your driving speed. Depending on Automatic Emergency Braking to avoid a collision can result in serious injury or death'.

⚠ Warning

'**Obstacle-Aware Acceleration** is not designed to prevent a collision. In certain situations, it can minimise the impact of a collision. Depending on Obstacle-Aware Acceleration to avoid a collision can result in serious injury or death'.

The Forward collision warning and the Obstacle-Aware Acceleration do not activate the brakes. Hence, the applications are less relevant for Phantom-braking. The Automatic Emergency Braking application has 6 warnings, where the following warning is relevant for phantom-braking:

⚠ Warning

'Several factors can affect the performance of Automatic Emergency Braking, causing either no braking or inappropriate or untimely braking, such as when a vehicle is partially in the path of travel or there is road debris. It is the driver's responsibility to drive safely and remain in control of the vehicle at all times. Never depend on Automatic Emergency Braking to avoid or reduce the impact of a collision'.

2.9 Volkswagen Golf electric (E-Golf)

The Automatic Emergency Braking (AEB) is part of a safety application called Front Assist that includes Autonomous Emergency Braking and a Pedestrian Monitoring system. These systems are automatically activated when Front Assist is activated. The Owner manual has a generic warning for the Front Assist application:

⚠ Warning

'The Front Assist system technology cannot overcome the laws of physics and system-related limits. Do not allow the increased convenience Front Assist can provide, tempt you into taking extra risks. The driver is always responsible for braking in time. If the Front Assist system issues a warning, immediately apply the brake to slow the vehicle down or avoid the obstacle, depending on the traffic situation.

- Always adjust your speed and driving style to road, traffic, weather, and visibility conditions.
- The Front Assist system cannot prevent accidents and serious injuries on its own.
- The Front Assist system can issue unnecessary warnings in certain complex driving situations, for example, when driving in tight curves.
- The Front Assist system can issue unnecessary warnings when its function is impaired, for example, if the radar sensor is dirty or if the position of the radar sensor has been changed.
- The Front Assist system does not react to animals or vehicles crossing your path or approaching in the same lane.
- Always be prepared to take full control of the vehicle at all times'.

The Front assist application has four phases: 1) The Distance warning, 2) The Advance warning, 3) the Immediate warning and 4) The Autonomous Emergency Braking. The Immediate warning is activated if the driver does not react on the advance warning within a speed range of 30 – 250 km/h. The Immediate warning may initiate a short active braking manoeuvre ('short, jerky braking'). The AEB system becomes active if the driver has not reacted to the Immediate warning within a speed range 5 – 250 km/h. The Front Assist can initiate an automatic braking manoeuvre that will 'abruptly decelerate the vehicle with increased braking force. The activation occurs shortly before a potential collision to reduce the vehicle speed and help minimise the effects of a collision'.

The Owner manual has some clear statements on objects that cannot be detected:
'Front Assist may react unnecessarily, react with delay, or not react at all in the following situations:

- When vehicles are traveling slightly offset to the left or right in front of your vehicle.
- When vehicles are crossing in front of your vehicle.
- When loads or attachment parts on other vehicles in front of your vehicle protrude to the side, rear, or above the normal vehicle dimensions.
- When there is oncoming traffic.
- When pedestrians are standing, moving toward you, or moving away from you'.

The Owner manual also have some clear statements on the systems limitation:
'Front Assist may react unnecessarily, react with delay, or not react at all in the following situations:

- When driving in tight curves.
- When the accelerator pedal is depressed.
- When Front Assist is switched off or if there is a system fault.
- When the ASR is manually switched off.
- When the ESC is taking corrective action.
- When several brake lights on the vehicle are not working.
- When the radar sensor is dirty or covered.
- When the vehicle is in Reverse **(R)**.
- When the vehicle is accelerating quickly.
- When weather conditions are poor.
- When narrow vehicles, such as motorcycles, are moving in front of your vehicle.
- When the system cannot detect the traffic situation clearly.
- When there are metal objects, for example, tracks or metal plates in the road.'

3 Driver survey

As previously stated, to obtain data that can reveal the frequency of how often phantom braking occurs in Norway, SVV wished to conduct a survey with owners of newer relevant vehicles that are equipped with such extra equipment. To this end, a research study was carried out among the Norwegian population. Five research questions were formulated to fulfil the project objectives. Table 2 presents the research questions with their corresponding web-survey items.

Table 2. Research questions addressed in the web-survey

RQ	Research questions	Survey questions
RQ1	How frequent does phantom braking occur, and which consequences (in terms of accidents) has it produced?	2, 3, 4, 5, 7, 8
RQ2	Under which circumstances has phantom braking occurred?	6, 9, 10
RQ3	To what extent do individuals have interest in driving assistance systems in cars regardless of phantom braking?	11, 12, 13, 14, 15
RQ4	Do individuals trust the driving assistance systems?	16, 17
RQ5	What is the attitude of individuals towards driving assistance systems after having experienced phantom braking?	18, 19

3.1 Questionnaire

The questionnaire was based on exploratory research with the aim to investigate the experiences, interest, and trust of driver assistance systems among Norwegian drivers. The questionnaire was divided in four sections:

i. Experiences with driver assistance systems; aimed to achieve O1, in which the respondents were asked whether they felt they had received help from the driver assistance systems, and whether they had ever experienced phantom braking. The respondents were also asked about the frequency of phantom braking episodes and whether a critical situation had occurred as a consequence of them.

ii. External factors that may have affected the functionality of the driver assistance systems; aimed to achieve O2, based on a 9-factor measurement instrument depicting possible special conditions that could have triggered phantom braking episodes. A 5-point Likert-type scale was used, ranging from '*never*' to '*very often*'. In addition, an open-ended question was formulated, asking the respondents to describe in more detail the special conditions that occur most often for phantom braking.

iii. Interest and attitude towards driver assistance systems; aimed to achieve O3 and O4, in which the respondents were asked about their interest about driver assistance systems and whether these were an important asset of their vehicle before they bought it. Both questions used a 5-points Likert-type scale from 'Not interested at all' to 'Very interested' and from 'Not important at all' to 'Very important', respectively. Three additional closed-ended questions aimed to answer whether and to what extent the respondents had read the user manuals of the vehicles. The respondents' level of trust towards the driver assistance systems was also investigated via a 5-point Likert-type scale question, ranging from 'very little' to 'very much'. Finally, their attitudes towards the driver assistance systems after having experienced phantom braking was also analysed via 2 closed-ended single-choice questions.

iv. The last section of the survey was designed to establish the demographics data of the sample, including gender, age, and education. The driving characteristics of the sample was also investigated, including questions related to the approximate average distance driven in the last year, driving area/speed limit where the respondents drive the most, number of days a week that the respondents use their car, type of car and when they acquired their car.

The complete questionnaire is presented in Appendix A, in its original language (i.e. Norwegian) as presented to the respondents.

3.2 Procedure

Due to the aim of the project, the target respondents of the survey were the owners of newer relevant vehicles that are equipped with the driver assistance systems. Eight different car models registered on the year 2019 and onwards were selected (as presented in Section 2): *Audi E-Tron, Hyundai Ioniq, Hyundai Kona, Jaguar I-Pace, Mitsubishi Outlander, Nissan Leaf, Tesla Model 3*, and *Volkswagen Electric*. The registered owners were selected according to the list of the Autosys system and provided by Statens Vegvesen to the research group. The web-survey was distributed via invitations using phone text messages (short message service – SMS), identified to yield a higher response rate than other online devices (De Bruijne & Wijnant, 2014). The phone numbers of the car owners were found via *Respons Analyse*; company responsible for the distribution of the survey invitation via SMS. The sampling frame comprised 24,996 mobile numbers, distributed among the 8 car models. The car model with the largest subsample was Tesla Model 3, representing 22% of the sample frame.

The SMS invitations were sent on the start of the week 17, 2021, at a rate of 5,000 messages per 1.5 hours to avoid overloading the system. This helped also to protect against excess traffic in the web-survey program. A total of 3,415 individuals responded the web-survey, representing a response rate of 13.7%. The sample size provided a confidence interval of 1.6, with 95% confidence level, which is considered appropriate for web-surveys. The web-survey was open for responses throughout week 17, yielding 5 days of data collection. The questionnaire was developed and presented using the software Microsoft Forms, offering a user-friendly interface for the respondents and available to be used via computer or mobile device. It is important to indicate that the personal information gathered was used only to find the phone numbers and send the survey invitations, no personal information was saved nor related to the survey responses. Considering that personal information was collected (i.e. gender, age, education), the research study was subject to an application to the Norwegian Social Science Data Services (NSD – *Norsk senter for forskningsdata*). The NSD granted the approval to perform the study.

3.3 Sample

The final sample size of 3,415 consisted of individuals between 18 and over 65 years old. Table 3 below shows the distribution of the sample according to their gender, age group and education level. The male population of the sample is overrepresented, representing over 82% of the respondents. The proportions of the different age groups indicate a higher representation of the age groups from 36 to 65 years old (n = 2,530, 74.1%). The smallest age group consisted of individuals between 18 and 25 years old (n = 32). The majority of the sample (76%) reported to have a higher education level.

Table 3. Demographic characteristics of the sample (*N* = 3415) – N (%)

Gender	Female	577 (16.9%)
	Male	2831 (82.9%)
	Prefer not to answer	7 (0.2%)
Age groups	18-25 years	32 (0.9%)
	26-35 years	275 (8.1%)
	36-45 years	737 (21.6%)
	46-55 years	1043 (30.5%)
	56-65 years	750 (22.0%)
	+ 65 years	578 (16.9%)
Education level	Primary school	65 (1.9%)
	Secondary school	754 (22.1%)
	University	2596 (76.0%)

The largest proportion of respondents was the owners of Tesla Model 3 cars (26.9% respondents of the sample), followed by the owners of Audi E-Tron (18.2%) and the owners of Volkswagen electric (11.4%), see Figure 1. The distribution of the responses for the rest of the studied car models was as following: Hyundai Kona (9.6%), Nissan Leaf (9.1%), Jaguar I-Pace and Mitsubishi Outlander (both representing 7.1% each). The smallest group was the respondents owning a Hyundai Ioniq (3.8%). A total of 6.9% of the respondents did not report the type of car that they use. These results are in line with the registration statistics from the years 2019 and 2020, showing the 20 best-selling car types. In that list, Tesla Model 3 cars were one of the most sold cars in 2019, whereas Volkswagen Golf and Audi E-tron were also among the 5 most sold cars in Norway (OFV, 2020).

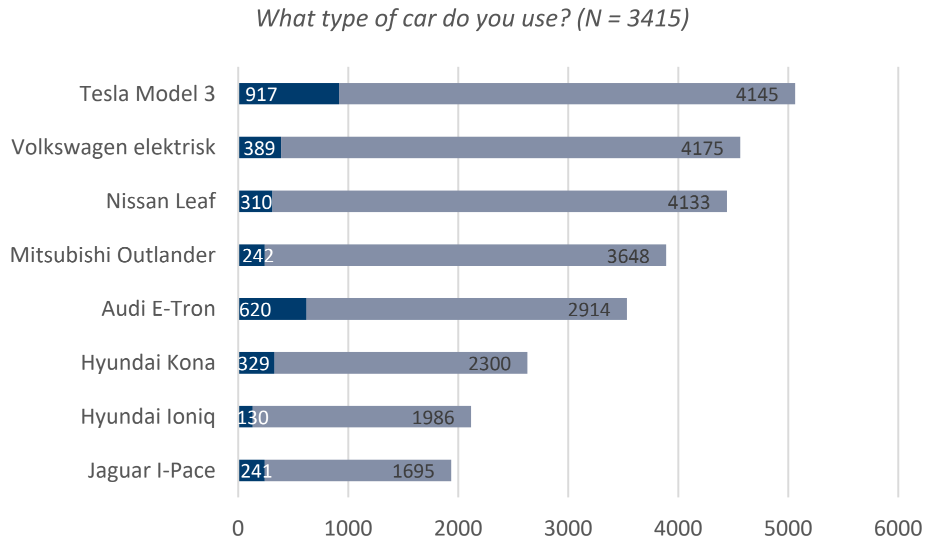

Figure 1. Distribution of car type respondents among the surveyed sample frames.

In addition, the driving characteristics of the sample was also analysed, as shown in Table 4. In line with our expectations, the results indicated that the majority of the sample owned a 2019 car model. Although the Autosys list was generated based on drivers who registered the acquisition of their car in 2019 and onwards, a small proportion of the respondents (2.9%) reported to have acquired their car with driver assistance system in 2018. This might be since some respondents reported to have had more than one car with driver assistance systems. Another reason, as indicated by some respondents, might have been that although they bought their car in 2018, this was delivered and thus, registered in 2019. The results also show that a large proportion of the respondents reported driving more than 10,000 km in the last year and 69% of the total sample size reported to drive mostly in countryside, where speed limits are over 50 km/h.

Table 4. Driving characteristics of the sample (*N* = 3415) – N (%)		
Year for acquired car	2018	99 (2.9%)
	2019	2576 (75.4%)
	2020	433 (12.7%)
	2021	66 (1.9%)
	Other/No response	241 (7.1%)
Distance driven last year	0 – 5,000 km/year	127 (3.7%)
	5,000 – 10,000 km/year	559 (16.4%)
	10,000 – 15,000 km/year	1043 (30.5%)
	15,000 – 20,000 km/year	924 (27.1%)
	More than 20,000 km/year	762 (22.3%)
Speed limit/area for most driving	City - speed limit under 50 km/h	1060 (31.0%)
	Country - speed limit over 50 km/h	2355 (69.0%)
Nr. cars with driver support system	1 car	2027 (59.4%)
	Between 2 and 5 cars	1367 (40.0%)
	More than 5 cars	21 (0.6%)

3.4 Survey results

The following sections present the main findings for the five research questions of the study. Descriptive statistics were primarily used to reveal the characteristics of the sample. Considering the type of questions presented in the survey, using mainly ordinal and nominal level of measurements, non-parametric statistical tests were used to analyse possible relations between the studied groups. The statistical tests were performed using the IBM SPSS statistics 27 software. The cut-off point for the statistical results is a *p*-value of 0.05, as conventionally used. Figures depicting the results and distribution of the survey questions are presented where appropriate in each section. The responses from the open-ended questions are of a qualitative nature and are presented and examined in the Section Discussion.

3.4.1 Frequency and consequences of phantom braking

A large proportion of the respondents (91%) reported to have had a car with driver assistance systems for over 1 year. To the question regarding whether the respondents had experienced that the driver assistance systems helped them to deal with a critical situation, 45.1% reported that the ADAS helped them, whereas 46.8% reported that they did not experience obtaining help from the ADAS, see Figure 2. To the question about whether the respondents were aware that the ADAS were either activated or deactivated, 58.9% of the respondents (n = 2011) reported to be aware of the activation status of the ADAS in their cars, whereas 10.9% reported to not be aware of the ADAS activation status. Other respondents reported to have been unsure of the ADAS activation status (5.5%) or to have been aware only sometimes (4%).

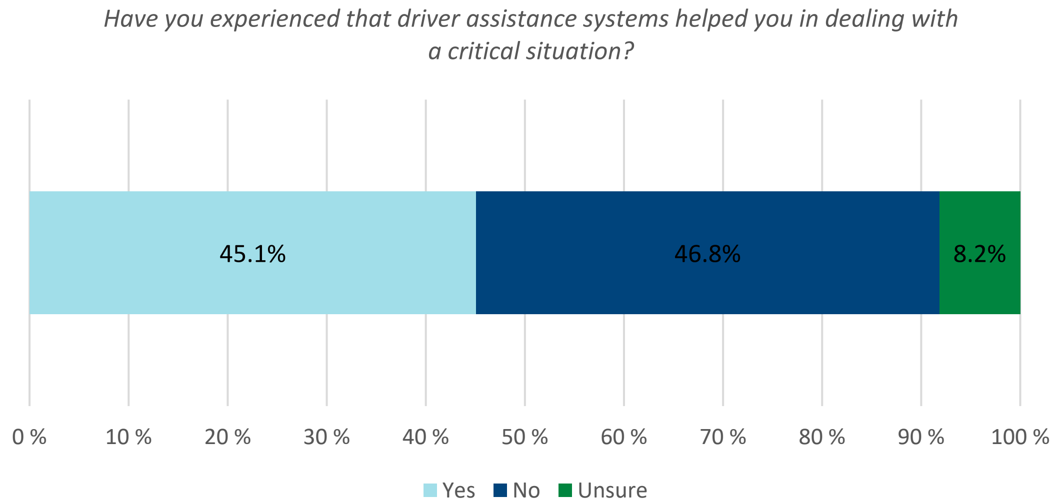

Figure 2. Distribution of the responses for experiences with ADAS in critical situations.

Regarding the frequency of occurrence of phantom braking, 27.9% of the sample reported to have never experienced phantom braking, indicating that over 72% of the respondents have experienced phantom braking at least once in their lives as a driver, see Figure 3. Respondents reporting to have rarely experienced phantom braking represents 29.6% of the sample, whereas those who have experienced it sometimes represent the largest group, 32.4% of the sample.

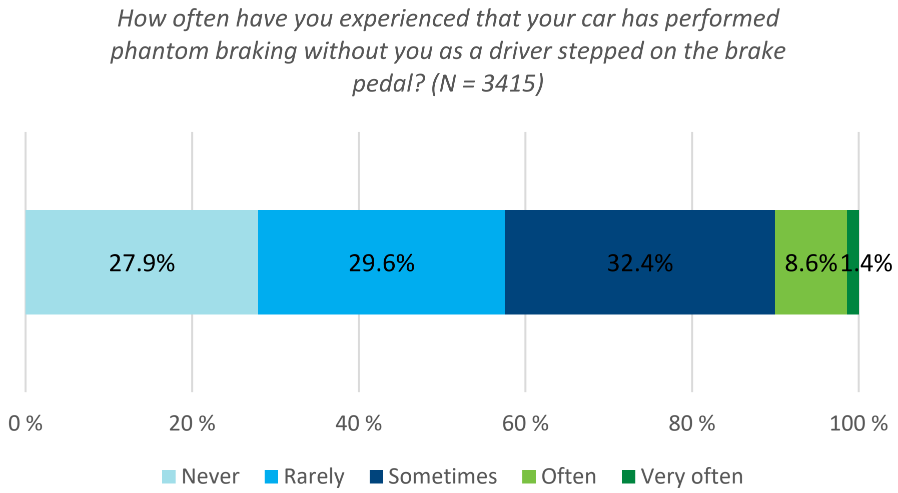

Figure 3. Frequency of occurrence of phantom braking among the survey respondents.

Finally, whereas 2,528 individuals (74% of the sample) reported that no accidents occurred as a consequence of phantom braking, only 10 individuals (0.3%) reported to have had accidents product of the phantom braking. The severity of these accidents were described by the respondents and these are given as part of the Discussion.

3.4.2 Circumstances related to phantom braking

To answer RQ2, the respondents were asked to indicate under which driving speed they have experienced phantom braking. The alternatives for the responses ranged from under 40 km/h to 90 km/h. The results show that phantom braking has been experienced under all the possible driving speed alternatives presented in the survey, with a larger occurrence in driving speeds between 70 and 90 km/h (29.5% of the sample), see Figure 4. A Spearman correlation analysis was performed to reveal whether there was a relationship between the driving speeds and the frequency of phantom braking episodes. The results indicate a strong negative correlation between driving speed and frequency of phantom braking, r_s = -0.773, $p < 0.001$, indicating that when driving speed increases the frequency of phantom braking decreases, or vice-versa.

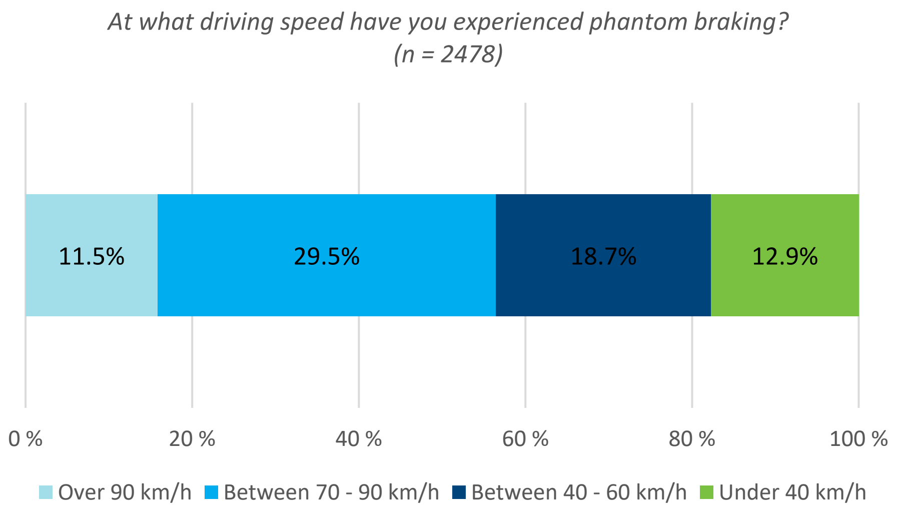

Figure 4. Distribution of the responses for driving speed and phantom braking episodes.

Regarding the circumstances in which phantom braking occurred, the respondents were asked to rate how often phantom braking happened under special conditions e.g. related to visual, climatic or physical conditions. Nine different alternatives were presented to the respondents:

1. Lighting conditions (e.g. daylight, low road/street lighting, dark without street lighting)
2. Weather and driving conditions (e.g. sun, backlight, rain, snow, fog)
3. Road/street geometry (e.g. straight stretch, sharp curve, slack curve)
4. Roadside terrain (e.g. narrow cuts, railing)
5. Constructions next or across the road (e.g. bridges, railroad crossings, tunnel portals, signs portals, large masts)
6. Oncoming traffic (e.g. large/small oncoming vehicles on straight line, large/small oncoming vehicles in slack curves/sharp curves)
7. Uneven lighting conditions on the road surface (e.g. shadows of constructions, big trees, houses)
8. Significant changes on the road surface (e.g. new asphalt, bridge joints)
9. Poor visibility due to dirty windshield or video camera

The question presented a 5-point Likert-type scale, ranging from '*Never*' to '*Very often*'. Figure 5 below presents the distribution of the responses for the frequency of phantom braking episodes under the studied special conditions. Due to the focus of the study, the alternative '*Never*' is omitted in the presentation of the figure to aid visibility of the results.

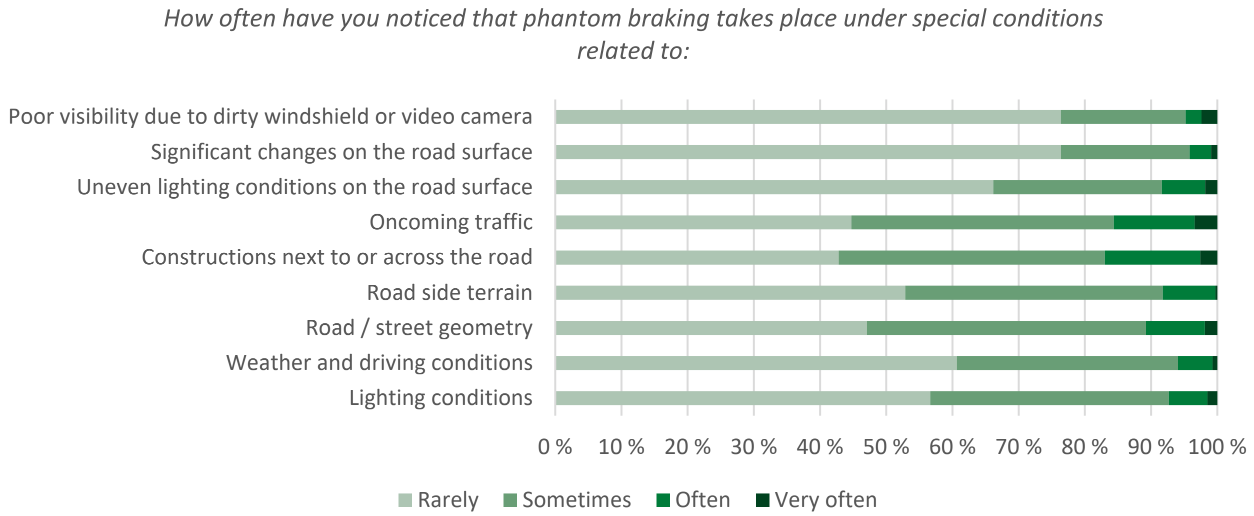

Figure 5. Frequency of phantom braking episodes under special conditions.

For a better understanding, Table 5 shows the frequency and percentage of the reported phantom braking episodes distributed in the nine special conditions. The column on the far right of Table 5 indicates the sum of the frequency of phantom braking episodes (Rarely to Very often) under each studied condition, without considering the scale point '*Never*'. The results show that although a large proportion of the respondents report to have never experienced phantom braking under the nine studied conditions, phantom braking happens under all of these, with higher frequency in conditions with special road/street geometry, followed by oncoming traffic, and constructions next to or across the road.

Table 5. Reported frequency and percentage of phantom braking under special conditions (N = 3415).

	Never	Rarely	Sometimes	Often	Very often	SUM*
Lighting conditions	2608 (76.4%)	457 (13.4%)	291 (8.5%)	47 (1.4%)	12 (0.4%)	807
Weather conditions	2589 (75.8%)	501 (14.7%)	276 (8.1%)	43 (1.3%)	6 (0.2%)	826
Road / street geometry	2032 (59.5%)	651 (19.1%)	583 (17.1%)	123 (3.6%)	26 (0.8%)	1383
Roadside terrain	384 (69.8%)	545 (16.0%)	401 (11.7%)	82 (2.4%)	3 (0.1%)	1031
Constructions next to the road	2408 (70.5%)	431 (12.6%)	405 (11.9%)	145 (4.2%)	26 (0.8%)	1007
Oncoming traffic	2186 (64.0%)	550 (16.1%)	487 (14.3%)	150 (4.4%)	42 (1.2%)	1229
Uneven lighting on the road	2818 (82.5%)	395 (11.6%)	152 (4.5%)	39 (1.1%)	11 (0.3%)	597
Changes on the road surface	2983 (87.3%)	330 (9.7%)	84 (2.5%)	14 (0.4%)	4 (0.1%)	432
Poor visibility - dirty camera	2961 (86.7%)	352 (10.3%)	87 (2.5%)	11 (0.3%)	11 (0.1%)	461

** Sum of the frequencies without scale point 'Never'. The column is colour-coded based on statistical analyses indicating high correlation (dark green) to low correlation (light green).*

In addition, non-parametric statistical tests were performed to analyse possible associations. Spearman's Rho correlation analyses revealed positive correlations between the nine studied special conditions and the frequency of phantom braking episodes. In particular, strong correlations were found between the frequency of the phantom braking with Road/street geometry ($r_s = 0.532$, $p < 0.001$), oncoming traffic ($r_s = 0.533$, $p < 0.001$), and Constructions next or across the road ($r_s = 0.498$, $p < 0.001$). Moderate correlations were found between the frequency of phantom braking and lighting conditions ($r_s = 0.415$, $p < 0.001$), weather conditions ($r_s = 0.387$, $p < 0.001$), roadside terrain ($r_s = 0.450$, $p < 0.001$), and uneven lighting conditions on the road ($r_s = 0.363$, $p < 0.001$). Low degree correlations were found between the frequency of phantom braking and changes on the road surface ($r_s = 0.285$, $p < 0.001$) and Poor visibility due to dirt in the video camera or windshield ($r_s = 0.257$, $p < 0.001$).

3.4.3 Interest in Advanced Driver Assistance Systems

To address RQ3, five questions divided in two topics were presented in the survey. The two topics were the interest of the respondents in ADAS, and to what extent the respondents read the user manuals regarding the ADAS before and after experiencing phantom braking. Both questions regarding the interest in ADAS used a 5-point Likert-type scale. The question concerning how important it was for the respondents to have the ADAS in their car before they bought it, showed an average interest of $M = 3.19$ ($SD = 1.31$), indicating that in average, the respondent's interest was neutral. There was however a slightly higher number of scores indicating the ADAS as an important feature in the car (27.3%), see Figure 6 [a]. The following question aimed to investigate the change in interest after the respondents obtained their car with ADAS. Although the average results showed a slightly increase in interest $M = 3.70$ ($SD = 1.13$), there was a considerable increase in the proportion of participants who reported to be interested in ADAS in their car. The results indicated that 33.2% were interested and 28.5% were very interested in them, see Figure 6 [b]. A Spearman correlation analysis showed that there was a positive strong correlation between the importance of counting with ADAS before buying a car and the interest in them after getting it ($r_s = 0.693$, $p < 0.001$).

In addition, to further explore the results, a Kruskal-Wallis H test showed that there was a statistically significant difference in interest in ADAS between the age of the respondents, $X^2(5) = 39.845$, $p < 0.001$, with higher mean rank scores in younger respondents. However, due to the imbalance of age conditions, these results should be taken with caution.

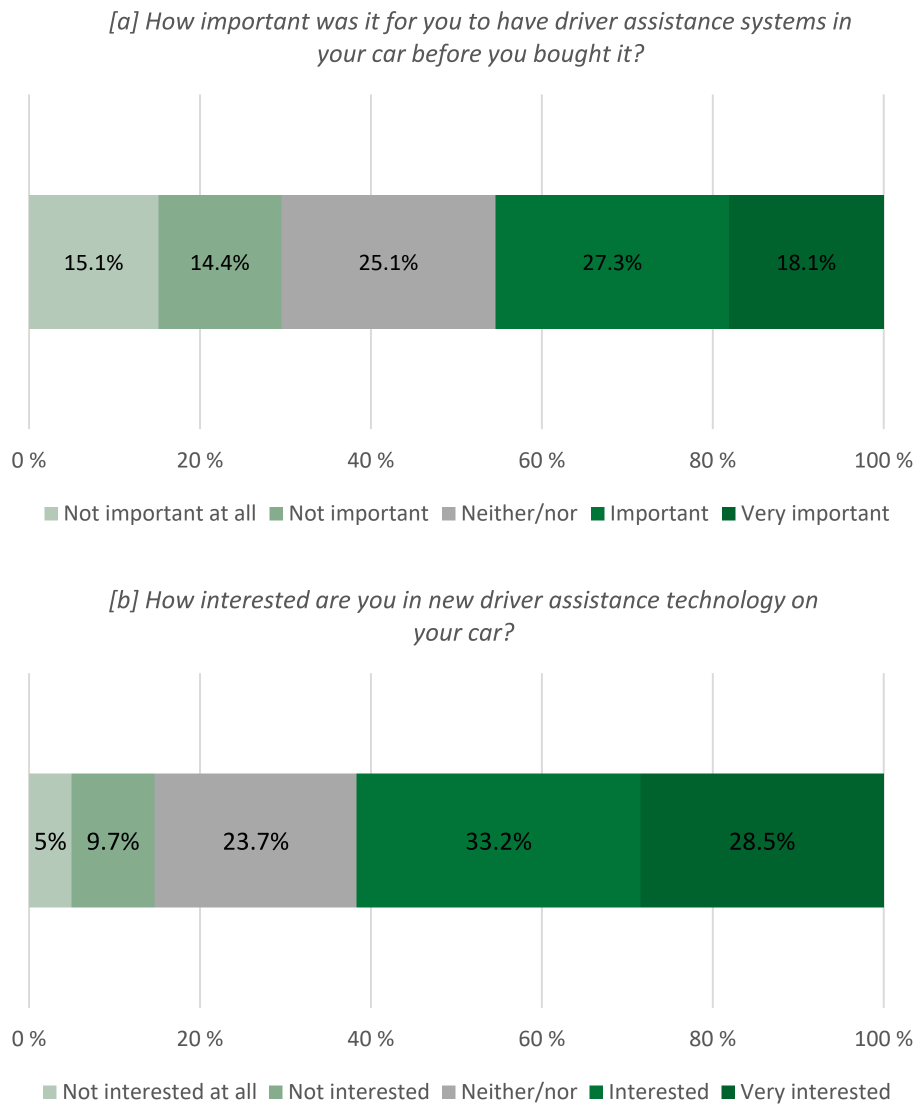

Figure 6. Interest of the respondents in ADAS before [a] and after [b] obtaining a car.

Regarding the interest in reading about the ADAS in the car user manual before and after having experienced phantom braking, specific questions were presented in the survey: for evaluating how carefully the respondents had read the user manuals on how the ADAS work, and about the limitations and warnings of the ADAS before using them. Over half of the respondents (54.8%) reported to have seen/read a little about ADAS in the user manual, 26% reported to have carefully read the user manual, and 19.2% reported to not have read the user manual. Similar proportions were found for how carefully they read about the limitations and warnings of the ADAS: 54.3% reported to have seen/read a little, 24.4% reported to have read carefully about them, and 21.3% reported to not have read anything yet. A third question aimed to investigate whether the respondents had read more about the ADAS after experiencing phantom braking. Focusing on the respondents who have had phantom braking, the results show that despite having experienced phantom braking 42.3% of the respondents reported to not have read more about ADAS, whereas 16.8% reported to have read more about ADAS after the experience, see Figure 7.

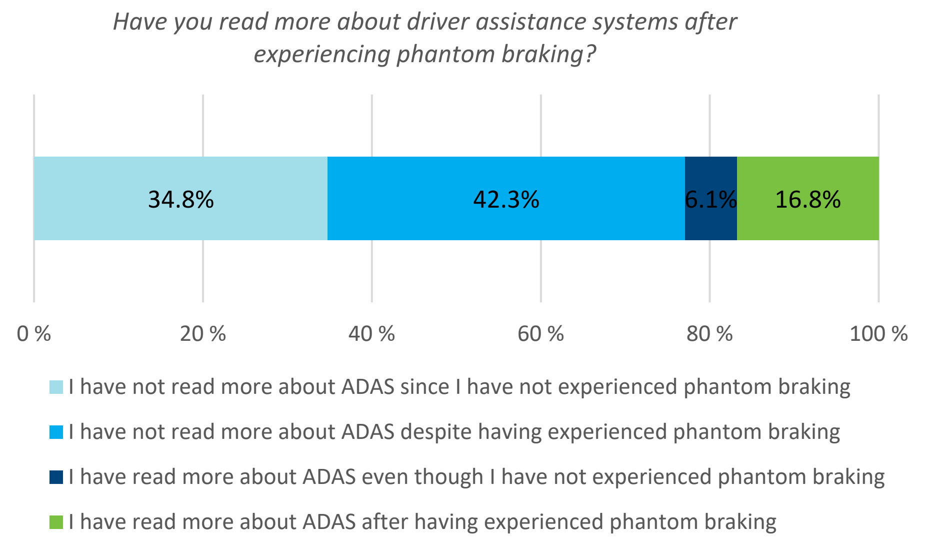

Figure 7. Distribution of responses for reading about ADAS after experiencing phantom braking.

3.4.4 Trust in Advanced Driver Assistance Systems

The respondents were asked to indicate their level of trust in the ADAS in a 5-point Likert-type scale ranging from '*very little*' to '*very much*'. The results show an average score of M = 3.2 (SD = 1.9) among all the respondents. Indeed, a large proportion of the respondents (42.1%) reported to have a neutral attitude regarding the trust in ADAS. However, the results also showed a higher tendency towards the positive end of the scale. The results showed that 37.2% of the respondents have some level or very high level of trust in ADAS, see Figure 8.

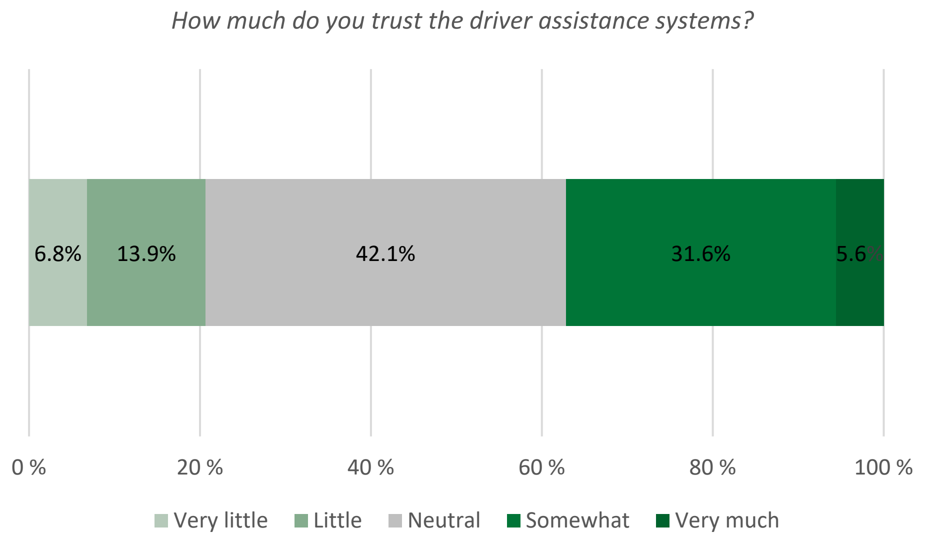

Figure 8. Distribution of responses for trust in Advanced Driver Assistance Systems.

Further analysis were carried out to uncover possible age differences for trust in ADAS. A Kruskal-Wallis H test showed that there was a statistically significant difference in trust in ADAS between the age of the respondents, $X^2(5) = 25.847$, $p < 0.001$, with lower mean rank scores among the respondents in the age group 56 to 65 years old.

3.4.5 Attitudes towards ADAS after phantom braking

The final research question (RQ5) aimed to investigate the users attitude towards ADAS after having experienced phantom braking. One question explored whether phantom braking (experienced or not) impacted on the opinion of cars with ADAS. Among the respondents who have not changed their opinions, the results showed that a large proportion of the respondents (56.7%) are still positive to them, whereas 2.9% of the respondents have not changed their negative opinion towards cars with ADAS. From the respondents who have reported having changed their opinion about ADAS in cars, similar proportions were found towards both directions. Whereas 11.7% have become more positive to them, 12.2% have become more negative to them, see Figure 9 [a]. A 16.6% of the respondents reported to be 'unsure' about whether their opinions had changed.

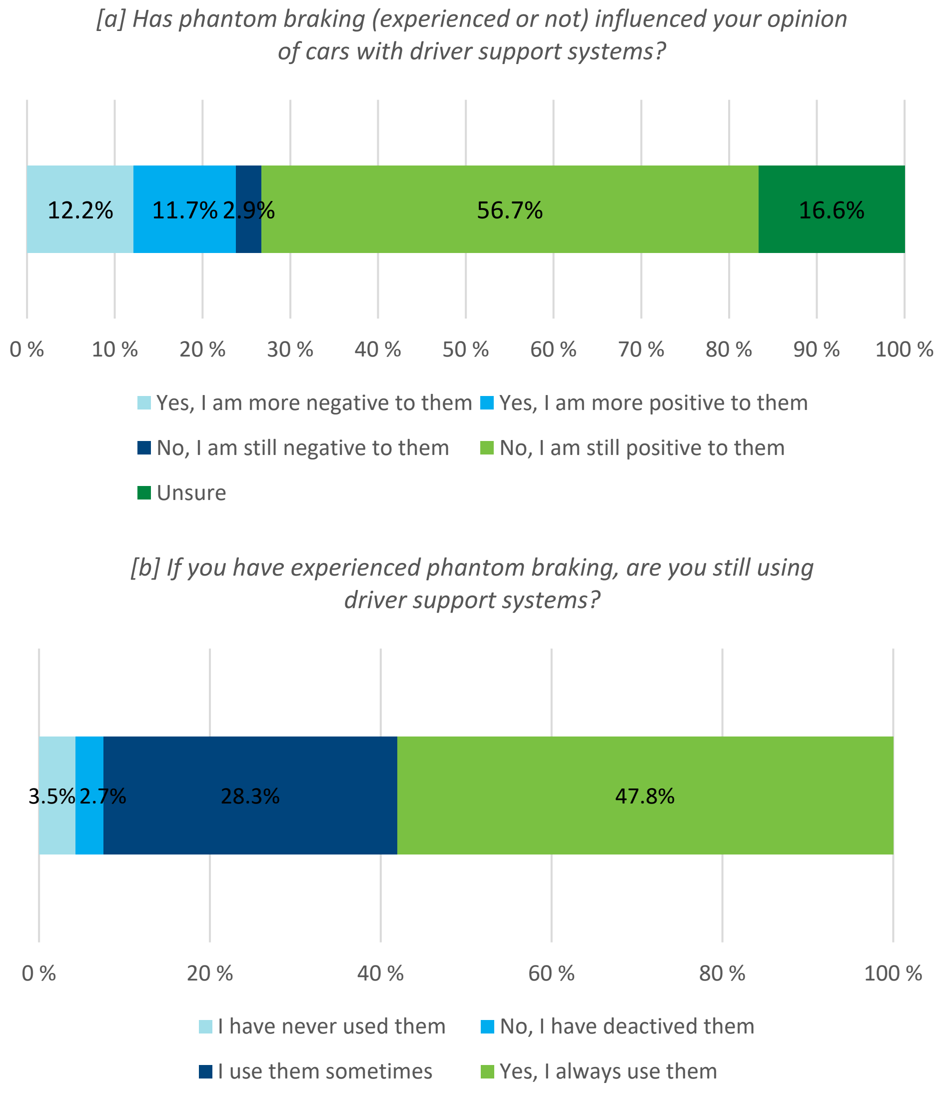

Figure 9. Opinion of cars with ADAS [a] and level of use of ADAS after experiencing phantom braking [b].

Another question explored among the respondents who had experienced phantom braking, their use of ADAS in their cars. The question was presented using a close-ended single-choice questions between 5 alternatives, one of them stating that they had not experienced phantom braking. Considering the focus of the question, that alternative has been removed from the analyses. The results show that 3.5% of the respondents have never had ADAS activated in their cars. From the respondents who had experienced phantom braking, a large proportion (47.8%) reported to always use ADAS, 28.3% reported to use them sometimes, and only 2.7% reported to have deactivated ADAS in their cars, see Figure 9 [b].

4 Discussion

The present study aimed to map and analyse the frequency of phantom frequency among Norwegian drivers who own a car with Advanced Driver Assistance Systems registered from the year 2019 onwards. The study also focused on uncover the possible conditions that might have triggered episodes of phantom braking, and how the users attitudes, opinions, trust, and use have changed after experienced phantom braking. To this end, a web-survey was conducted. Prior to the web-survey, a deep analysis of Owner manuals of the 8 different car types selected for this project was carried out.

The review of the Owner manuals clearly shows that the car producers are using different names on similar Advanced Driver Assistance Systems (ADAS) applications. The descriptions of the similar applications also show that although the applications may have similar names, they are not always comparable regarding functionalities, constraints, and prerequisites. It is not within the scope of this project to describe the ADAS applications more than what has been referred from the owner manuals. The scope of this project was to document to which extend the driver/owner has enough information to understand the main functionality and limitations of the Automatic Emergency Braking (AEB) application (or similar applications) and that he/she is warned about the possible occurrence of unexpected braking (phantom-braking).

Although the reviewed owner manuals have different names and descriptions of AEB and similar applications and the level of details and readability may differ between the manuals, the main observation is that the driver/owner are in all manuals clearly informed that unexpected braking may occur. The circumstances and reasons for unexpected braking have not always the same clear explanations but different functionality and limitations could be a reason for that.

Concerning the results obtained by the web-survey, and due to the survey nature, the data is based on the subjective information provided by the respondents and thus no real effects or associations can be derived from the results. Although correlation analyses have been performed, these provide only possible bivariate associations. It is important to indicate that a significant correlation does not necessarily mean causality. The statistical results thus should be taken with caution. For example, although the results show a strong association between the frequency of phantom braking and specific special conditions, the occurrence of phantom braking might also be influenced by the presence of confounding factors which have not been reported in the survey. However, in this particular research project, the aim of the survey was not to test a hypothesis, but to acquire an initial understanding of the frequency and conditions for phantom braking. In that regard, the results of the study offer valuable insights about the phantom braking problematic in Norway.

The results show that around 28% of the respondents reported to have never experienced phantom braking, indicating that over 70% of them have experienced phantom braking at least once in their lives. The frequency of these occurrences varied across the respondents, indicating that whereas some respondents experience phantom braking rarely or sometimes, others experience them often or very often. The results show that, in general, the frequency in which episodes of phantom braking occur is considered as 'sometimes'. Indeed, this is not a new problematic, with owners of cars with these systems complaining about these episodes naturally experienced as negative and frightening (Haugen, 2019; Solås, 2019).

Despite the high percentage of phantom braking occurrence, only 10 individuals (0.3% of the sample) indicated that phantom braking led to traffic accidents. To the researchers' knowledge, there has been no fatal accident product of phantom braking registered in Norway. Moreover, it becomes difficult to attribute responsibility of a traffic accident to phantom braking alone in situations with limited knowledge about the driving and human conditions in which an accident takes place. Among the responses obtained by the survey, there was found that particular episodes of phantom braking led to traffic accidents. A large number of respondents considered that those accidents were not critical, whereas few respondents described their phantom braking episodes '*to cause a chain collision with 3 cars in total*', that they produced *'almost a collision towards cyclists'*, or that these happen to collide *'directly to the roadside rail at 110 km/h'*.

Concerning the driving speed in which phantom braking usually occurs, the results show a larger occurrence in driving speeds between 70 and 90 km/h. Although this response obtained the higher score, it is important to mention that phantom braking seems to have been experienced under all the possible driving speeds presented in the survey. Moreover, comments from the respondents confirm this, indicating that they *'have experienced phantom braking in more than one particular driving speed*'. Although the statistical results suggest that when driving speed increases the frequency of phantom braking decreases (or vice-versa), these are only a possible association and does not prove causality. Further research is thus necessary.

Regarding the conditions in which phantom braking took place, the results suggest that three conditions are most frequently associated with these episodes: *i.* road/street geometry (e.g. straight stretch, sharp curve, slack curve) *ii.* oncoming traffic (large/small oncoming vehicles on straight line, large/small oncoming vehicles in slack curves/sharp curves), and *iii.* constructions next to or across the roads (e.g. bridges, railroad crossings, tunnel portals, signs portals, large masts). The results concerning the road geometry and the constructions adjacent to the roads are in line with the study of Storsæter et al. (2020), who discussed that road design and maintenance strategies are crucial in the effective functioning of automated driving features. Not only their study points out that road elements can be difficult to be registered by these systems, but also indicate that whereas LED signs are hard to read by car cameras due flicker, materials with high reflectance such as glass or mirrors can impact on the object distance detection by Lidar systems. Indeed, this was mentioned by some respondents who claimed that ADAS in their cars do '*not read electrical (diode-based) speed signs*'.

In relation to this road/street geometry, further insights could be collected from the open-ended questions and direct debriefing communications from some respondents who contacted the researcher responsible of the survey. A couple of comments indicated that there is a larger distance between traffic signs in Norway compared to other countries. The speed adjustment based on these apparently distant traffic signs seems to create a conflict with the sensors/cameras of the vehicles with ADAS, something that is seen by few respondents as a contributor to phantom braking. The distance between traffic signs in Norway is regulated to minimum values, such as 50 m as minimum on free stretch of road outside densely populated areas, and 100 m as a minimum on motorways, and on other roads where there are no restrictions on location options (SVV, 2014). Whether the distances between the traffic signs have been considerable larger to the minimum distances is unknown and no direct conclusion can be derived from it. It is, however, an interesting insight, which warrants further study. Additionally, some responses mentioned that the difference between the technologies used in cars with ADAS (i.e. cameras or Lidar) could also play a role on the identification of traffic and road elements. This is in accordance with previous research, which have shown that even the projection of objects that are not physically present in the roads can also trigger phantom braking dependent to the technology type that Tesla cars use (Nassi et al., 2020). Further research is thus required to confirm these hypotheses (i.e. distance between traffic signs and difference in ADAs technologies to detect road elements). Other special conditions such as the lighting conditions (level and distribution on the road), weather conditions, and roadside terrain have been also reported by the respondents to be associated with phantom braking.

Moreover, other condition seen as a contributor to phantom braking was also reported by some respondents in the open-ended questions. This condition was reported to be a conflict between the map in the car's navigation system and the actual physical conditions present in the roads, or due to traffic signs establishing maximum driving speed different from outdated map in the car. This problematic was reported by more than one respondent:

- '*The new road was straight, while the old one had a sharp turn. The car was programmed to slow down in sharp turns*.'
- '*The vast majority of cases of so-called phantom braking occur because there is no correspondence between the marked speed limit on the road you are driving on and what the map/sign recognition shows. This is typical of, for example, newly opened road sections where the speed limit has previously been lower. 95% of the phantom brakes experienced have been due to this particular phenomenon. On sections where the speed limit and map correspond, I have never experienced phantom braking, while on sections as mentioned above, such situations can easily be recreated*.'
- '*Most cases of phantom braking that I experience are related to the car also using map data. Example: i. E6 south of Hamar. Here there are level crossings, while the car still thinks it is ordinary crossings, based on map data. It then slows down in front of each "virtual" intersection. ii. Outdated speed signs. The autopilot will comply with the maximum speed when this is activated on "non-motorways". In some places, the old map data has reduced speeds, and then slows down because the speed in maps is lower.*'

How often the map data system is updated in each car is dependent on many factors, such as the map provider, the Norwegian Roads Administration's provider of updated traffic regulations data and naturally, the car producer company. The results suggest that it is crucial to maintain a continuous communication between the road authorities and the companies responsible to update the map data in vehicles with ADAS, for the benefit of road safety.

Regarding interest in ADAS, although the respondents' average interest before buying a car was shown to be neutral, a slightly higher tendency towards high interest could be seen. The results suggest that the interest in ADAS increased after buying a car with them. These results are in accordance with previous research showing that drivers reported being more positive towards ADAS (in particular with Intelligent Speed Adaptation - ISA) after using them (Lahrmann et al., 2001). As expected, the results also suggest that the interest increased more for people who previously considered important to count with them. In other words, people who considered them important before buying a car had also more interest in the ADAS in their car.

However, the results showed an interesting finding. Despite the increase of interest in ADAS among the respondents, and despite having experienced phantom braking, the results showed that only 42.2% reported to not have read more about ADAs in their car user manual. This proportion of respondents differ greatly from the 16.8% who reported to have read more after experiencing phantom braking. Although one could expect that having previously experienced phantom braking would lead to deeper reading of the systems in the car user manual, this seems not to be the case among the results. These results are of importance as previous research has pointed out that without proper knowledge and even training in ADAS, the drivers can be unaware of the limitations and warnings of the cars' advanced systems (Parasuraman, 2000), something that can lead to fatal traffic accidents (Zahabi et al., 2021). A possible explanation of why the respondents do not read more the user manuals might be the length of these. Considering that some of these manuals might be over 100 pages, it might be difficult for the drivers to reach the information in a rapid manner.

Concerning the trust in ADAS, the results showed that in average, the respondents reported a neutral level of trust in these systems. A slightly higher tendency towards higher level of trust in the question scale was shown, indicating that more respondents trust in ADAS than the ones who reported to not trust them. This could be explained by the familiarity with automated vehicles in Norway, due to the visibility of various pilot studies in the Norwegian roads. Yet, additional research is needed to prove this hypothesis. Furthermore, an age difference was found significant for trust in ADAS. The statistical results indicated that people in the age range 56 to 65 years old have lower level of trust in ADAS. Age-related differences were also found between younger and older drivers regarding the interest towards ADAS. Driver training could contribute to increase the interest among different driver groups. Although these results should be taken with caution due to the unbalanced conditions among the different age groups, they warrant further investigation. Particularly considering that previous research has found age-related differences of the effects of ADAS on younger and older drivers (Bao et al., 2020).

Finally, concerning the attitude towards ADAS after experiencing phantom braking, the study showed interesting findings. Despite having experienced phantom braking before, more than half of the respondents (56.7%) reported to have still a positive attitude towards them. Moreover, a large proportion of the respondents (47.8%) also reported to continue using ADAS, whereas only 2.7% reported to have deactivated ADAS in their cars. These findings confirm the results concerning the slightly higher interest and trust in ADAS among the surveyed drivers.

5 Concluding remarks

The aim of this study was to map the prevalence of phantom braking in Norway among the drivers of 8 specific car types from 2019 and onwards. A prior analysis of the Owner manuals of these 8 car types indicates that:

- The reviewed owner manuals have different names and descriptions of AEB. Although similar applications and the level of details and readability may differ between the manuals, the main observation is that the driver/owner are in all manuals, except one, clearly informed that unexpected braking may occur. However, the owner/driver is clearly warned about the AEB limitations in all manuals.
- The circumstances and reasons for unexpected braking have not always the same clear explanations but different functionality and limitations could be a reason for that.

The results of the conducted web-survey with 3,415 respondents, concerning the frequency of phantom braking and the conditions under these took place reveal that:

- Over 70% of the respondents report to have experienced phantom braking at least once in their lives. In general, the frequency of the phantom braking episodes seems to vary among the respondents, from rarely to very often.

- Phantom braking seems to happen under different driving speeds, with a slightly higher tendency of occurrence between 70 and 90 km/h.
- Among the studied conditions, three special circumstances are most frequently associated with phantom braking: *i.* road/street geometry (e.g. straight stretch, sharp curve, slack curve) *ii.* oncoming traffic (large/small oncoming vehicles on straight line, large/small oncoming vehicles in slack curves/sharp curves), and *iii.* constructions next to or across the roads (e.g. bridges, railroad crossings, tunnel portals, signs portals, large masts).
- From the open-ended questions and extra insights from the respondents, other conditions were identified as possible phantom braking triggers. These included: *i.* Traffic sign elements such as driving speed signals presented in diode-based materials might not be read by the ADAS, *ii.* distance between traffic signs not registered by the vehicles, and *iii.* different ADAS technologies (e.g. cameras vs Lidar) and their ability to register road elements.
- More than one respondent indicated that a very common condition associated with phantom braking was a conflict between the map in the car's navigation system and the actual physical conditions present in the roads, e.g. traffic signs establishing maximum driving speed different from outdated map in the car. These results suggest further study and communication between all the parts (e.g. authorities and producers) for the proper updating process of the vehicles' map data.

In addition, further results regarding the interest, attitudes, and trust towards ADAS indicated that:

- Although the interest in ADAS increased after owning (and driving) a car with such systems, and having experienced episodes of phantom braking, the results reveal that the respondents do not seem to read more about ADAS in their cars.
- Most of the respondents reported to have a neutral level of trust towards ADAS, with a slightly higher tendency towards a higher level of trust.
- Despite having experienced phantom braking before, not only a large number of the respondents reported to have still a positive attitude towards ADAS, but also reported to continue using them. A small number of respondents (2.7%) reported to have deactivated the ADAS in their vehicles.

6 References

Bao, S., Wu, L., Yu, B., Sayer, J.R. (2020). An examination of teen drivers' car-following behavior under naturalistic driving conditions: With and without an advanced driving assistance system. *Accident Analysis & Prevention*, 147. Doi: https://doi.org/10.1016/j.aap.2020.105762

De Bruijne, M. & Wijnant, A. (2014). Improving Response Rates and Questionnaire Design for Mobile Web Surveys. *Public Opinion Quarterly*, 78 (4), 951–962. Doi: https://doi.org/10.1093/poq/nfu046

European Commision. (2016). Advanced driver assistance systems. Report European Road Safety Observatory.

Hagl, M. & Kouabenan, D. R. (2020). Safe on the road – Does Advanced Driver-Assistance Systems Use Affect Road Risk Perception? *Transportation Research Part F: Traffic Psychology and Behaviour,* 73 (4), p. 488-498. Doi: 10.1016/j.trf.2020.07.011

Haugen, A. (2019). Tesla Norge undersøker klager om "fantombremsing". E24!. URL: https://e24.no/teknologi/i/XgnJxm/tesla-norge-undersoeker-klager-om-fantombremsing [Last accessed: 14.05.2021]

Kyriakidis, M., Van de Weijer, C., van Arem, B. & Happee, R. (2015). The Deployment of Advanced Driver Assistance Systems in Europe. SSRN Electronic Journal. Doi: 10.2139/ssrn.2559034

Lahrmann, H., Madsen, J. R., & Boroch, T. (2001) Intelligent speed adaptation – development of a GPS based ISA system and field trial of the system with 24 test drivers. *Proceedings of the 8th World Congress on Intelligent Transport Systems*. Sydney, Australia

Nassi, B., Mirsky, Y., Nassi, D., Ben-Netanel, R., Drokin, O. & Elovici, Y. (2020). Phantom of the ADAS: Securing Advanced Driver-Assistance Systems from Split-Second Phantom Attacks. *Proceedings of the 2020 ACM SIGSAC Conference on Computer and Communications Security.* October 2020, p. 293-308. Doi: https://doi.org/10.1145/3372297.3423359

OFV. (2020). Registreringsstatistikken. Opplysningsrådet for Veitrafikken. URL: https://ofv.no/registreringsstatistikk [Last accessed: 14.05.2021]

Parasuraman, R. (2000). Designing automation for human use: Empirical studies and quantitative models. *Ergonomics,* 43 (7), p. 931-951.

Solås, S.V. (2019). Advarer mot "fantombremsing" på Tesla. NRK Nyheter – Oslo og Viken. URL: https://www.nrk.no/osloogviken/advarer-mot-_fantombremsing_-pa-tesla-1.14714384 [Last accessed: 14.05.2021]

SSB. (2021). Trafikkulykker med personskade. *Statistisk Sentralbyrå.* URL: https://www.ssb.no/transport-og-reiseliv/landtransport/statistikk/trafikkulykker-med-personskade [Last accessed: 20.05.2021]

Storsæter, A.D., Pitera, K. & McCormack, E. D. (2020). The automated driver as a new road user. *Transport Reviews*. DOI: 10.1080/01441647.2020.1861124

Ringen, S. (2019). Dybdeanalyser av dødsulykker i vegtrafikken 2019 [English title: In-Depth Analysis of Fatal Road Accidents in the year 2019]. Statens Vegvesens Rapporter. Report Nr. 691.

SVV. (2014). Traffikkskilt – Del 1 Fellesbestemmelser. Håndbok N300. Statens Vegvesen.

Zahabi, M., Razak, A. M. A., Mehta, R. & Manser, M. (2021). Effect of advanced driver-assistance system trainings on driver workload, knowledge, and trust. *Transportation Research Part F: Traffic Psychology and Behaviour,* 76, p. 309-320. Doi: https://doi.org/10.1016/j.trf.2020.12.003

Appendix A: Questionnaire (in Norwegian)

A Appendix A: Survey questionnaire (in Norwegian)

Erfaringer med førerstøttesystem

2.Hvor lenge har du hatt bilen med førerstøttesystem?

- Mindre enn 6 måneder
- Mellom 6 til 12 måneder
- Over 1 år

3.Har du opplevd at førerstøttesystemer bisto deg i å håndtere en kritisk situasjon?

- Ja
- Nei
- Usikker

4.Var du bevisst at førerstøttesystemet var av eller på?

- Ja
- Nei
- Noen ganger
- Usikker
- Har ikke opplevd fantombremsing

5.Hvor ofte har du opplevd at bilen din har foretatt fantombremsing uten at du som sjåfør tråkket på bremsepedalen?

	Aldri	Sjelden	Noen ganger	Ofte	Veldig ofte
	○	○	○	○	○

6.På hvilke kjørehastigheter har du opplevd fantombremsing?

- Over 90 km/t
- Mellom 70 - 90 km/t
- Mellom 40 - 60 km/t
- Under 40 km/t
- Har ikke opplevd fantombremsing

7.Ble det noen ulykker forårsaket av fantombremsingen?

- Ja
- Nei
- Har ikke opplevd fantombremsing

8.Hvis du svarte "Ja" på forrige spørsmål, hvor alvorlig/e var ulykken/e?

Eksterne forhold som kan ha påvirket førerstøttesystemets funksjonalitet

9.Hvor ofte har du registrert at fantombremsingene skjer under spesielle forhold knyttet til:

	Aldri	Sjelden	Noen ganger	Ofte	Veldig ofte
Lysforhold (f.eks. dagslys, mørkt og veg/gatebelysning, mørkt uten gatebelysning)					
Vær og føreforhold (f.eks. sol, motlys, regn, snø, tåke og regn)					
Veg/gategeometri (f.eks. rettstrekning, krapp kurve, slak kurve)					
Vegens sideterreng (f.eks. trange skjæringer, rekkverk)					
Konstruksjoner ved siden av eller over vegen (f.eks. bruer, kryssing av jernbanespor, tunnelportal skiltportaler og store master)					
Motgående trafikk (store/små motgående kjøretøyer på rettstrekning, store/små motgående kjøretøyer i slake kurver/krappe kurver)					
Ujevne lysforhold på vegoverflaten, f.eks. skygger av konstruksjoner, store trær, hus, osv.					
Vesentlige endringer på vegoverflaten som ny asfalt, bruskjøt/brufuge					
Dårlig sikt pga. skitten frontrute foran videokamera(er) i frontrute					

10.Kunne du beskrive nærmere de spesielle forholdene over som opptrer oftest? gjerne bare med noen få stikkord.

Interesse for og holdning til denne type førerstøttesystemer

11.Hvor viktig var det for deg å ha førerstøttesystemer i bilen din før du kjøpte den?

Ikke viktig i det hele tatt 1 2 3 4 5 Veldig viktig

12.Hvor interessert er du av ny førerstøtteteknologi på bilen din?

Helt uinteressert 1 2 3 4 5 Svært interessert

13.Hvor nøye leste du brukerhåndboken (evt. på bilens skjerm) om hvordan førerstøttesystemene virker?

- Har ikke lest brukerhåndboken
- Har sett/lest litt om førerstøttesystemer i brukerhåndboken
- Har lest nøye om førerstøttesystemer i brukerhåndboken

14.Hvor nøye leste du om førerstøttesystemenes begrensinger og eventuelle advarsler før du tok dem i bruk?

- Har ikke lest noe ennå
- Har sett/lest litt om begrensinger og advarsler
- Har lest nøye om begrensinger og advarsler

15.Har du lest mer om førerstøttesystemer etter å ha opplevd fantombremsing?

- Jeg har ikke lest mer om førerstøttesystemer siden jeg ikke har opplevd fantombremsing
- Jeg har ikke lest mer om førerstøttesystemer selv om jeg har opplevd fantombremsing
- Jeg har lest mer om førerstøttesystemer selv om jeg ikke har opplevd fantombresing
- Jeg har lest mer om førerstøttesystemer etter opplevd fantombresing

16.Hvor mye stoler du på de førerstøttesystemene?

Veldig lite 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ Veldig mye

17.Hvis du svarte 1 eller 2 på forrige spørsmål, hvorfor stoler du ikke på førerstøttesystemene?

18. Hvis du har opplevd fantombremsing, bruker du fortsatt førerstøttesystemer?

- Jeg har aldri brukt dem
- Nei, jeg har deaktivert dem
- Jeg bruker dem av og til
- Ja, jeg bruker dem alltid
- Har ikke opplevd fantombremsing

19.Har fantombremsing påvirket din mening om biler med førerstøttesystemer?

- Ja, jeg har blitt mer negativ til dem
- Ja, jeg har blitt mer positiv til dem
- Nei, jeg er fortsatt negativ til dem
- Nei, jeg er fortsatt positiv til dem
- Usikker

Til slutt litt opplysninger om deg selv

20.Kjønn

- Kvinne
- Mann
- Foretrekker å ikke svare

21.Hva er alderen din?

- 18 - 25
- 26 - 35
- 36 - 45
- 46 - 55
- 56 - 65
- 65 +

22.Hva er din høyeste gjennomførte / pågående utdanning?

- Grunnskole (7- eller 9-årig)
- Videregående skole
- Universitet / høgskole

23.Hvilke type førerkort har du?
Du kan velge flere alternativer.

- Personbil (B/BE)
- Moped (AM)
- Motorsykkel (A, A1)
- Lastebil (C/CE)
- Traktor (T)
- Minibuss (D1)
- Buss (D)
- Lett lastebil (C1/CE)
- Snøscooter (S)

24.Hvilken type bil bruker du?
Vennligst oppgi merke/modell/årsmodell, f.eks. Audi e-tron 2019

25.Når anskaffet du bilen som du bruker til vanlig og som har førerstøttesystem?

26.Hvor mange dager i uka bruker du bilen din?

1 2 3 4 5 6 7

27.Omtrent hvor mange kilometer har du kjørt det siste året?

0 - 5.000 km/år

5.000 - 10.000 km/år

10.000 - 15.000 km/år

15.000 - 20.000 km/år

Mer enn 20.000 km/år

28.Hvor kjører du mest?

By - fartsgrense under 50 km/t

Land - fartsgrense over 50 km/t

29.Hvor mange biler med førerstøttesystemer har du eid?

1 bil

Mellom 2 og 5 biler

Mer enn 5 biler

Takk for din deltakelse!

SINTEF

Technology for a better society
www.sintef.no