How Human-Machine Interaction keeps pace with Automated Vehicles: a systematic review

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Abstract

Human Machine Interface (HMI) is a design concept that improves the interaction between the driver and the automated vehicle, which leads to greater safety and comfort for the driver and greater safety for the road user. Therefore, many papers and patents are published every year. Many papers use different methodologies and materials due to some limitations. Finding an insight about the development of HMI in automated driving could be tough. An overview, such as a systematic review, could be used to create this insight. This paper provides a detailed systematic review, which contains 340 analyzed papers and distinguishes them over 20 different categories. Results show an increasing interest in HMI for automated driving systems that reflects the common interest of the general population, an increasing interest of some levels of automation and the use of certain methodologies and materials. Lastly, several insights, caveats, and future implications are discussed.

Contents

1 Introduction

Traveling by car is a popular transport method in the EU (Fiorello, Martino, Zani, Christidis, & Navajas-Cawood, 2016). The average EU citizen travels around 12 000 km by car each year ("Change in distance travelled by car", n.d.) and travels less with other transportation methods, like public transport and flight (Grunewald, 2008; "Passenger mobility per capita", n.d.). Compared to other transportation methods, traveling on road by car isn't the safest method (Isidore, 2015). In the European Union alone there were over 25 thousand fatalities and 1 million injury accidents on the road in 2016 ("Annual Accident Report", 2018). In most of these fatalities and accidents cars were involved. Moreover, around 72% of the car accidents are caused by behaviour errors (Thomas, Morris, Talbot, & Fagerlind, 2013; Petridou & Moustaki, 2000). These kinds of errors can be avoided by automating vehicles with systems such as Advanced Driver Assistance Systems (ADAS; Hamid et al., 2017; Marchau, van der Heijden, & Molin, 2015). ADAS are aid systems that increase the safety or aids the driver with some tasks (Kala, 2016). Systems like Lane Departure Warning (LDW) are seen as ADAS, where the driver is warned by modalities like visual, audible, and/or vibration signals when the vehicle moves out of the lane (Blom, 2017). ADAS also pave the way to make automated vehicles possible ("How ADAS is making autonomous driving a reality", 2019). The Society of Automotive Engineers (SAE) distinguished automation in vehicles between six levels (SAE International, 2018). At level 0, the driver performs the dynamic driving task, which includes steering, acceleration, deceleration, monitoring driving environment, response executing, maneuver planning and signaling to other road users. At level 1, the automation assists the driver by performing the lateral or longitudinal vehicle motion control and the driver performs the rest of the monitoring task. The driver still has to intervene if the system fails. At level 2, the automation performs both the lateral and longitudinal vehicle motion control, but like the previous level the driver still has to monitor the system and has to intervene if the system doesn't perform correctly. At level 3, the automation controls the vehicle laterally and longitudinally. The driver has to be receptive to intervene. So if the system reaches its limits, the driver has to take over the automation. At level 4, the driver isn't expected to intervene or monitor the automation. The automation can intervene itself. At level 5, the automation will perform all the driver's tasks, so the vehicle doesn't need a driver and could only contain passengers.

However, it is found that in situations such as level 2 & 3, the human can fall in one or more of the six automation pitfalls (Parasuraman & Riley, 1997): lack of situation or mode awareness, loss of manual control skills, low or high mental workload, behavioral adaptation, misuse of automation and disuse of automation. These automation pitfalls have also been seen in the aviation industry where automation has been generally used (Billings, 1991; Parasuraman & Riley, 1997). It is expected that automation and its pitfalls will also be seen in the upcoming self-driving automotive industry (Hancock, 2019). To prevent automation pitfalls, an automated vehicle has to interact with the driver and provide information (Debernard, Chauvin, Pokam, & Langlois, 2016).

A Human Machine Interface (HMI) is a design concept that improves the interaction between the machine (like a vehicle) and the driver (Ke et al., 2018). For example, if the automation of an automated vehicle fails, the driver must be informed (by the vehicle) which situation he or she is in and the driver has to take over the automation's tasks to bring the vehicle back to safety. Moreover, if the driver falls asleep behind the steering wheel on a level 3 vehicle, the system should detect the driver if he or she is still able to monitor the system and correct it if necessary. The automation should for example wake up the driver or aid the driver to take over the vehicle. However, it is found that sometimes drivers ignore advice of the automation (Alcorn, 2019). Furthermore, it is also possible that the driver doesn't trust the automation and doesn't use the automation at all. HMI could be used to increase trust in the automation, so the driver will use the automation. In the previous examples HMI is applied to avoid automation pitfalls, namely situation awareness, misuse of automation and disuse of automation.

Nowadays, cars with level 2 automation are already on the road. For instance, several car companies like Mercedes-Benz, Tesla and Volvo have nowadays implemented it in their car models (Hyat & Paukert, 2018; Vincent, 2018). However, vehicles with SAE level 3 or higher haven't been allowed to be sold on the market yet (Hetzner, 2019), but research about level 3 or higher vehicles and other levels is still going on.

Research about HMI in automated driving are published each year (e.g., Hassoun, Laugier, Lefort, & Meizel, 1994; Liu, Sun, Yan, & Zhang, 2019) . Some papers presents its own data and performed their research differently. Therefore, comparing these research with each other could be more challenging as these researches are using different methods and variables, such as using different kind of simulators and participant demographics. To compare these data with each other and identify a common outcome from these studies, a systematic review can be used. This paper will compare the data of 340 papers and distinguished them between 20 different categories, such as SAE levels, simulator fidelity & participant data. The purpose of this systematic review is to build an overview of the published research that consists of subjects related to HMI in automated vehicles. Additionally, this systematic review focuses on HMI between the driver & the automated vehicle and defined an automated vehicle as a four-wheel public road vehicle, which is the most common type of motor vehicle (CBS, 2019c) and affiliated with the most traffic fatalities (CBS, 2019d).

2 Methodology

For this systematic review, three major steps were performed: (1) data gathering, (2) filtering and (3) paper categorization (see Figure 1).

2.1 Data gathering

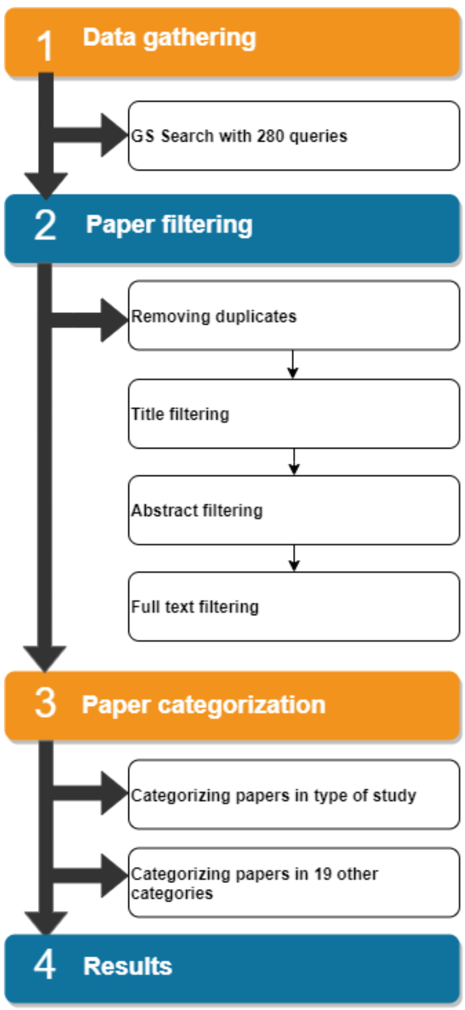


Figure 1. Methodology research design

During data gathering, queries were submitted in Google Scholar (GS) by using Harzing's Publish or Perish (PoP; version 6.16.10586.648, 19-26 march 2019) (Harzing, 2007). PoP is a software program that uses data sources such as GS to retrieve and analyze citations. GS searches throughout the entire content of its papers. This is both an advantage and disadvantage, because, for example, when a paper mentions a query keyword only once, it will appear between the results. For certain research aiming to be all-encompassing, this will be considered an advantage, but in most cases, researchers will not be looking for papers accidentally mentioning a search term once or twice, but they will be looking for papers where the search terms are related to the papers' subject. Moreover, the results from GS contain patents, citations and "grey literature". Citations are papers that are no longer found online and are not used for this systematic review. Grey literature, such as theses and conference proceedings, are literature that are not found in academic sources. This type of literature may provide undiscovered data and could be useful for this systematic review. Other databases like Scopus and Institute for Scientific Information (ISI) won't provide results such as patents, citations and "grey literature". Therefore, GS provides far more results per query than other databases (Gusenbauer, 2019; Harzing, 2010). Lastly, GS provides a longer coverage in time compared to other databases (Harzing, 2010). With these advantage and disadvantages given, GS was chosen to acquire all-encompassing results for this systematic review.

To receive results from GS, a set of queries were predefined and used to gather data. Each query contains an element of each query domain as given in Table 1. Elements of the second column contain adjectives, and elements of third column contain nouns. Both columns combined create word combination related to the subject of automated driving, like "automated vehicle" and "self-driving car".

Topic	Adjective	Nouns	NOT-operator
Human Machine Interaction	automated	vehicle	pedestrian
Human Computer Interaction	autonomous	car	wheelchair
Human Machine Interface	self-driving	pod	military
Human Computer Interface	cooperative	shuttle	business
	driverless	driving	
		bus	
		transport OR transit	

Table 1. The three query domains used for this systematic review

The fourth domain are keywords that were excluded from the search query, as it was found during trial searches that these keywords provided a substantial amount of irrelevant results. The four domains combined formed a search query such as the following:

"Human machine interaction" AND ("Automated Vehicle" OR "Automated Vehicles") NOT (pedestrian wheelchair military business).

A total of (2*4*5*7=) 280 queries were made with the given query domains from Table 1. The number 2 represents the singular and plural of the topic and nouns columns (e.g., "Human Machine Interaction" and "Human Machine Interactions"). Note,in case where GS gave more than 1000 results for an query, GS only could provide the first 1000 results, the other results couldn't be received due to a limitation in GS's result page system. To receive the other results, the query was split in two time periods (e.g., from 2015 to 2019 and from 0 to 2014). A table with the amount of results per query can be found in Appendix A. After gathering the results, the results were filtered.

2.2 Paper filtering

Due to the amount results given by GS, a filtering process in order to acquire all-encompassing results was chosen. The manual filtering procedure contained four steps (see Figure 1, Paper filtering [step 2]). First, after retrieving the citations by using GS, the citations were saved and the duplicated were removed. Many citations reappeared in different queries, because the papers mentioned multiple queries. For example, if a paper mentions the two combined query domains, *autonomous car* and autonomous bus, the citation appeared in two different query results. These kind of citations are effortlessly identifiable, because the author(s), title and publishing year are exactly the same. So if these duplicates are found, they were deleted. As a result, only unique results remained.

Second, the articles were filtered based on whether its title was deemed relevant for this systematic review. Titles that clearly indicated to be about topics irrelevant for this systematic review were discarded, such as titles that described smart cities, unmanned (aerial) vehicles or autonomous trucks.

Third, the remaining papers' abstracts were read. When an abstract wasn't considered to be about HMI in automated driving, the paper was excluded from this systematic review.

In the final step, the remaining papers were fully read to determine its relevance. This resulted in a total of 364 papers that were deemed relevant for this systematic review. These were used for the next step in our methodology of the systematic review, namely the paper categorization step.

2.3 Paper categorization

The categorization process entailed two steps. It was firstly studied how the papers were structured and which sections the paper contained. After that, similarities between papers were found and the papers could be categorized in five major types of studies: experimental study, theoretical study, model study, survey study and patent. In this systematic review, an experimental study is considered to be a paper which contains a description of an experiment in the methodology where the described HMI is evaluated and tested on participants (e.g., Talimonti, 2017) If a paper contained a description (e.g., Carsten & Martens, 2019), review (e.g., Cabrall et al., 2017), or overview about HMI (e.g., Bengler, 2017), and it is not evaluated or tested on participants (e.g., Yun, Lee, Yang & Yang, 2018), it is defined as a theoretical study. A paper is considered a model study if it described a mathematical model that can simulate HMI in automated driving, such as human behaviour, and if the model is also evaluated. If a paper contains participants or experts that evaluated HMI of an automated vehicle, it was considered an survey study. A paper was also considered a survey study if the author presents a survey which could be used for future survey studies or future experimental study. Lastly, if a paper contained a patent, GS will mark it explicitly. The remaining papers were categorized as "Miscellaneous studies", which encompass papers such as workshop, books and video analysis.

After the papers were categorized on paper type, and after careful consideration, other categories were found in the paper types. The category was considered to be useful, if it was common in more than 20% of the paper type. These 19 other categories could be determined in total (see Table 2), namely (publishing) year, SAE level, country, number of references, used variables, participant data, subjective & objective metrics, immersion, configuration, simulator's software & hardware, used interaction. experiment type, international patent classification (IPC), number of IPCs, kind of theoretical paper and type of study. Sections 2.3.1 to 2.3.6 describe which categories each type of study has and how they are found.

Table 2. The categories of each type of study

Categories	Paper type					
	Experimental	Patent	Theoretical	Model	Survey	Other
Year	x	x	x	x	x	x
SAE level	x	x	x	x	x	x
Country	x		x	x	x	x
Number of references	x		x	x	x	x
Used variables	x			x	x	
Participant data	x				x	
Subjective Metrics	x				x	
Objective metrics	x			x		
Immersion	x					
Configuration	x					
Simulator's software	x					
Simulator's hardware	x					
Used Interaction	x					
Experiment type	x					
Environment	x					
International Patent Classification (IPC)		x				
Number of IPCs		x				
Type of theoretical study			x			
Type of study						x
Total	**15**	**4**	**5**	**6**	**7**	**5**

2.3.1 Categorizing experimental studies

As told in previous the section, an experimental study is, in this systematic review, considered to be a paper, which contains experimental description in the methodology section. The described HMI is evaluated and tested on participants. To determine which categories are the most common in experimental studies, the studies were read. After reading, approximately 20% of the 154 experimental papers, 15 categories were found to be the most common in experimental studies. These 15 categories were also considered to be the most common categories in the rest of the experimental studies. In the following sections the definition of each category and how each category is found will be explained.

Publishing year

The year of publishing was often given by GS. If the publishing year wasn't given, the year was found on the research history of the author's Researchgate page, or it was found in the paper, for example on the cover sheet or on the first page of the paper.

Country

The country of the first author's office could also be found on the cover sheet (see e.g, Petermeijer, Bazilinskyy, Bengler, de Winter, 2017) or on the first page of the paper (see e.g, Wulf, Rimini-Döring, Arnon, & Gauterin, 2014).

The country was often placed clearly under the names of the authors (e.g., Mok,Johns, Yang, Ju, 2017) or it was referred with a footnote (e.g., Wandtner, Schömig & Schmidt, 2018).

SAE level

After reading the methodology section of the paper, not only the used SAE level could be found, but also the simulator's immersion, configuration, software, hardware, experiment type, used interaction and environment. The method finding the other categories will be explained further.

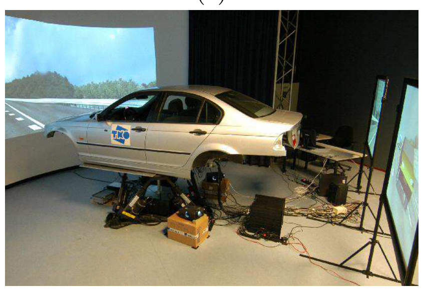
Most methodology sections explicitly mentioned their SAE level. In cases where this section didn't mention a SAE level, the SAE level was determined either by comparison if other well-known levels of automation were used (i.e., BASt and NHTSA; see Smith, 2013), or by carefully reading the description of the automation, and deciding which SAE level most closely resembled the description. For example, a paper by Hassoun and colleagues (1994) was published before a consensual definition of levels of vehicle automation existed, but based on the methodology within their paper, it could be determined that the level of automation they used in their experiment was similar to SAE level 2. The automation here controls the longitudinal and lateral dynamics, but the driver has to monitor the system and has to interfere if the automation fails. SAE level 0 was mentioned when the automation aids the driver and doesn't control the longitudinal or lateral dynamics. Also, level 0 papers were used for this systematic review, because its research in HMI could also be used for higher SAE levels. For example, in the paper of de Nijs (2011), haptic guidance is researched with a SAE level 0 automation. This interaction type could also be used for safe intervention during autonomous driving at SAE levels 1 to 3 (Brockmann, Allgaier, Timofeev, & Becker, 2016).

Immersion

The category immersion was divided by five types of immersion: Non-Immersive Virtual Reality (NIVR), Semi-Immersive Virtual Reality with a viewing angle less than 180 degrees (SIVR<180), Semi-Immersive Virtual Reality with a viewing angle between 180 and 360 degrees (SIVR>180), Total-Immersive Virtual Reality (TIVR) with a viewing angle of 360 degrees and real driving with real vehicles. A NIVR immersion is defined as in the article of Baus and Bouchard (2014), where an experiment contains a simulator with a single screen which simulates the driver's view, such as the one that can be seen in Figure 2a. A simulator with three screens or more which simulates the driver's view of the car was in this systematic review considered a simulator with SIVR immersion, such as the one that can be seen in Figure 2b & 2c. If a simulator contained 360 degree view by using a curved screen or VR glasses, it was in this systematic review considered to be a TIVR immersion, such as the one that can be seen in Figure 2d & 2e. Lastly, if an experiment was performed in a real car and not in a simulator, the experiment was considered to be a real driving (see e.g., Figure 2f).

(a)

(b)



(c)

(d)

(e)

(f)

Figure 2. (a) shows a NIVR (Holländer & Pfleging, 2018), (b) shows a SIVR<180 (Eom & Lee, 2015), (c) shows a SIVR>180 , (d & e) show a TIVR (Hock et al, 2016; "New driving simulator taken into operation in Sindelfingen: Investment in cutting-edge technologies," 2010) and (f) shows a real driving experiment (Farah & Koutsopoulos, 2012).

Configuration

The configuration category was divided by two types: a Fixed Base (FB) and a Moving Base (MB) configuration. A FB simulator configuration was defined as a static experimental setup (see Figure 3a & 3b) and a MB simulator configuration in this was defined as a dynamic experimental setup, where the simulator mimics natural dynamics (Denne, 2004). The advancement of a MB simulator's configuration is given with the Degrees of Freedom (DoF). DoF are a set of parameters that define the configuration of an object, such as a vehicle (Grodzinski

& M'Ewen, 1954). For example, a simulator that could singly or in any combination simulate a vehicle moving in three linear directions (e.g. moving in the X, Y and Z axis) and three angular directions (e.g. rotating around X, Y, Z axis) could simulate 6DoF (Stewart, 1965). The MB configuration was divided in 6 types: unknown number of DoF, 3DoF, 4DoF, 6DoF, 8DoF and 13DoF. The simulators from Figures 3c & 3d have for example a 6DoF configuration and the simulators from Figures 3e & 3f have for example an 8DoF- and 13DoF-configuration. The more DoF a MB configuration has, the higher the physical fidelity (Pool, 2012), and the higher behaviour-fidelity in participants, which is much more than at a FB configuration (Pool, 2012).

Fidelity

With the found immersion and configuration, a simulator's fidelity could be determined. Table 3 shows the fidelity of particular immersion and configuration, which is based on Wynne's (2019) rating table. However, Wynne's rating used five levels of immersion and different viewing angle steps. With these different immersion levels given, there are also different fidelity ratings. A FB simulator with a single screen smaller than 25 inch was rated in Wynne's system as a very low fidelity simulator, while this paper's system rated every simulator with a single screen as a very low fidelity simulator. Also, a FB simulator with a SIVR<180 immersion is rated as low fidelity; in Wynne's table, a screen bigger than 25 inch is classified as a low fidelity with the same FB configuration. Mid fidelity ratings were simular in both systems, only in this review a FB simulator with high immersion (i.e. SIVR>180 & TIVR) was also rated as a mid fidelity simulator. High fidelity rating were also similar, only in this systematic review simulators with more than 6DoF and low immersion (i.e. NIVR & SIVR<180) were also rated as a high fidelity simulator. Very high fidelity simulators were in both rating systems rated as simulator with more than 6DoF, only the viewing angle in both were different. In Wynne's rating system, a very high fidelity simulator had a viewing angle more than 270 degrees, instead of 180 degrees.

The higher the immersion, the higher the impact on the participants behaviour (Klüver, Herrigel, Heinrich, Schöner, & Hecht, 2016). The simulator's configuration has a bigger impact on participant's behaviour than the immersion, which is why any MB configuration has been categorized with at least a mid fidelity (Klüver et al., 2016).

Configuration		Immersion			
		NIVR	SIVR		TIVR
			<180	>180	
FB		v.low	low	mid	mid
MB	**3DoF**	mid	mid	high	high
	4DoF	mid	mid	high	high
	6DoF	high	high	v.high	v.high
	8DoF	high	high	v.high	v.high
	13DoF	high	high	v.high	v.high

Table 3. Configuration and immersion of simulators, and associated fidelity.

Experiment type

The experiment type was divided into four categories: Field Test (FT), Test Track Study (TTS), simulation experiment and Wizard of Oz (WoO) experiment. A FT and TTS are both only in real vehicles. However, the two types of experiment could be distinguished from each other through their location: the FT experiments are performed on public roads, while TTS experiments are performed on private circuits. A WoO experiment could be performed in the three previous experiment types. During a WoO experiment the participants think that the automation system is autonomous, but it's actually controlled by a unseen human operator (see Figure 4; Harwood, 2018).

Interaction

Used interaction was divided into five categories: visual, auditory, vibrotactile, haptic and other interactions. The interaction was found when it was explicitly mentioned in the methodology section, or if it was derived from the picture of the experimental setup, such as in Figure 6, which shows a visual interaction.

Environment

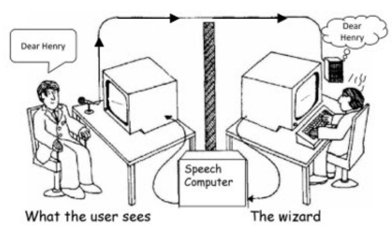
The environment was divided into six major categories: highway, rural, urban, track, public road (PR) and lane change (LC). In most studies the environment is specifically mentioned in the methodology section, while in some studies it had to be derived from the given figures in the methodology section. For example, Figure 6a-e show a highway, rural, urban, track and PR environment, respectively, when an experiment entailed a lane-changing scenario (e.g., to overtake other road users, or avoid a crash/critical situation), it was labeled as a LC (see e.g., Figure 6f).

Variables

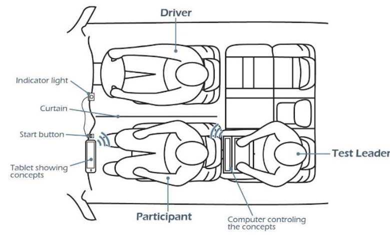
Reading both the results and methodology section gave the used variables, participants' data, objective and subjective metrics. Used variables were distinguished into five major variables, namely HMI types, Non Driving Tasks (NDT), automation, environment, participant type. The variables could be found by

(a) (b) (c) (d) (e) (f)

Figure 3. (a) & (b) show a FB configuration (Befelein et al., 2018; Damböck et al., 2011), (c) & (d) show a 6 DOF MB configuration (Forster et al., 2019; Nilsson et al., 2013), (e) shows a 8 DOF MB configuration (Sadeghian Borojeni et al., 2018) and (f) shows a 13 DOF MB configuration (National Advanced Driving Simulator Overview, 2010).

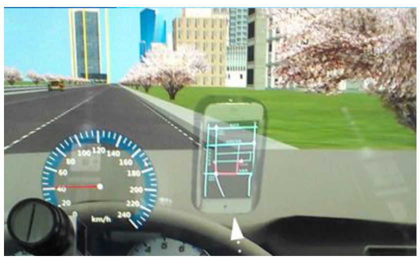


(a)



(b)

Figure 4. (a) shows a general WoO experimental setup (Harwood, 2018) and (b) shows a WoO setup in a TTS experimental setup (Ekman et al., 2016).



(a)

(b)

Figure 5. (a) & (b) show a setup with a visual interaction (Schartmüller et al., 2018; Wang et al., 2014).

reading the data from the result figures or reading the experiment design in the methodology section (see for example Figure 7). If a figure compares results with different type of HMI, such as comparing auditory signals of HMI (e.g., Fagerlönn, Lindberg, Sirkka, 2015), comparing visual signals (e.g., Dziennus, Kelsch, Schieben, 2016) or multiple modalities (e.g., Petermeijer, Doubek, de Winter, 2017), it is defined as a variable of HMI types. A figure that compares results with or without NDT, such as driving while reading a magazine and comparing the results without reading the magazine (Eriksson & Stanton, 2017), it is defined as NDT variable. Moreover, if a figure compares results different automation, such as driving manually and driving with level 3 automation (Vogelpohl et al., 2019), it is defined as an "automation" variable. Furthermore, a figure that compares results in different environments, such as different types of weather (Li, Blythe, Guo, & Namdeo, 2018) or traffic situations (Wulf, Zeeb, Rimini-Döring, Arnon, & Gauterin, 2013), it is defined as an "environment" variable. Lastly, if a figure compares results between different participants type, such as comparing young and old participants (Gold, Körber, Hohenberger, Lechner, & Bengler, 2015), it is defined as a "participant type" variable.

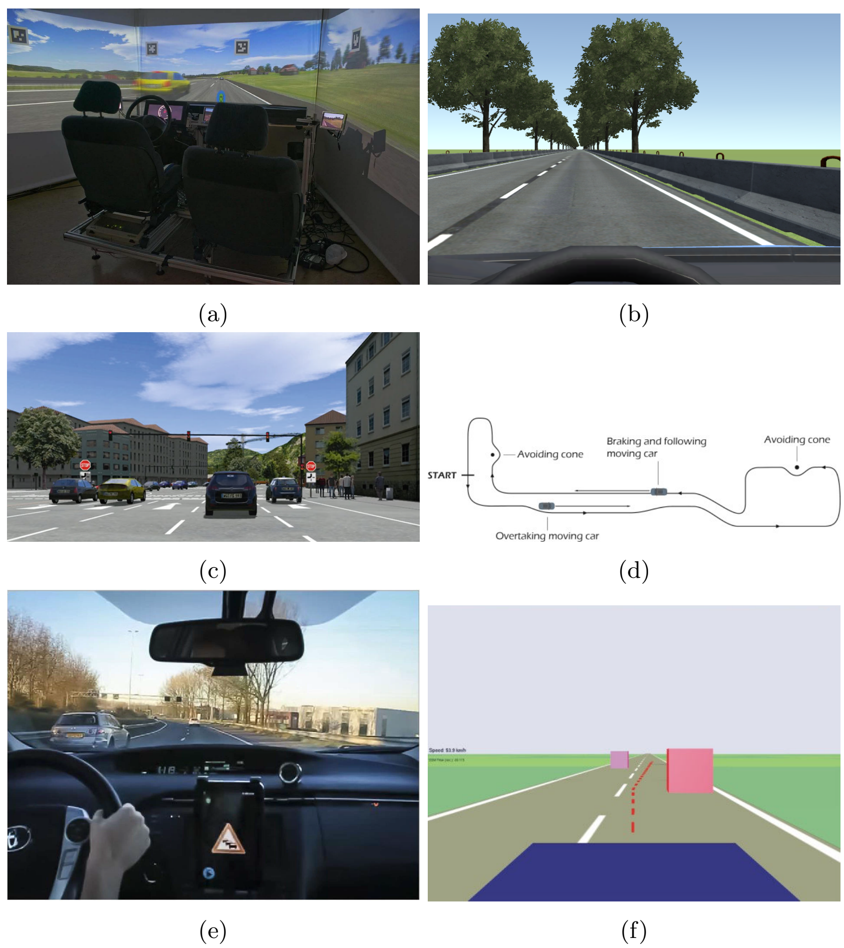


Figure 6. (a) shows a highway environment (Vogelpohl et al., 2019), (b) shows a rural environment (Faltaous et al., 2018), (c) shows a urban environment (Rittger & Götze, 2018), (d) shows a track environment, (e) a Public Road (PR) environment (Risto & Martens, 2013) and (f) shows a environment where the driver had to change lanes to avoid crashes with objects (Brandt et al., 2007)

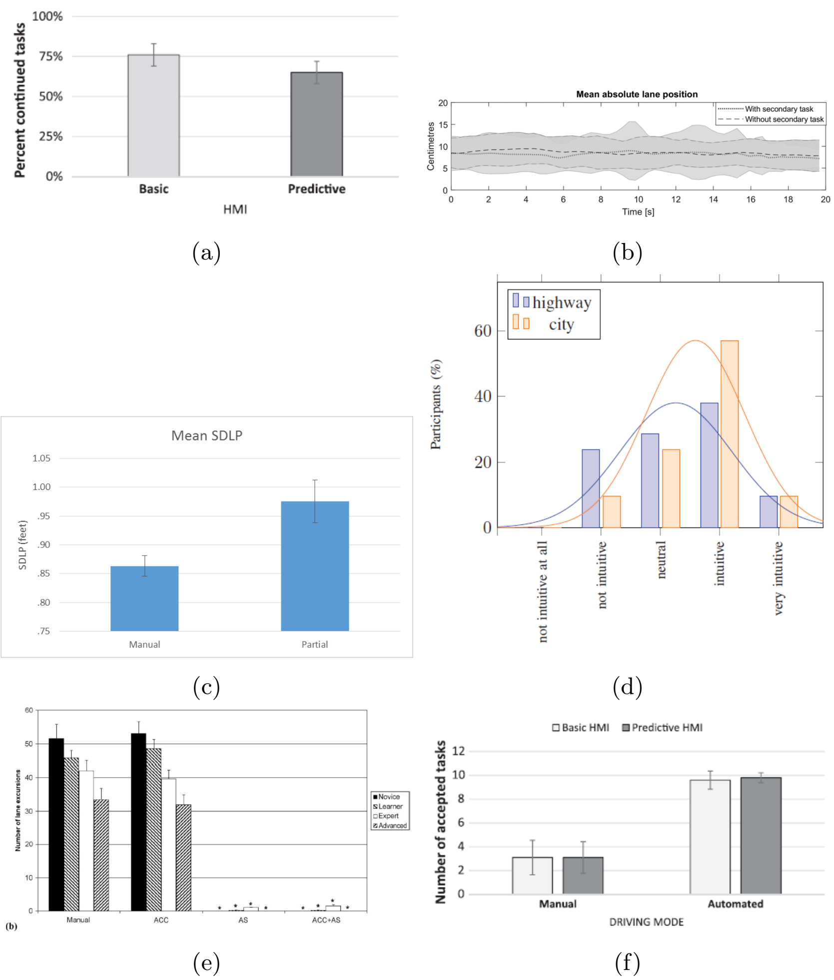


Figure 7. (a) & (b) show a figure where HMI types are used as a variable (Wandtner et al., 2018b), (c) shows a figure where Non Driving Tasks (NDT) are used as a variable (Eriksson & Stanton, 2017), (d) & (e) show a figure where automation is used as a variable (Large et al., 2017; Wandtner et al., 2018b), (f) shows a figure where environment was used as a variable (Gauerhof et al., 2015), (g) shows a figure where participants types where used as a variable (Young & Stanton, 2007)

Participant data
After reading approximately 20% of the 154 experimental papers, it was found that participant data could be distinguished in two common subcategories: amount and age. Both subcategories were also distinguished in three and four sets, respectively, the subcategory "amount" contained total, male and female sets: the total set shows the total amount of participant used for the study, while the male and female set shows how many male and female participants is used. Some studies only showed the amount of one type of sex used for the study. By subtracting the total amount of participants with the amount of the particular sex, like subtracting the total amount of participants with the amount of female participants (e.g., Sbîrcea, 2017), the amount of the other sex was found. Secondly, the subcategory age contained mean, standard deviation (SD), min and max sets. Some studies only show the mean age and SD of their participant groups. To calculate the overall mean age and SD, equations 1 & 2 were used, where N_x gives the size of the sample i, $\mu_{X\,i}$ gives the average of sample i and $\sigma_{X\,i}$ gives the SD of sample i.

$$\mu_X = \frac{\sum_i N_x \mu_{X\,i}}{\sum_i N_{xi}} \tag{1}$$

$$\sigma_X^2 = \sum_i {\sigma_X}_i^2 \tag{2}$$

Moreover, some studies do not mention the SD age of the participant (e.g., Guoe et al, 2019) or do not mention both the mean and SD age (e.g., Kuehn, Vogelpohl & Vollrath, 2017). To compare the age range between these studies, the participants, minimum and maximum age is also noted.

Objective metrics
From the methodology and result section the subjective and objective metrics are found. The objective metrics were distinguished in five most common major categories: Reaction Time (RT), Gaze behaviour (GB), Non Driving Task Performance (NDTP), longitudinal vehicle metrics, and lateral vehicle metrics. An experiment that measured RT related objective metrics, such as response time or task completion time, was also labeled as RT. If an experiment tracked eye movement, head movement, pupil dilation, blink rate or other gaze tracking methods, it was labeled as a GB experiment. An experiment that measured NDTP, such as performing tasks on a tablet (e.g., Sadeghian Borojeni et al., 2018), it was also labeled as a NDTP metric. The category longitudinal vehicle metrics had three major subcategories: headway, speed and acceleration. The subcategory headway contained metrics related to the distance between the front of the vehicle and oncoming traffic. Moreover, the subcategory speed contained everything related to longitudinal speed, such as maximal speed, speed violation or speed profile. Lastly, the subcategory acceleration contained everything related to longitudinal acceleration, such as maximal acceleration.

The category lateral vehicle metrics had two major subcategories: steering and lane keeping. Every metric that was related to steering, such as reversal rate, steering torque or force, were labeled as a steering metric. Every metric that was related to lane keeping, such as time to lane crossing, were labeled as a lane keeping metric.

Subjective metrics
The most common subjective metrics were distinguished in seven major categories: usefulness, trust, workload, comfort, acceptance, understandable, situation awareness. An experiment is labeled with one or more of these categories if it mentions it specifically. There are some exceptions. If the participant had to rate the ease of use, the experiment was labeled as usefulness. An experiment that contain participants that rated discomfort was labeled as an experiment that had a comfort metric. If participants had to rate mode awareness, the experiment was labeled as situation awareness.

The number of references was found by counting the references, if it was written in APA style. If papers numbered their references, the number of the last reference was used.

2.3.2 Categorizing patents

This systematic review categorized patents by publishing year, SAE level, International Patent Classification (IPC), and the total number of IPCs. The publishing year and SAE level were found by using the method described studies in Section 2.3.1. All patents are classified with an IPC system, which provides a hierarchical system for the classification of patents according to the different areas of technology (World Intellectual Property Organisation [WIPO], 2020). The IPCs are given on the site page of the patent, such as Google Patents.

2.3.3 Categorizing theoretical studies

To determine which categories are the most common in theoretical studies, 20% of the 65 of theoretical studies were read. After reading these studies, it was found that five categories were the most common in theoretical studies and it was considered that these five categories were also most common in the rest of the theoretical studies. The five categories are the publishing year, the country of the first author's office, SAE level, kind of theoretical paper, and number of references.

The year of publishing, country of the first author's office, SAE level, and number of references were found by using the method described in Section 2.3.1.

Five different kinds of theoretical papers have been found: summary, design, experiment concept, literature review and concept presentation. A paper was labeled as a summary, when a given paper summarized the current literature about HMI in automated driving (e.g., Meschtscherjakov, 2017). A paper got a design label, if it described a design, framework, or model about HMI in automated driving (e.g., Qin, Hao, Zhang, 2018). If a paper describes an experiment and it was intended to be tested on participants, but will be performed in the future, it was labeled as experiment concept (e.g., Son et al, 2018). Furthermore, a paper was labeled as a literature review, if it contained a literature review (e.g., Lu & de Winter, 2015). Lastly, if a paper describes a new concept for HMI in automated vehicles, but the concept will not be tested on participant or is already tested on participants, it was labeled as a concept presentation (e.g., Lee, Lee, Xie, 1999).

2.3.4 Categorizing model studies

Due to the low quantity of the model studies, all the model studies were read to determine the categories and the following six categories were found: publishing year, the country of the first author's office, SAE level, variables, metrics, and number of references. All the six categories were found with the same method described in Section 2.3.1. Variables and metrics had different subcategories in model studies. Variables had three major subcategories: automation, environment and model vs experiment. At the last variable, the models result data is compared with other experiment's result data (see Figure 8). Metrics had only three subcategories: longitudinal vehicle metrics, lateral vehicle metrics and yaw dynamics. Longitudinal and lateral metrics were determined through a similar methodology as described in Section 2.3.1, while yaw vehicle metrics contain everything related to yaw dynamics, such as yaw rate and heading error.

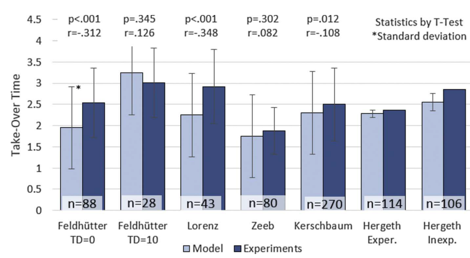


Figure 8. Comparison of the model's result data with result data from another experiment (Gold et al., 2018).

2.3.5 Categorizing survey studies

As with model studies, survey studies also had a low quantity of papers. These studies were also read fully and seven categories have been found: publishing year, the country of the first author's office, SAE level, variables, participant data, metrics and number of references. All categories and subcategories were found with the same method as described in Section 2.3.1 and in Section 2.3.3, where some sections in the paper were read.

2.3.6 Categorizing other studies

The other studies are categorized with five categories: publishing year, the country of the first author's office, SAE level, type of study and number of references. These categories were found with the same methodology as described in Section 2.3.1 & 2.3.3.

3 Results

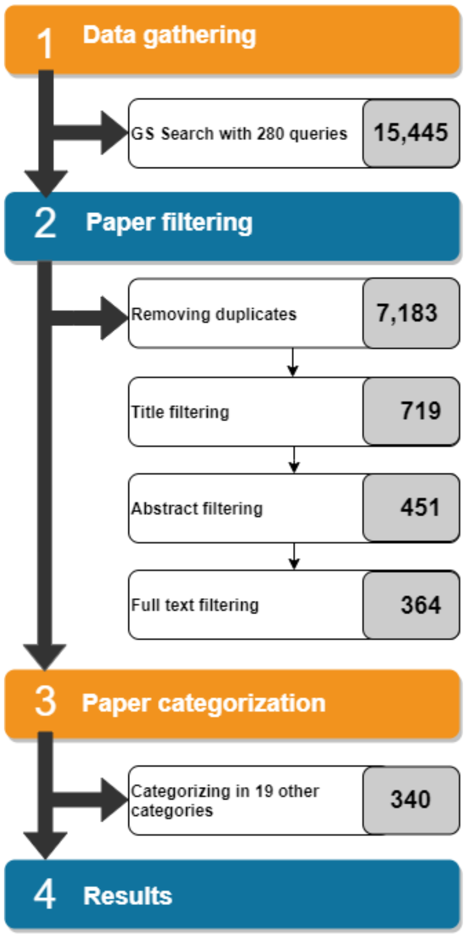


Figure 9. Visual representation of the amount of results

In the previous section the methodology of gathering results, paper filtering and paper categorization are described. The 280 queries provided a total of 15,455 results (Figure 9). The duplicates were removed and 7,183 unique results remained. After title filtering, 719 relevant results remained, which accounts for 10% of the unique results. Additionally, due to practical reasons, non-English papers were excluded from this research. In the next step, the abstracts of the remaining results were read, which gave 451 remaining papers. These remaining papers were fully read, and it was found that another 87 results deemed to be irrelevant. Eventually, 364 results, or, in other words, 5.1% of the unique results, were left for analysis. These 364 results were categorized in 5 major types of studies: experimental, patent, theoretical, model and survey.

After categorizing the 364 results, 340 results were used for this systematic review, as, after careful consideration, another 24 papers were deemed to be irrelevant. 75% of these irrelevant papers were a duplicate of another paper (e.g., Rau et al., 2015). Furthermore, 78% of duplicate papers originated from patents, because Google Scholar couldn't distinguish the publication date with the granted date; most of the times, the publication date was shown in GS, and therefore, the patent showing this was used for this systematic review. The other duplicates were caused by GS copying error in author's name(s) and errors in titles from different sources. Moreover, one paper got through the filtering process, but couldn't be analyzed due to inaccessibility (i.e., Marberger et al., 2017). This paper isn't used for this research. Lastly, 5 papers, or 1,4% of the total, were deemed irrelevant for this systematic review due to filtering mistakes.

With the gathered and analyzed data, the results will be presented in the upcoming sections. Figure 10a shows the publication rate, the number of papers that have been published each year. The first paper about HMI in automated driving was published in 1994. After 2001, a small amount of papers were published in each year, From the 2010s onward, more papers about HMI more published, possibly due to (among others) the legalization of field tests with self-driving vehicles, and the introduction of the six-level classification system of the SAE (Millikin, 2011; Lowensohn, 2014; SAE International, 2014). After 2013 there were more than 10 papers published each; thereafter, the amount of publications grew with an average of 59% each year. This growth stopped in 2017, where the amount of published papers exceeded 80 publications since then.

Figure 10b shows which type of study has been published each year. Between 1994 and 2003, theoretical studies were the most dominant, while between 2004 and 2011 none of the study types dominated. Between 2012 and 2014, experimental studies were the most common type of study. In 2015, the amount of published patents surpassed experimental studies with one published paper. The small gap between these studies lasted until 2016 and after 2017 experimental studies took the lead and published 350% and 36% more papers than patents.

In 2010 and 2012, the amount of experimental studies and patents published were growing each year. The amount of published patents declined in 2017 with 50%, (as can also seen in Figure 10a), while the amount of published papers about HMI was still growing in the same period. In 2018, the amount of experimental studies published declined with 24%, while the amount of published papers about HMI in automated driving in 2017 and 2018 were similar. Patents and model studies increased in the same period with 150% and 200%, respectively. The amount of theoretical studies, surveys and other studies didn't change in the same period. In the subsections 3.1 to 3.4, the results for each type of study will be presented.

Figure 10c shows the amount of papers for each SAE level per year. From 2004 to 2010 there was no clear dominating SAE level and after 2010 SAE level 0 was the leading SAE level and got more than 5 mentions in the papers. Three years later, all SAE levels were mentioned at least once, likely due to higher publication rate overall (as seen in Figure 10a). In 2014, levels 2 and 3 were more common in published studies, probably due to the rollout of the first vehicles with SAE level 2 (Lowensohn, 2014) and to the introduction of the SAE automation levels (SAE International, 2014). After that year car, companies rolled out vehicles with level 2 (Hyat & Paukert, 2018; Vincent, 2018). Around 2016, major car companies announced researching level 3 & 4 automation and invested in developing the technology (Faggella, 2020). After 2017, SAE level 3 was the most mentioned in papers and level 0 the second. In 2018, the mentioning of SAE levels 1, 3, 4 & 5 were grew with 63, 30, 33 & 31%, respectively, while, according to Figure 10a, the total amount of published papers about HMI in automated driving were nearly constant. Other SAE levels such as 0 & 2 declined with 14 and 20% in the same period.

As seen in Table 2, patents were not being categorized by their publishing country. The remaining 248 papers (340-92 (see Section 3.2)), or 74% of all the papers, were found to originate from 24 different countries. Figure 10d shows the top 5 of the most publishing countries who, combined, accounted for 74% of the total amount of publications. Germany published the most papers with 39% of the total, while USA and UK followed with 13 and 8.8%, respectively. Figure 10e presents the publication rate of the top 5 most publishing countries and the "Other countries", which are group of non-top5 countries, and shows that the amount of papers published by Germany and the grouped "Other countries" have been growing since 2010. The grouped "other countries" published at its peak 19 papers, where China published 21%, South Korea and Japan 16% and Austria 11% of these 19 papers. Another seven countries published one paper that year. In 2018 the amount of published papers by USA and UK dropped. This may be due to a fatal crash between a pedestrian and a self-driving car in the US, after which some companies decreased (Wakabayashi & Conger, 2018) or even suspended (Perry, 2018) the amount of field tests.

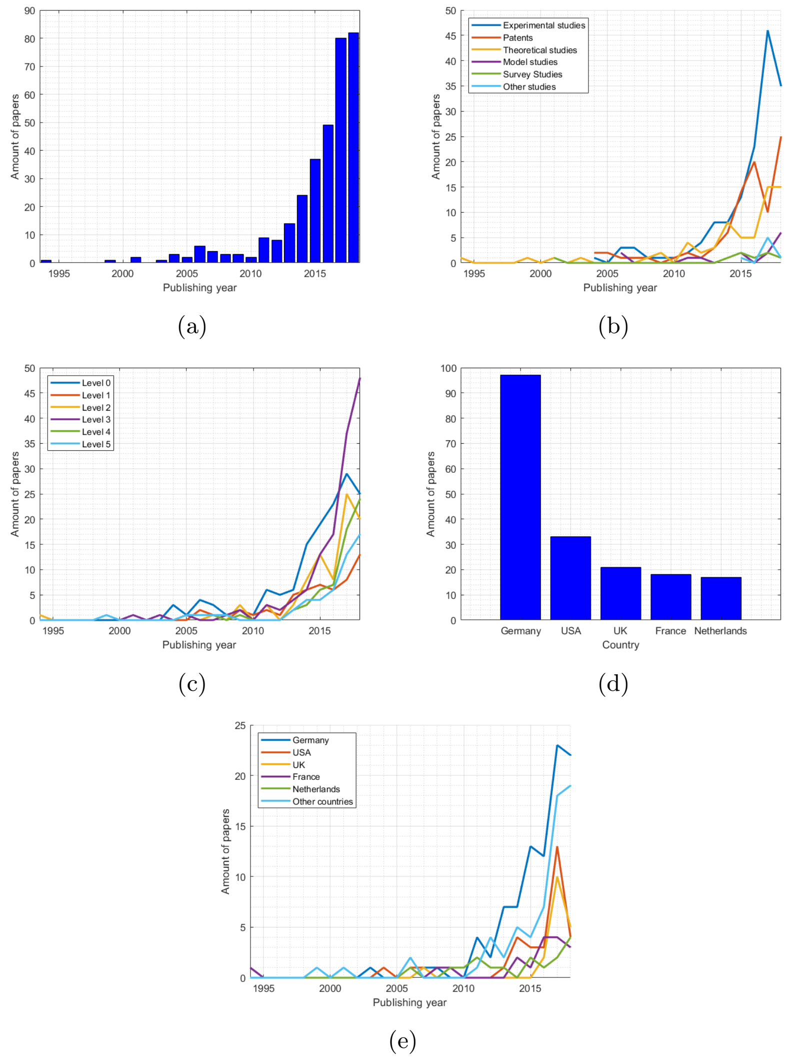
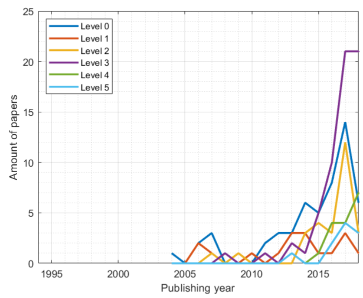
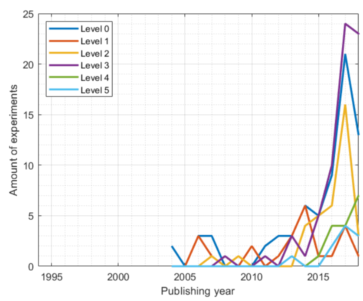


Figure 10. (a) publication rate, the amount of papers published each year. (b) amount of papers published for each type of study, (c) amount of papers that represent a SAE level, (d) shows top 5 of most publishing countries and (e) publication rate of the 5 most publishing countries.

3.1 Experimental studies



(a)



(b)

Figure 11. (a) amount of experimental studies and (b) amount of experiments in experimental studies that mentioned a SAE level

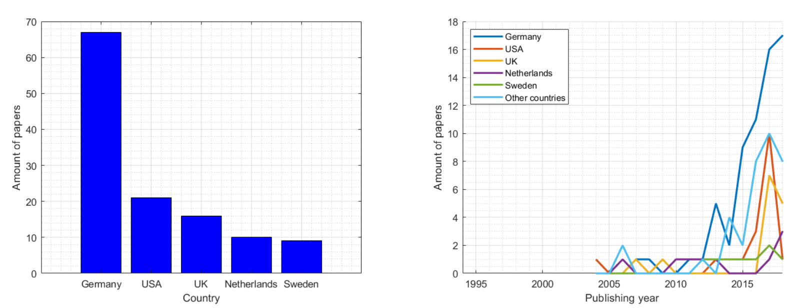
During paper categorization, five types of papers have been found, the most common paper type being experimental studies. These 154 experimental studies have been analyzed and described 193 experiments. Figure 11a shows the corresponding SAE level(s) of each paper. The first experimental study was published in 2004 by Griffiths and Gillespie on the topic of shared control between human and automation. This SAE level 0 study contained one experiment and was published in USA. After the first published experiment, there wasn't a clear dominating SAE level in experimental papers. After 2011, level 0-experiments were leading in experimental papers as the most mentioned SAE level. In 2013 and 2015 level 0-studies were with SAE level 1 and 3 to most common SAE level in experimental studies. After 2016, level 3-studies were more common, level 0-studies were the second common till 2018, where level 4-studies were the second most published studies. In the same period, nearly all SAE levels got similar growth in the same period as seen in Figure 10b. Between 2017 and 2018 mentioning of SAE levels 0, 1, 2 & 5 declined with 57, 200, 75 & 25%, respectively, while level 3 stayed the same and level 4 and increased with 70%. A similar decline is also seen in Figure 10b, which shows a decline of published experimental papers with 24%. In 2018, there were 21 level 3-experimental studies published and was with 51% the most mentioned.

Figure 11b shows the corresponding SAE level(s) of each experiment. This Figure has similar trends as Figure 11a. Level 0 was in 2011 the most mentioned SAE level, although in 2013 and 2014 level 1 was equally often mentioned. In 2015, level 0 & 3 were both the most common SAE level. In 2016, level 3 surpassed level 0 with the amount of mentions and is leading experiments since then. In short, since 2015, level 3 experiments were most prevalent. The trends as seen in Figure 11a is also seen in Figure 11a. In fact, the gap between level 3 & 0, which are the first & second most common levels, is much smaller in experiments. For example, in 2017 both levels peaked in mentions, level 0 was with 33% less mentioned in papers than level 3. In experiments the same level was with 13% less mentioned than level 3. Between 2017 and 2018 both Figures showed a decline in most SAE level mentions and a growth with level 4. However, Figure 11b also shows a decline in level 3 mentions.

Tables 18 to 22 in Appendix B1 show all 154 experimental studies with their performed experiments in alphabetical order.

3.1.1 Countries

In the previous section, the SAE levels from experimental studies were discussed; in this section the countries of the first author's office will be discussed. Figure 12a shows the top 5 most publishing countries out of the 19 unique countries that published experimental studies. The top 5 countries published 82% of total amount of experiments. Germany published 44% of total amount of experimental studies, USA 18, UK 9, Sweden 6 and Netherlands 6%. Figure 12b shows the publication rate of the top 5 countries and the "Other countries", which are the grouped non-top5 countries. In 2015, Germany was the first country that published more than five experiments and published more experiments after that year. The grouped "Other countries" passed this line after 2016 and USA & UK passed this line a year later. In 2018, UK, USA & Other countries dropped the amount of published experiments with 20, 90 & 29%, respectively. This similar drop has been seen in the previous Figures 10b, 11 & 12b. In contrast, Germany and the Netherlands saw a increase in their amount of published experiments in the same year with 6 and 200%. As told in the previous section, the 90% drop in US published experiments could be caused by the fatal crash between a pedestrian and a self driving car, some companies decreased (Wakabayashi & Conger, 2018) or even suspended (Perry, 2018) the amount of field tests after that.



(a) (b)

Figure 12. (a) top 5 most publishing countries and (b) the top 5 countries' publication rate and the other countries

Figure 13 shows the used SAE level of the top 5 most publishing countries and the grouped non-top5 "Other countries". The majority of Germany's ex-

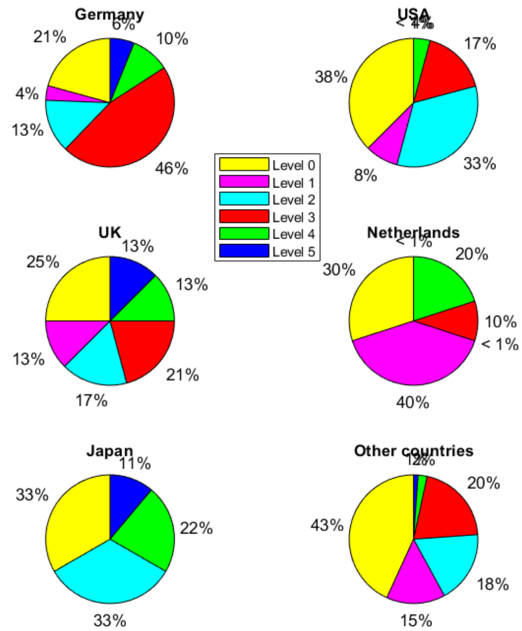


Figure 13. The SAE levels of the top 5 most publishing countries & the other non-top5 countries

periments are related to level 3 or higher, while the majority of the experiments published from USA, Netherlands, Japan & "other countries" contain SAE level 2 or lower. The UK has a nearly a equal split in higher (levels 3, 4 & 5) and lower (levels 0, 1 & 2) SAE levels. German, American, Dutch, Japanese and other countries' experiments had at least 1 SAE level that stands out. For example, a big fraction of American, Dutch, Japanese and other countries' experiments mentioned the SAE level 0. Level 1 experiments also had a huge fraction in Dutch experiments. Similarly, level 2 experiments were also common in Japanese and American experiment.

3.1.2 Fidelity

While analyzing 193 experiments, 141 immersions and 140 configurations of the used simulator have been found. There are five experiments found with a Moving Base (MB) configuration that contained an unknown number of DoF; these experiments are not used for further analysis. Moreover, there are six experiments found where the immersion is not given and there are another five experiments where the configuration is not given. With the found immersion & configuration, 132 fidelities according to the rating system of Table 3. Table 4 shows the amount of experiments with their associated immersion and configuration. It could be found that a FB configuration is with 70 % the most used configuration and 6DoF MB configuration the second with 23%. SIVR>180 was with 46% the most used immersion and SIVR<180 the second with 29%.

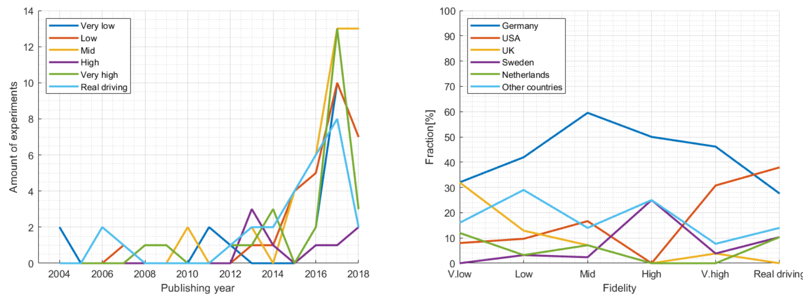
Configuration		**Immersion**			
		NIVR	**SIVR**		**TIVR**
			<180	**>180**	
FB		25	31	37	3
MB	**3DoF**	0	1	0	0
	4DoF	0	1	0	0
	6DoF	3	4	22	1
	8DoF	0	1	2	0
	13DoF	0	0	0	1

Table 4. The amount of experiments found associated with their configuration and immersion

Figure 14a shows experiments' publication rate categorized in fidelity (see Table 3). After 2015, all fidelity and real driving experiments grew in popularity. The same trend is also been seen in Figure 10a & 10b. In 2017, very low and very high fidelity experiments were published in more than 10 experiments, while in previous years it was less than 3 publications. While according to Figure 10a, in 2017 & 2018, the amount of published papers was constant, the amount of published experiments real driving and fidelity experiments decreased (except for high and mid fidelity) in the same period.

Figure 14b shows the presence of the most publishing countries in simulators fidelity. UK published the most experiments in very low fidelity studies, while its presence in higher fidelity experiment declined after every level of fidelity. USA published a low amount of experiments with lower fidelity simulators and no experiments in a high and very high fidelity simulator. However, USA published the most experiments where the participants had to drive in real vehicles. Table 5 & 6 show the experiments categorized in fidelity and real driving. It could be found that experiments in mid-fidelity simulators were with 32% the most used and high fidelity simulators with 6.1% the least. SAE level 0 was popular in the real driving experiments and in very low & low fidelity experiments. Level 3 was more popular from mid to very high fidelity experiments. The haptic interaction was relatively most common in high fidelity experiments.

Figure 15a shows the amount of participants vs the mean age in the experiments. The median age and amount increases in each level of fidelity. It is also seen that 69% of the very low fidelity experiments had a number of participants and mean age between 0 & 30, at other fidelities the percentage is around 40%, and at real driving experiments the percentage is at 6.3%. Additionally, it is also seen that at nearly each higher level of fidelity the amount of participant and the the average age of the participant increases. The participants of real driving experiments (M=36.8, SD=6.438) were, according to a one tailed t-test, signif-



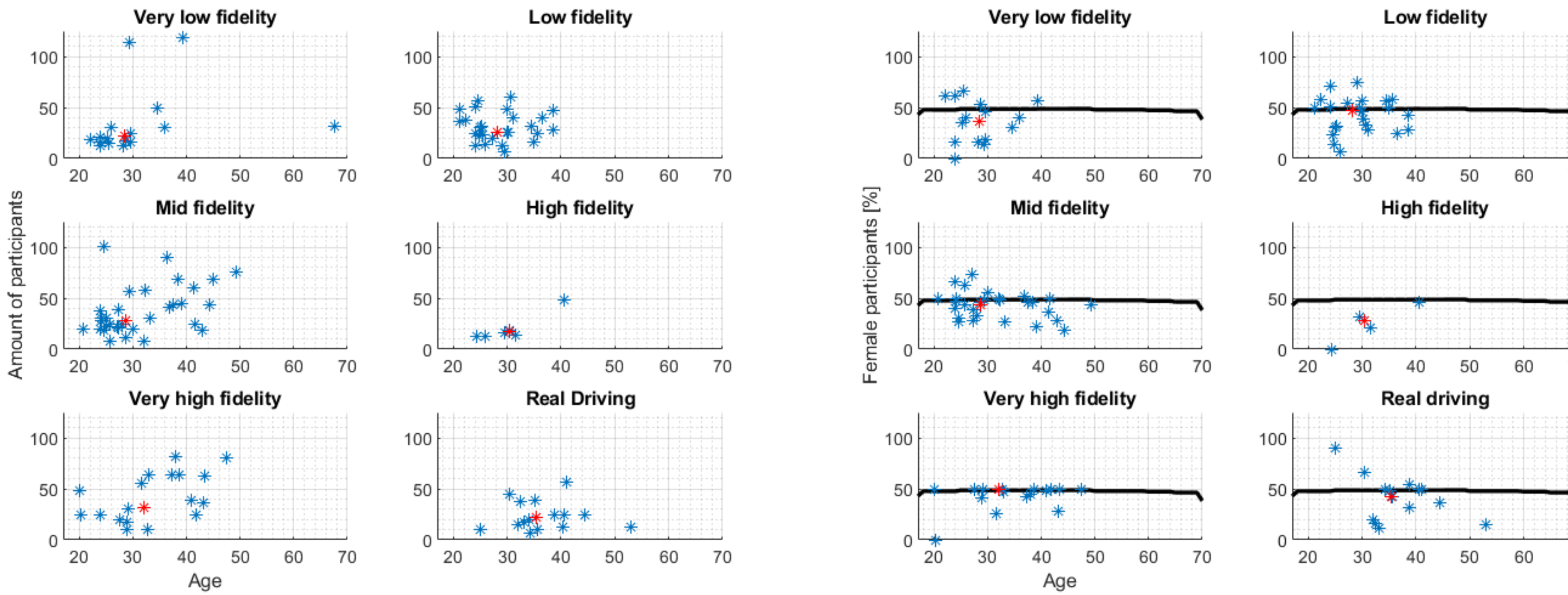
(a)

(b)

Figure 14. (a) shows the publication rate of various fidelity experiment and (b) shows the presence of the most publishing countries in fidelity experiment.

icantly older than other simulator experiments (M=31.0, SD=7.701), t(117)=-2.8, p=0.0026. Furthermore, real driving experiments (M=22.6, SD=14.0) had significantly less participants per experiment than other simulator experiments (M=34.7, SD=27.0), t(156)=2.3, p=0.011.

Figure 15b shows the percentage female participant vs the age in the experiments. The black line represents the percentage of female license holders in the Netherlands (CBS, 2019a, 2019b). Low fidelity experiments (M=41.6, SD=18.2) had significantly the same percentage female participants as the average percentage % female citizens (between 20-70 years, M=48) with a driver license, t(26)=-1.8, p=0.080. Very high fidelity experiments had, with 59%, the most experiments, which were within the 2.5% range of the black line. Around 25% of the other fidelities, such as low & mid, and real driving had experiments within the same range. Furthermore, between 17 and 29% of the mid, high very high fidelity and real driving studies had participants between 40-50 years old, which is the median age of the Dutch driver license holder (CBS, 2019a, 2019b). Lastly, there are 8 experiments (4.1% of the total) in mid fidelity(2), very high fidelity(4) and real driving experiments(2), which contain participants corresponding with the median age and average percentage female sex of the Dutch drivers.



(a) (b)

Figure 15. (a) the amount of participant vs the mean age of the participants (b) the percentage of female participant vs the mean age of the participants of every experiment categorized in fidelity levels and real driving. The red * represents the median value

Fidelity	#	SAE level						Country						Interaction				
		0	1	2	3	4	5	DE	US	GB	SW	NL	Other	Visual	Auditory	Vibrotactile	Haptic	Other
Very low	25	44	12	32	36	12	12	32	8.0	32	0	12	16	60	20	0	20	0
Low	31	39	13	13	29	19	3.2	42	9.6	13	3.2	3.2	29	71	32	13	3.2	0
Mid	42	26	4.8	9.5	57	9.5	4.8	60	17	7.1	2.3	7.1	14	81	45	21	9.5	2.4
High	8	38	25	0	38	0	0	50	0	0	25	0	25	38	25	0	50	0
Very high	26	42	19	31	46	3.8	0	46	31	3.8	3.8	0	7.7	69	50	0	31	0
Real driving	29	41	10	34	17	0	3.4	28	38	0	10	10	14	66	24	10	24	6.9

Table 5. The amount of experiments, the used SAE levels, the publishing countries and the type of interaction used in the experiments, categorized in terms of fidelity. The amount is given in numbers and the rest of the columns are given in percentages. The biggest value in the row is highlighted in green and the smallest in red

Fidelity	Variables						Participant					
	HMI types	NDT	Automation	Environment	Participant type	Other	#	Mean	SD	Min	Max	Female participant [%]
Very low	48	8.0	24	12	8.0	12	897	30.8	6.82	22.5	50.8	35
Low	58	6.5	19	19	9.7	6.5	870	28.6	6.40	20.2	45.2	41
Mid	62	14	12	19	4.8	7.1	1573	31.4	6.85	19.8	56.6	41
High	88	0	25	13	0	25	225	31.8	7.49	23.4	46.8	25
Very high	58	19	46	7.7	0	3.8	948	33.3	8.41	20.6	58.9	40
Real Driving	45	0	24	10	10	3.4	632	36.8	10.4	21.8	54.2	38

Table 6. Used variables and the participant data in the experiments, categorized in fidelity. The data from the used variables are given in percentages and the participant data are given in sums and averages. In other words, the number of participants are given in the amount of participant used for a specific fidelity and the mean age gives the mean age of the participant of a specific fidelity. The biggest value in the rows of used variables are given with green and the smallest in red

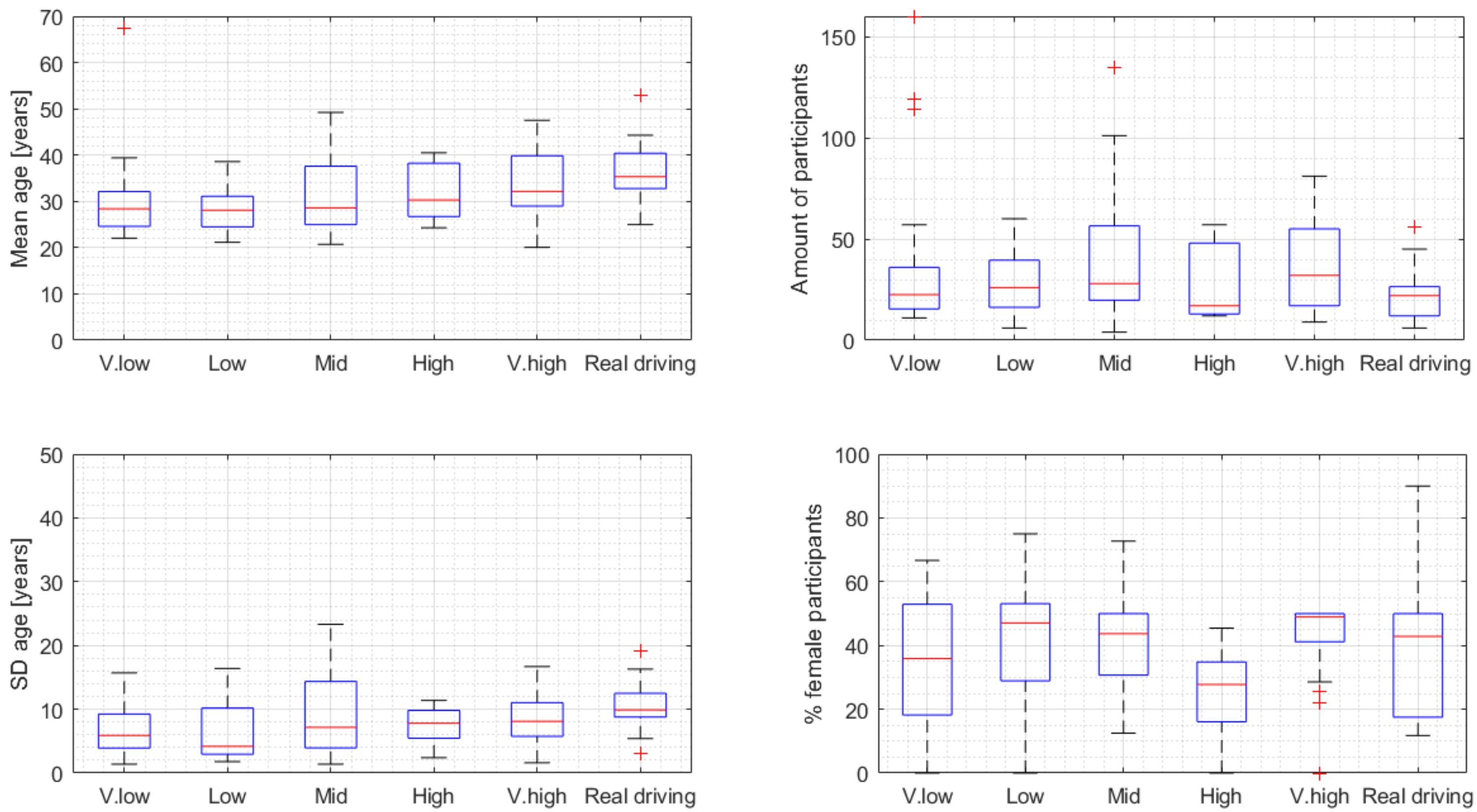


Figure 16. Participant's mean age, amount, standard deviation of age and female percentage of all the fidelity experiments.

Figure 16, show four boxplots which contain participant's mean age, amounts of participants, participant's standard deviation in age, and the percentage of female participant,s and are separated in fidelity and real driving. Note that some experiments does not give the participant's mean age, amount of participants, participant's standard deviation age and the percentage of female participants, which is why these undefined values are not used in this boxplot. The amount of undefined values was 13-44%, 0-4%, 13-48%, and 13-38% for the mean age boxplot (top left), participant amount boxplot (top right), standard deviation boxplot (bottom left), and female participant boxplot (bottom right) boxplots, respectively. More than 25% of the experiments contained undefined values in the mean, SD and female participant boxplot.

According to Figure 16, a simulator with a higher level of fidelity had a higher median amount of participants. At real driving experiment, the median amount of participant per experiment was compared to other experiment, the least, and the IQR was also the smallest.

Moreover, the higher the fidelity of a simulator the higher, the higher the mean and standard deviation age of the participants. At real driving, the the mean age and standard deviation age was found to be the largest.

Furthermore, the higher the simulator's fidelity, the higher the percentage of female participants. Three quarters of the very high fidelity experiments even had more than 40% female participants and even 50% of the experiments had even more than 49% female participants. Half of the real driving experiments had more than 40% female participants.

3.1.3 Metric

Table 7 show the popularity of objective metrics in specific SAE levels, fidelities and interaction. It is seen that objective metrics which are related to on human drivers, such as Reaction Time (RT) and vehicle control (i.e. Vehicle metrics), are more common at SAE levels were the human driver sits behind a steering wheel (i.e, levels 0 to 3). The longitudinal metrics, Headway and Speed, were the most common at levels 0 and 1. At level 0, these metrics are used to research the effect of driving aids (e.g., Farah & Koutsopoulos, 2012) and at level 1 these metrics are used to test the effect of the automation that controls the longitudinal dynamics, such as adaptive cruise control (e.g., Feenstra & van der Horst, 2006). Furthermore, gaze behaviour (GB) was the second most common objective metric in SAE levels 2 and 3. At these levels, the monitoring performance during driving and during a take over request is researched (e.g., Feldhütter, Hrtwig, Kurpiers, Hernandez & Bengler, 2019). Lastly, Non Driving Task Performance (NDTP) was the most common objective metric at level 2 experiments. At this level the effect of non driving task on driving performance and monitoring task are researched (e.g., Large et al., 2017).

Looking at the fidelity's metrics, it is found that more than 30% of the very low fidelity and real driving experiments had both the GB as the most used objective metric, while it is less used in the higher fidelity experiments. Moreover, very low, high, very high fidelity and real driving experiments had lane keeping

(LK) as a metric. In the same table it could also be found that 42% of the experiments containing haptic interactions also used LK as a metric (cf. Table 5). Low fidelity experiments also uses LK metric for their research, but used haptic interactions the least. This metric may be used in other interactions, such as visual and auditory. Thus, haptic experiments used LK metric to research its performance, but if LK metric is used it doesn't mean the experiment contains haptic interactions. Furthermore, it could be found that more than 50% of the mid and very high fidelity experiments had RT as an objective metric. In the same table, it could be found RT is with 59% the most common metric in SAE level 3 experiments, which are with more than 45% performed in mid to very high fidelity experiments (see Table 5). At these experiments, the RT of the participants are researched during a take over request (e.g., Feldhütter, Gold, Schneider & Bengler, 2017). The RT metric was also common at visual, auditory and vibrotactile interaction due researching warning signals (e.g., Petermeijer, Doubek, de Winter, 2017). Lastly, the NDTP metric is one of the least used metric in real driving experiments, probably due to placing participant into dangerous driving conditions (de Winter, van Leeuwen, & Happee, 2012). At simulators, this metric is more common. However, by performing a wizard of oz type of experiment, it's possible to perform real driving experiments, without placing the participants in dangerous driving conditions (e.g., van Veen, Karjanto, Terken, 2017).

Table 8 shows the popularity of subjective metrics in specific SAE levels, fidelities and interaction. It is found that workload, with more than 20%, is often used as a subjective metric. It is also found that the subjective metrics usefullness, trust, comfort & situation awareness are more used at higher SAE levels (i.e., levels 4 & 5) where it is not expected that the participant has to drive the vehicle.

Looking at the fidelity's metrics it could be seen that usefulness and workload are much less used in high and very high fidelity experiments. The comfort subjective metric was much less used in very low and very high fidelity experiments. Trust was also much less used in high and very high fidelity experiments, but it was used in more than 30% of the low fidelity and real driving experiments. Moreover, the acceptance metric was much less used in very low experiments, but most used in very high fidelity experiments. Furthermore, the metric understandable is much less used in very low, mid and very high fidelity experiments. Lastly, the metric situation awareness was the least used in nearly any fidelity, very low and mid fidelity experiments are exceptions.

Looking at interaction metrics it is seen that workload is most used as a subjective metric at haptic interactions, while trust, comfort, understandable and situation awareness was used less than 10% in haptic interaction experiments. Moreover, the comfort metric is used the most at vibrotactile experiments, while acceptance was never used as a metric at vibrotactile experiments. At this interaction, the participant evaluated the effect of using this interaction. Situation awareness is the least used in nearly all interactions, except at the vibrotactile interaction where 16% of the experiments used it as a metric (e.g., Petermeijer, 2017).

		#	RT	GB	NDTP	Vehicle metrics							
						Longitudinal				Lateral			Other
						Headway	Speed	Acceleration	Other longitudinal metrics	Steer	Lane Keeping	Other lateral metrics	
SAE level	**0**	73	33	15	12	9.6	21	5.5	8.2	14	26	5.5	5.5
	1	25	36	16	8.0	28	20	8.0	8.0	8.0	8.0	0	8.0
	2	39	46	33	18	7.7	5.1	0	7.7	13	26	2.6	10
	3	69	59	28	8.7	7.2	8.7	7.2	4.3	10	17	12	2.9
	4	18	28	11	11	0	0	11	0	0	0	0	5.6
	5	10	0	10	10	0	0	0	0	0	0	0	0
Fidelity	V. low	25	32	32	16	12	16	0.0	0.0	4.0	32	12	4.0
	Low	31	35	16	6.5	6.5	13	0.0	9.7	9.7	23	6.5	3.2
	Mid	42	52	21	2.4	7.1	14	0.0	0.0	9.5	7.1	4.8	2.4
	High	8	25	0.0	13	13	13	0.0	0.0	13	63	13	13
	V. high	26	58	15	23	7.7	7.7	7.7	15	7.7	23	3.8	12
Real driving		29	34	31	3.4	3.4	14	6.9	6.9	10	14	3.4	0.0
Interaction	**Visual**	131	49	21	11	7.6	11	6.1	3.8	9.9	18	6.1	3.8
	Auditory	65	68	23	9.2	11	9.2	7.7	9.2	12	20	7.7	6.1
	Haptic	36	36	11	2.8	2.8	14	8.3	11	19	42	17	5.6
	Vibrotactile	19	53	21	0	0	11	0	5.3	5.3	5.3	0	0

Table 7. The percentage of experiments that used an specific objective metric. The columns show the various objective metric and the row distinguish each other from SAE levels, fidelities and interaction. The amount of mentions (#), is given in numbers and the rest of the columns are given in percentages. The biggest value in the row is highlighted in green and the smallest in red

		#	Usefullness	Trust	Workload	Comfort	Acceptance	Understandable	Situation awareness
SAE level	0	73	19	11	25	5.5	8.2	4.1	4.1
	1	25	20	24	24	8.0	20	12	0.0
	2	39	18	23	15	7.7	15	2.6	10
	3	69	26	22	20	8.7	12	7.2	12
	4	18	44	44	28	22	17	5.6	22
	5	10	30	70	20	30	20	20	30
Fidelity	V. low	25	24	16	28	8.0	8.0	8.0	12
	Low	31	39	39	23	9.7	9.7	16	6.5
	Mid	42	21	24	26	9.5	9.5	4.8	16.7
	High	8	0.0	0.0	25	13	13	13	0.0
	V. high	26	15	7.7	15	3.8	23	3.8	3.8
Real driving		29	10	31	10	10	14	6.9	3.4
Interaction	Visual	131	26	24	21	9.9	12	9.2	7.6
	Auditory	65	22	23	20	4.6	14	6.2	6.2
	Haptic	36	11	5.6	28	5.6	11	0.0	0.0
	Vibrotactile	19	32	11	21	11	0.0	5.3	16

Table 8. This table shows the percentage of experiments that used an specific objective metric. The columns show the various subjective and the row distinguish each other from SAE levels, fidelities and interaction. The amount of mentions (#) is given in numbers and the rest of the columns are given in percentages. The biggest value in the row is highlighted in green and the smallest in red

3.2 Patents

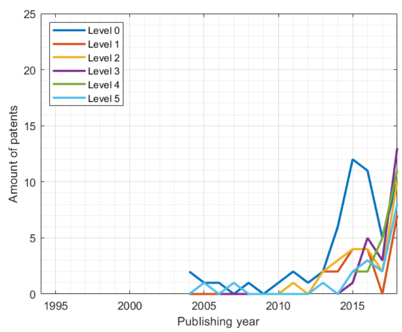


Figure 17. The amount of patents that mentioned a SAE level of automation. Note: Some studies mentioned more than one level of automation

After reading patents it was found out there were still some duplicates in the results. GS sometimes gives two publication dates: the date when the patent is filed but not granted and the date after the application is granted. The oldest date, i.e. the filing date without the patent being granted, was used for this systematic review, because it was also the most used by GS. After removing 14 duplicates, there were 92 patents left to analyze. A Table from Appendix C1 shows all 92 patents on alphabetical order.

The first patent, about HMI in automated driving, was published in 2004 by Miller & Tascillo and was about a blind spot warning system for a vehicle. Remarkably, between 2014 and 2017 the gap between the most mentioned level and the second most mentioned was much bigger than in 2018. Since 2014 SAE level 0 got more than 5 mentions and between 2014 and 2016 it was 100% to 200% more mentioned than the second most popular levels, which were level 2 in 2014 & 2015 and level 3 in 2016. In 2017, nearly all levels dipped in the amount of mentions with 33% & 100%. only level 4 got with 150% more mentioned. A year later, level 3 took the lead or 18% more mentioned with level 4, which was got the second place. Levels 0 and 2 share the third place, which were nearly as much mentioned as level 4. In short, between 2014 and 2017 level 0 was clearly the most popular SAE level, but in 2018 level 3 took the lead and was closely the most popular SAE level. This may be due to the interest shift of inventors, between 2014 and 2017 inventors were most interested in level 0 and in 2018 level 3 & other levels. Moreover, in 2018 all levels of automation had a growth between 83% and 700% compared to the previous year.

All patents are classified with the International Patent Classification (IPC) system. A total of 555 different IPCs have been found. 59% of the IPCs are mentioned once in patents, 19% of the IPC are mentioned twice and 8% of the IPC are mention thrice. Table 9 shows the used IPC groups and subgroups used in patents. IPC group B, which describes according to Espacenet.com performing operations and transporting, is with 64% the most mentioned IPC group. IPC group G, which describes physics, is with 28% the second most mentioned IPC group. IPC group H, which describes electricity, is with 2,2% the third most mentioned IPC group. Moreover, in the same Table it is also seen that 62% of the IPC descibes vehicles. The other 38% describes other things than cars such us controlling computing, signaling etc. Table 10 shows all the IPCs that get mentioned by more than 10 patents. 9 of these IPCs are in the B60 subgroup, which describes vehicles in general. The other 2 IPCs are in the G05 subgroup, which describes controlling and regulating. The IPC B60W50/14 was the most mentioned IPC with 30% of the patents, the second most mentioned IPC is B60W2050/146 which got mentioned in 24% of the patents and the third most mentioned IPC is B60K35/00 which was mentioned with 23% of the patents.

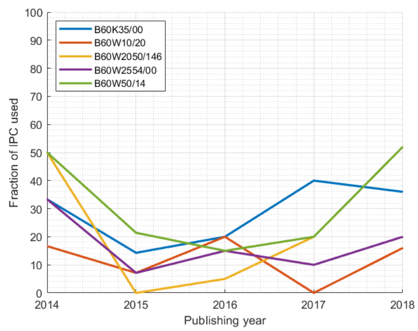


Figure 18. The top 5 most mentioned IPC in % per year

Figure 18 shows the fraction rate of the top 5 IPC mentioned by patents. The IPCs B60W2050/146 and B60W50/14 represents the yellow and green curves. Both curves have a U shape. In 2014 and 2018 both IPCs were with 50% the most mentioned in patents. In 2015 B60W2050/146 (yellow) was the least mentioned with 0% and in 2016 B60W50/14 (green) was the least mentioned with 15%. In 2014 the IPCs B60K35/00 (blue) and B60W2554/00 (purple) had the same amount of mentions. 5 years later, B60K35/00 (blue) got 80% more mentioned than B60W2554/00 (purple).

Figure 19 shows the SAE levels of the top 5 IPCs. Low SAE levels (i.e. levels 0, 1 & 2) were mentioned around 60% in patents with the IPCs B60W50/14 and B60W2050/146 (top left & right). High SAE levels (i.e. levels 3, 4 & 5) were also mentioned around 60% with the IPC B60W10/20 (middle right). IPCs B60K35/00 (middle left) and B60W2554/00 (bottom left) mentioned low and high SAE levels around 50%.

IPC	Description	Total
A61	Medical or veterinary science; hygiene	11
B60	Vehicles in general	745
B62	Land vehicles for travelling otherwise than on rails	28
B66	Hoisting; lifting; hauling	1
E04	Building	1
G01	Measuring; testing	56
G02	Optics	28
G05	Controlling; regulating	43
G06	Computing; calculating; counting	96
G07	Checking-devices	3
G08	Signalling	83
G09	Education; cryptography; display; advertising; seals	25
G10	Musical instruments; acoustics	2
H01	Basic electric elements	6
H04	Electric communication technique	17
H05	Electric techniques not otherwise provided for	4
Y02	Technologies or applications for mitigation or adaptation against climate change	7
Y10	Technical subjects covered by former uspc	1
Total		**1204**

Table 9. This Table shows which International Patent Classification (IPC) groups and subgroups are used in patents. It also shows what the IPC subgroups stands for and how often in got mentioned. The description is found on Espacenet.com

IPC	Description	Total
B60K35/00	Arrangement of adaptations of instruments	21
B60W10/18	Conjoint control of vehicle sub-units of different type or different function including control of braking systems	12
B60W10/20	Conjoint control of vehicle sub-units of different type or different function including control of steering systems	15
B60W2050/146	Display means	22
B60W2520/10	Longitudinal speed	14
B60W2554/00	Input parameters relating to objects	15
B60W50/08	Interaction between the driver and the control system	10
B60W50/10	Interpretation of driver requests or demands	10
B60W50/14	Means for informing the driver, warning the driver or prompting a driver intervention	28
G05D01/0061	Control of position, course or altitude of land, water, air, or space vehicles, e.g. automatic pilot with safety arrangements for transition from automatic pilot to manual pilot and vice versa	10
G05D2201/0213	Road vehicle, e.g. car or truck	12

Table 10. This Table shows the International Patent Classifications (IPC) which were mentioned by at least 10 patents. It also shows what the IPC stands for and how often it got mentioned.

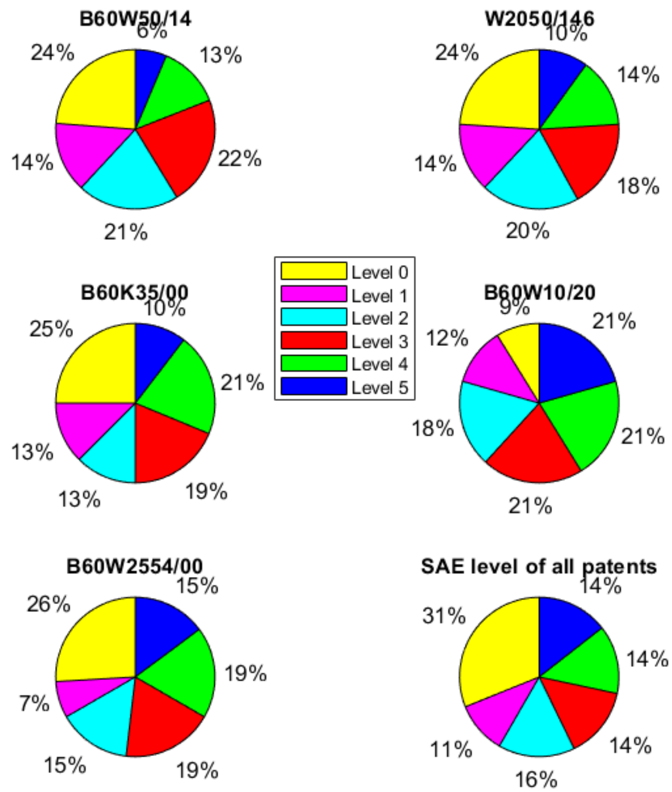


Figure 19. Top 5 IPC's SAE levels. The most mentioned IPC is found on the top left of the figure, the second most mentioned is found on the top right and the fifth most mentioned is found on the bottom left. On the bottom right all the patents' SAE levels are shown.

3.3 Theoretical studies

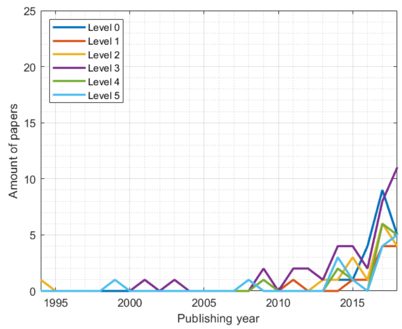


Figure 20. The amount of theoretical studies that mentioned a SAE level

This systematic review contain 65 theoretical studies As mentioned above, in 1994 the first theoretical study was published about HMI in automated driving (as seen in Figure 10b and Figure 20) by Hassoun et al and was about an assistance system for diagnosis and monitoring of driving manoeuvres. This French paper describes SAE level 2, where the the automation performs both the lateral and longitudinal vehicle motion control, but the driver still has to monitor the system and has to intervene if the system doesn't perform correctly. After the year 2000, a couple of theoretical studies have been published about HMI in automated driving. The first one was about designing a human vehicle interface for an intelligent community vehicle and was published by Lee, Lee & Xie in 1999. This paper describes all the SAE levels. In 2017, level 0 got more than 5 mentions and was nearly as much mentioned than the second placed SAE level 3, which was one time less mentioned. The next year, level 3 took the lead and was between 120 and 175% more mentioned than other levels. From Figure 20 it can be concluded that level 3 is yet the most mentioned SAE level in theoretical, due its interest by scientists. A Table from Appendix D1 shows all the 65 theoretical studies with their corresponding SAE level(s) on alphabetical order.

3.3.1 Countries

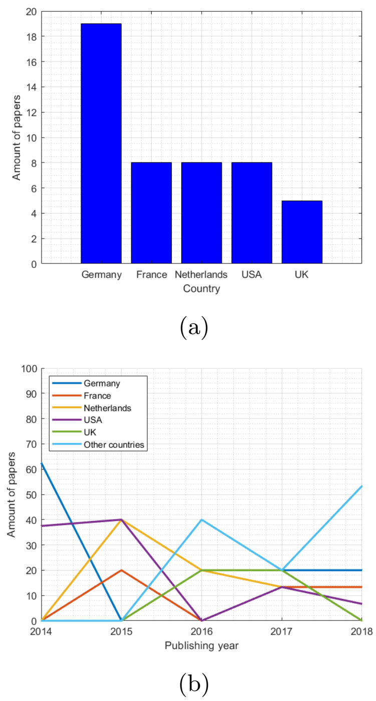


Figure 21. (a) a bar diagram of the top 5 most publishing countries and (b) a publication percentage of the top 5 countries and the other countries between the years of 2014 and 2018.

A amount of 15 different countries published theoretical studies. Figure 21a shows a bar diagram with the top 5 most publishing countries, which published 74% of total amount of the studies. Germany published 29% of the theoretical studies. France, Netherlands & USA published 12% of the theoretical studies and UK published 7.7% of the theoretical studies.

Figure 21b shows the publication fraction rate of the top 5 countries and the other countries between the years of 2014 and 2018. Germany published in 2014 the majority of the theoretical studies. The year later, the amount of published paper dipped with 100% and between 2016 and 2018 Germany published 20% of the theoretical studies. After 2015, the Netherlands published at least one paper each year. However, the fraction of published studies is decreasing since 2015. The decreasing of fraction of published studies are also seen in USA, but the decreasing has started since 2014. Published studies by other countries are, however, increasing since 2015 and published theoretical studies from other countries are also dominating in 2016 and 2018.

Figure 22 shows the published SAE levels by country in theoretical studies. Nearly 50% of the Dutch and German theoretical papers were about low SAE levels (.i.e, levels 0, 1 & 2). USA, UK and the grouped non-top5 "other countries" had 40 & 60% distribution for low and high SAE levels. France had an opposite distribution: 60% of the papers mentioned low SAE levels and the other 40% had high SAE levels. Compared to Figure 13 does nearly all theoretical studies' top 5 countries mention the higher SAE levels more often than experimental studies' top 5.

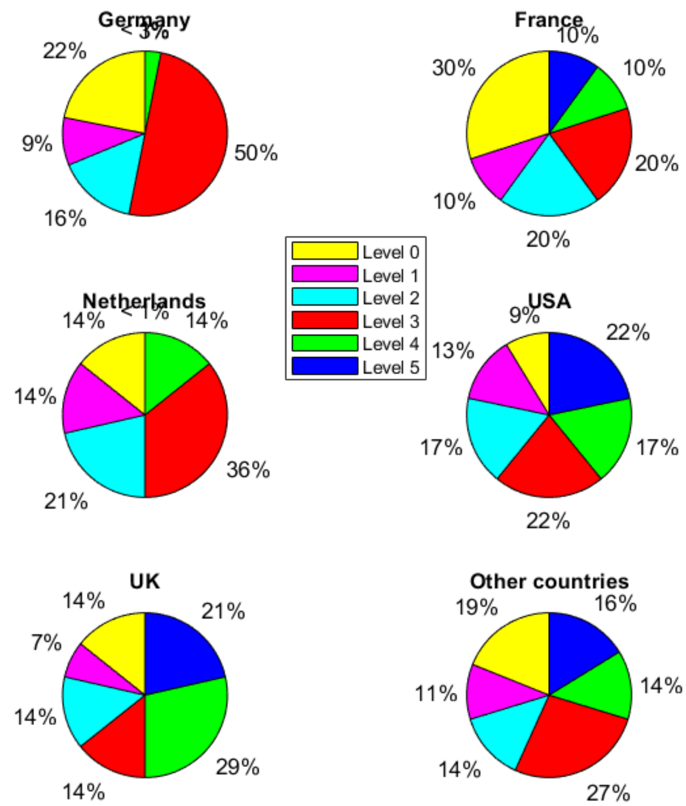


Figure 22. The SAE levels of the top 5 most publishing countries. The most publishing country is found on the top left of the Figure, the second most mentioned is found on the top right and the fifth most mentioned is found on the bottom left. On the bottom right the SAE levels of the other countries are shown.

3.3.2 Type of theoretical studies

After reading theoretical studies, five types of theoretical studies have been found. These types could be found in Table 11 with their top 5 publishing countries and SAE level. It is found that majority of summaries are published by Germany and mention the SAE levels 0, 1, 2 & the most often, these kind of summaries describe the current HMI in automated driving (e.g., Barat, Fromion, Feron, Guen, & Laine, 2017). It was also found that design types were mostly published by Germany and mentioned nearly all SAE levels with at least 32%, except level 1. Furthermore, it was found that experiment concepts and concept presentations were mostly published by non-top5 countries. Also, experiment concepts mentioned the low SAE levels (.i.e, levels 0, 1 & 2) the least, at concept presentations there wasn't a clear popular SAE level. Lastly, it was found out that literature reviews were mostly published by the Netherlands and the majority of the literature studies mentioned SAE level 3.

Type of theoretical study	#	Country						SAE level					
		DE	FR	NL	US	GB	other	0	1	2	3	4	5
Summary	22	36	4.5	14	23	9.1	14	45	32	41	64	23	14
Design	19	42	11	5.3	5.3	16	21	32	21	32	68	32	32
Experimental concept	5	0	20	0	20	0	60	0	0	20	60	20	20
Literature review	10	10	10	40	10	0	30	40	20	30	80	30	20
Concept presentation	10	20	30	10	0	0	40	30	10	20	30	20	30

Table 11. The percentage of mentioned countries and SAE levels in type of studies. The columns show the countries and SAE levels and the row distinguish each other from type of theoretical study. The amount,#, is given in numbers and the rest of the columns are given in percentages. The biggest value in the row segment is highlighted in green and the smallest in red

3.4 Other studies

During analyzing 15 model studies, eight survey studies and seven papers from different studies have been found. The result of these three kind of studies also have different categories (see Table 2 in the methodology section)

3.4.1 Model studies

The first model study was published in 2006 by Switkes and colleagues and was about force feedback in the steering wheel for lane keeping assistance. Switkes published this SAE level 0 study in USA. Switkes compared experimental results with model results. Tables 12 & 13 show all the model studies used for this systematic review in alphabetical order.

In 2018, most model studies have been published. Brazil, Germany and China published with 27% the most models. However, Brazil published less studies, so Germany and China published the most model studies with 27% of all the papers. It is also found that SAE level 0 is more mentioned than 50%. Furthermore, more than a third of the studies used Automation as a variable and used Lane Keeping (LK) as a metric. 71% of the level 0 models used LK, where the effect of driving aids are researched (e.g., Switkes, Rossetter, Coe & Gerdes, 2006).

3.4.2 Survey studies

The first survey study was published in 2001 by Ulmer and was about a comfort highway copilot driving assistance system. Ulmer published this SAE level 2 study in Germany and used automation as a variable in the results. Tables 14 & 15 show all the survey studies used for this systematic review in alphabetical order.

Germany published the majority of the survey studies with 63%. The majority of the survey studies mentioned SAE level 2 and half of them mention level 3 in the methodology. Remarkably, more than 85% of these studies are published after 2014, which is the year where level 2 vehicles are rolled out (Lowensohn, 2014; Hyat & Paukert, 2018; Vincent, 2018) and SAE levels are introduced (SAE International, 2014). Furthermore, the median survey study used 77 participant aged 44.9 years, which is compared to the boxplots in Figure 16 much higher. However, the percentage of female participant is similar with 41%. Lastly, 50% of the survey studies used automation as a variable and used behaviour as a metric in their results section.

3.4.3 Miscellaneous studies

After model studies and survey studies, there were 4 workshops, 1 book, 1 proposal and 1 video analysis. 71% of these studies have been published in 2017 and mentioned Level 4 & 5 the most. Table 16 shows the other studies and are categorized in SAE level.

Table 12. All the model studies sorted on alphabetical order. The columns show the publishing year, the country of the first author's office, the mentioned SAE level and the used variables in the model studies. The countries are coded in ISO 3166-1 alpha-2. Some studies published multiple models. The rows under these studies are used to categorize its models and doesn't show the number of the study, the author, the publishing year and the publishing country. For example, Hernandez published in 2018 a study with four models, so the study has four rows in the table.

#	Author	Year	Country	SAE level						Variables			
				0	1	2	3	4	5	Automation	Environment	ModelVSExp	Other
1	Bahram, Aeberhard & Wollherr	2015	DE			x	x	x		x			
2	Gold, Happee & Bengler	2018	DE				x					x	
3	Gonçalves, Olaverri-Monreal & Bengler	2015	DE				x						
4	Hernandez	2018	BR	x									Vehicles
				x									Vehicles
				x							x		
				x							x		
5	Jeong & Liu	2018	US	x								x	
6	Li et al	2017	CN				x			x			
7	Li, Li, Li, Burdet & Cheng	2017	CN			x				x			
8	Ludwig, Andreas, Flad & Hohmann	2018	DE				x			x			
9	Modi, Chesnakov, Zhang, Lin & Yang	2012	CN	x						x	x		Participants
10	Rath, Sentouh & Popieul	2018	FR			x				x			
11	Soualmi, Sentouh, Popieul & Debernard	2014	FR	x							x		
12	Switkes et al	2006	US	x								x	
13	Wang, Kaizuka & Nakano	2018	JP	x									Participants
14	Wardziński	2006	PL					x	x		x		
15	Wu, Chu, Mammar & Zhou	2011	CN	x	x	x							
Total				**10**	**1**	**4**	**5**	**2**	**1**	**6**	**5**	**3**	**4**
Total in %				**56**	**5.6**	**22**	**27**	**22**	**5.6**	**33**	**28**	**17**	**22**

Table 13. This is an extension of Table 12 and shows the metrics used at model studies. Some models used at Lane Keeping (LK) Time To lane Crossing (TTC) as a metric. At the steer metric some models used steering Angle (A) and steering Torque(T) as a metric. At the yaw metric some models used Heading Error (HE) and Yaw Rate (YR). Lastly, there are also other metrics like LAteral Accelerarion (LA), Take Over Time (TOT), Reaction Time (RT) and WorkLoad (WL).

#	Vehicle metrics						Other metrics
	Long		Lateral		Yaw	Other	
	Speed	Other	LK	Steer			
1	x	Acceleration, position					
2		Braking	TTC			Crashing	TOT
3							
4	x						
	x	Distance					
		Distance					
		Error					
5			x	A		LA	RT, WL
6							
7			x				
8				A, T			
9		Braking					
10			x	A, T	HE, YR	LA	
11	x		x	T	HE		
12			x	A	HE		
13			x				
14							
15							
Total	**4**	**6**	**7**	**5**	**3**	**3**	**2**
Total in %	**22**	**33**	**39**	**28**	**17**	**17**	**11**

Table 14. This Table shows all the survey studies sorted on alphabetical order. The columns show the publishing year, the country of the first author's office, the mentioned SAE level and the used variables. The countries are coded in ISO 3166-1 alpha-2.

#	Author	Year	Country	SAE level						Variables	
				0	1	2	3	4	5	Automation	Environment
1	Altendorf, Schreck & Flemisch	2017	DE			x	x				
2	Biondi et al	2018	US			x				x	
3	Fank	2017	DE				x				x
4	Gibson, Butterfield & Marzano	2016	GB					x	x	x	
5	Kraus, Sturn, Reiser & Baumann	2015	DE				x				x
6	Rödel, Stadler, Meschtscherjakov & Tscheligi	2014	AT	x	x	x	x	x	x	x	
7	Ulmer, Fritz, Gern, Herberger & Mehring	2001	DE			x				x	
8	Weyer, Fink & Adelt	2015	DE	x	x	x					
Total				**2**	**2**	**5**	**4**	**2**	**2**	**4**	**2**
Total in %				**25**	**25**	**63**	**50**	**25**	**25**	**50**	**25**

Table 15. This Table is an extension of Table 14 and shows the participant data, the metrics used in survey studies and number of references.

#	Participant data							Metric					Number of references
	Amount			Age									
	Total	Male	Female	Mean	SD	Min	Max	Behaviour	Usability	Trust	Comfort	Other	
1									x	x	x	2	28
2									x			3	58
3	7	5	2	45.14	14.61	27	62	1					19
4	35	11	24			18	40					x	20
5										x	x	5	14
6	336	158	178	33.24	13.01	18	65	x	x	x		2	26
7									x		x	1	9
8	118	94	24	44.9		21	66	x					46
Total	**496**	**268**	**228**					**3**	**4**	**3**	**3**	**6**	
Total in %								**38**	**50**	**38**	**38**	**75**	

Table 16. This Table shows all the miscellaneous studies sorted on alphabetical order. The columns show the publishing year, the country of the first author's office, the mentioned SAE level and the number of references. The countries are coded in ISO 3166-1 alpha-2.

Author	Year	Country	SAE level						Type of study	Number of references
			0	1	2	3	4	5		
Borojeni et al	2017	DE			x	x			Workshop	16
Brown & Laurier	2017	SE			x				Video analysis	71
Campbell	2017	US	x	x	x	x	x	x	Book	136
Frison et al	2017	DE					x	x	Workshop	13
Kim, Yoon, Kim & Ji	2015	KR					x	x	Workshop	12
Lobo, Ferreira, Rodrigues & Couto	2018	PT	x	x	x	x	x	x	Proposal	0
Tango et al	2017	IT					x	x	Workshop	7
Total			**2**	**2**	**4**	**3**	**5**	**5**		
Total in %			**29**	**29**	**57**	**43**	**71**	**71**		

4 Discussion

4.1 Limitations

This paper aimed to build an overview about the published research about HMI in automated driving. As described in the methodology, data was gathered by submitting queries in Google Scholar. Every query contained the same NOT operators: "pedestrian", "wheelchair", "military" and "business" to reduce results about pedestrian-machine interaction , wheelchairs and military vehicles. However, when a paper only mentioned this word once, Google Scholar will disregard the whole paper. If a paper uses an example that mentions that the researched HMI in public vehicles could also be applied in military automated vehicles, the paper could be excluded from the research. Having less papers mean there will be less data gathered and that could lead to a data loss. This form of data loss could be checked by comparing results with queries which contain NOT-operators and with queries which doesn't contain NOT-operators. The data loss was checked by removing the NOT-operators and filtering the extra results by using the same method as described in the methodology. It was found by removing the NOT-operators at 3 queries that received low amount of results, the amount of results increased between 80% and 450%, and it was found that the extra results weren't relevant for this systematic review. Thus, this data gathering process didn't contain any data loss. Moreover, each query contained word combinations referring to HMI and automated driving (see Appendix A). Even though, it has been tried to be all-encompassing, some works may not have been included, due to different use of terminology. Indeed, this issue, commonly known as construct proliferation could cause data loss (Shaffer, DeGeest, & Li, 2016). It is possible to counter this efficiently doing one of the following things: searching in general bibliographic databases, reviewing reference lists, searching specialist bibliographic databases and consulting subject specialists (Schucan Bird & Tripney, 2011; Shaffer et al., 2016). This systematic review searched in Google Scholar, which is considered as a general bibliographic database. Thus, construct proliferation, which could lead to data loss, was limited by using a general bibliographic database.

As described in the methodology and results, after receiving results the papers were filtered on the bases of title abstract and text. Filtering on the basis of the title limited the 7183 unique results to 719 results. During this filtering process there was a lack of an inter-rater reliability check, which could make the filtering process more reliable by using more raters (Gwet, 2014). If one rater has different results than other raters after the filtering process, it means that this rater didn't perform the filtering process as well enough as the others. Checking each other results could remove the filtering errors, like marking a paper as relevant for the systematic review while it isn't. This systematic review only had one rater who did the filtering process, so there isn't another rater to compare the results after the filtering process.

With categorizing the paper on SAE level, the risk on miscategorizing was high, because some papers were difficult to categorize due to ambiguous or lacking descriptions of their classification of automation. For example, some papers just mention "level 3" automation. If the papers used the classification from NHTSA the paper would be classified as level 3, 4 or 5 automation in SAE terms. This systematic review uses SAE classification, because the majority of the papers uses it too. Reading the paper was a solution to categorize the paper on SAE level.

As described in the methodology, non-English titles had to be excluded, due to practical reasons. This could lead to an absence of non-English papers about HMI in automated driving (Kotiaho, 1999). In Figure 10d, it could be seen that the western countries publishes the most papers, due to high research budgets, number of universities and high English proficiency (Man, Weinkauf, Tsang, Sin, & Hogg, 2004; Meo et al., 2013). It is found that countries that spends more on research, have a high number of universities and scientific journals, such as Japan, publish more papers than other countries (Meo et al., 2013). However, it is also found that if a paper is not written in English, the paper is also less cited (Kotiaho, 1999; Liming, Rousseau, & Zhong, 2013). Most non-English papers also cite papers that are written in their own preferred language (Liming et al., 2013), so these papers could not be found by tracing cited papers. To also include these non-English papers in this systematic review, these papers could be translated to English and could be analyzed with the same method as described in the methodology section.

Categorizing experiments on immersion was problematic. Firstly, it was initially planned to use four types of immersion: NIVR, SIVR, TIVR and real driving. A SIVR simulator was here defined as a simulator with at least one screen and have a viewing angle with less than 360 degrees. That meant that 63% of the experiments, where the immersion was given, had a SIVR immersion. It was decided that this definition is too broad and the SIVR type and thus SIVR was split in two types: SIVR<180 and SIVR>180. Secondly, some experiments didn't describe the immersion of their simulator in their paper. The immersion was sometimes found by looking at the figure with the experimental setup, like at Figure 2. NIVR, TIVR and real driving immersion were effortlessly found, because the distinction between these immersion is clear. The distinction between SIVR<180 and SIVR>180 is less clear and requires more effort, especially if the viewing angle was close to 180 degrees. If there wasn't a Figure that showed the experimental setup, the immersion wasn't noted. There are 57 experiments where the immersion wasn't found.

Like immersion, categorizing experiments on configuration was also problematic. Distinguishing a simulator with a FB and a MB simulator is clear, but distinguishing a MB simulator into five types of MB was problematic, especially if the amount of DoF wasn't mentioned. At these times the number of DoF is found by looking at the paper's Figure showing experimental setup or by looking at the description of the experimental setup.

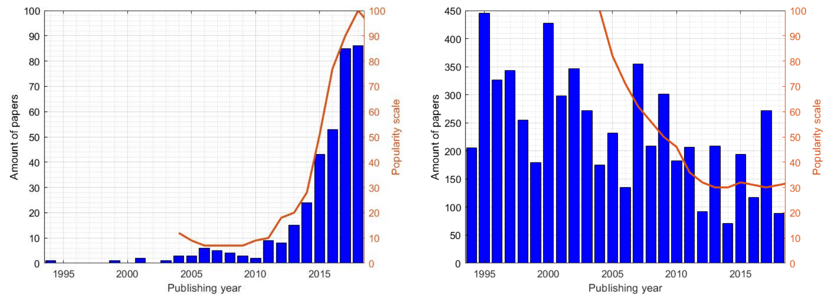
As described in the methodology the fidelity rating in Table 3 was based Wynne's fidelity rating, but there are some elements that are different, such as immersion levels. Wynne's system split the immersion into five levels: single screen smaller than 25 inch, single screen bigger than 25 inch, multiple screens with a viewing angle smaller than 180 degrees, multiple screen with a viewing angle between 180 and 270 and a screen with a viewing angle of more than 270 degrees. With the extra level of immersion, Wynne's system could determine the immersion more accurately. However, determining which simulator belong to which immersion level could be more inefficient at Wynne's system than our system, because it was found that not every paper describe the immersion of their simulator and needed to be determined from their experimental setup. Moreover, Wynne's paper researched 44 experimental studies, while this systematic review researched 193 experiments. Lastly, it was researched if the studies in Wynne's paper had different fidelity rating than this paper. It was found that both papers analyzed different studies, so it couldn't be found if the studies had conflicting fidelity ratings. In short, Wynne's fidelity rating system is more accurate, but is not efficient with the quantity of experiments used for this systematic review.

4.2 Publication rate

One of the results found in this systematic review was that from the early 2010s the number of published papers was grew significantly. In fact, in that period, is also a period where many events occurred in the self driving world: field test studies on self driving car were legalized (Millikin, 2011) and performed by for example car companies (Filippetti, 2011; Cellan-Jones, 2013; Fitchard, 2012) and universities (Heinstein, 2011). In the same period, the roll out of the first vehicles with SAE level 2 is also seen (Lowensohn, 2014), and the six level classification system of autonomous driving was also published (SAE International, 2014). Around 2016, major car companies announced researching level 3 & 4 automation and invested in developing the technology (Faggella, 2020). The rise of SAE levels 2, 3 & 4 is also seen in Figure 10c, where levels 2 and 3 rose significantly after 2014 and level 4 after 2016.

Figures 23a & 23b show bar diagrams with the number of papers published each year and the curve shows the Google Trends (GT) about the subject "self-driving car" and "traffic safety". GT shows the popularity of subjects at Google.com. Figure 23a also shows that the interests of scientists represent the interests of the general public, because the amount of published papers has the same trend as the popularity curve of GT. Figure 23b shows that in other domains such as traffic safety the interests of scientist doesn't represents the interests of the general public.

However, the data from GT is scaled from 0 to 100, which makes it harder to reproduce results (Rech, 2007; Nuti et al., 2014). For example, in Figure 23a the subject about HMI in automated driving had the value 100 in 2018, which is the maximum. Suppose that in 2019 the subject become more popular than 2018, the data won't have the same values as from the orange curve in Figure 23a. The popularity in 2019 will have the value 100 and the popularity in 2018 will have a lower value.

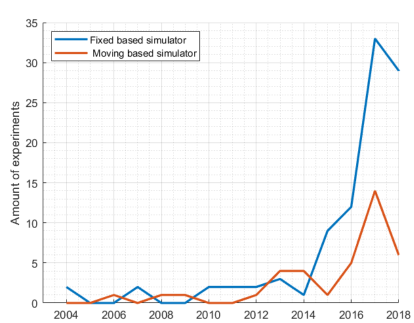


(a) (b)

Figure 23. (a) the amount of published papers per year with a blue bar graph and the popularity of the Google subject search "self-driving car" with an orange curve. The orange curve is retrieved from Google Trends and is scaled from 0 to 100, at 0 the amount of searches were at the lowest and at 100 the amount of searches or published papers was the most mentioned. (b) the amount of published papers about traffic safety between in a blue bar graph and the popularity of the Google subject search "traffic safety" with an orange curve

4.3 Paper categories

Experimental studies were the most published study (see Figure 10b). Experimental studies were mostly done with driving simulations which uses computers with great computing performance to run this. It has been found that the cost of computer performance is declining each year (Nordhaus, 2001; Sandberg & Bostrom, 2008), a Wikipedia page about FLOPS also confirms this. The growth of experimental studies may be related to declining cost of computer performance and may be related to the rising scientific respect to simulations (Sargent, 2017). Moreover, in Figure 14a and Table 4 is also seen that most experiments is performed in FB simulators. According to Figure 24, it is seen that amount of MB simulator experiments could not keep up with the growth of FB simulators. The popularity of FB simulators is due to the cost of the experimental setup (Wang, Zhang, Wu, & Guo, 2007). Indeed, the cost of a mid fidelity experimental with FB configuration and a TIVR immersion as seen in Figure 2e will cost, according to Coolblue's (coolblue.nl) prices, around 1,650 euros, which contain Oculus Rift S glasses (500 euros), Logitech G29 steering wheel (350 euros) and a desktop PC powerful enough to render the virtual environment (800 euros). In contrast, the hardware cost of a 6DoF platform is 47,000 euros (Stanek, 2019), which is nearly 30 times more expensive than the previous FB experimental setup. A complete 13DoF MB simulator cost even more, which is nearly 80 million dollars(Robichaud, 2009). Investing in a 6DoF or 13 DoF simulator needs to be considered, due to its cost. In Table 5 and Figure 14b, it could be seen that countries such as United



Kingdom, the Netherlands and the grouped non-top5 countries had a smaller fraction of publications in high and very high fidelity experiments, which indicates that investing in a 6DoF simulator might be too big for countries that doesn't invest much in R&D (Ciechański, 2018).

During the paper categorization process, 20% of the experimental papers were read. One of the category that was not common enough, was participant type, such as students, employees, researchers. While the type of participant was not noted of the remaining 80% of the experimental studies, the data of the first 20% was never deleted and still could be used. Although the sample size is small, it was found that 50% of the simulator experiments (N=10) had students as participants, while 33% of the real driving experiment's (N=3) were also students. Students are in a population group which are relatively young and are effortlessly recruitable if the experiment is in an university's campus. This is also why real driving experiments had older, but less participants than other simulator experiments (see Section 3.1.2).

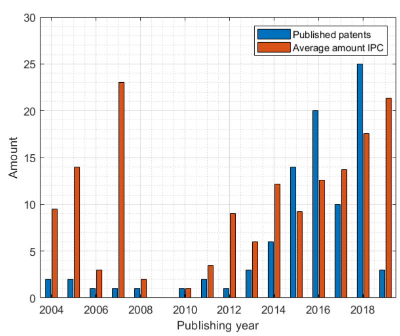
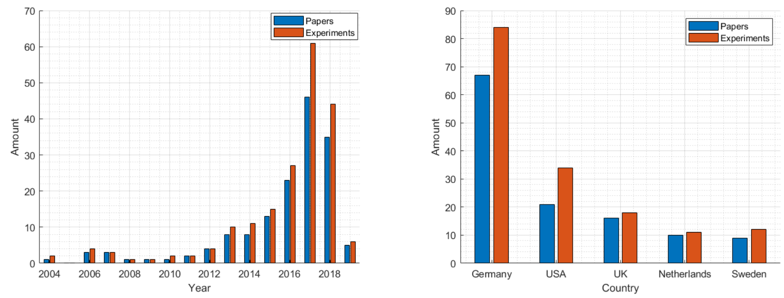


Figure 25. The amount of published patents vs the average number of used IPCs

Level 0, 1 and 2, were, after 2016, less mentioned than the higher levels of automation (see Figure 10c). It seems that the higher levels of automation may be more popular after 2016, because most car manufactures applied or announced applying level 2 automation in 2016 (Hyat & Paukert, 2018; Vincent, 2018). Researching higher level of automation is still a knowledge gap, because there aren't any level 3 cars yet ("40+ Corporations Working On Autonomous Vehicles", 2019). The growth of high levels of automation is also seen in patents, experimental and theoretical studies (see Figure 11, 17 and 20). Thus, since 2016 higher levels of automation like level 3, appear to become more popular each year. In 2018, all levels of automation had significant growths compared to the previous year in patents (see Figure 17). This may be due to the fact that inventors applying their inventions to any level of automation. For instance, a level 3 device that controls a vehicle, could also be used as a level 1-5 control device (Sato & Iwasaki, 2016; Jablonski, 2018). Notably, according to Figure 25, it is also seen that the average patent have more IPCs in the recent



(a) (b)

Figure 26. (a) shows the number of published experiments and experiments per year and (b) shows the number of papers and experiments of the top 5 countries

years, which indicates that inventors apply their patents not only in automated vehicles, but also in other domains. To resume, level 3 of automation appeared in most time the dominant level of automation in theoretical studies (see Figure 20). This may be due to the fact that authors discuss human behaviour at level 3 and compare it with different levels of automation (see e.g., Carsten & Martens, 2019; Flemisch et al., 2017).

At experimental studies the data is distinguished between two sets: the publication and the experiment data. The publication data shows information about the published papers, the experimental data shows information about experiments within these published papers. Figure 26a shows the difference in publication rate and Figure 26b show the difference in the top 5 publishing countries. On average the amount is at experimental data 28% higher, because some papers contain multiple experiments (e.g., Rittger Götze, 2018). There are 19 experimental papers containing more than one experiment and on average these 19 papers contained three experiments. It was chosen to use the experimental data, so the experiments could be separated and could be compared with each other. For example, Rittger & Götze (2018) published a paper with seven experiments, which all contain a automation level of 0. At the publication data set the experiments and its SAE levels will put on a par, at the experimental data the experiments are separated. This difference could also be seen in Figure 11, where the amount of SAE level 3 mentions was 50% higher at experiment data than publication data. The downside of using experimental data is the fact that some publishing countries and publication years are more represented in the data. SAE levels could vary among multiple experiment in one paper, but the publishing countries and publication years could not. For example, if a paper is published in 2016 and published three experiments, the publication date, 2016, will more represented three times more in the data. This is also seen in Figure 26b where the Netherlands is the fourth most publishing country by papers, but if the focus is published experiments, Sweden published more experiments than the Netherlands.

In Figure 14a, it could be seen that real driving and very high fidelity experiments dipped in 2018. In Table 5 and in Figure 14a, it could also be found that big fraction of the real driving and very high fidelity experiments are published in USA. At Figure 12b, it could be seen that amount of experiment published in USA dipped in 2018. It is also found that in that year the number of field test are suspended or even decreased by companies (Wakabayashi & Conger, 2018; Perry, 2018). The oldest experimental study published in 2018, was published on 5 March, before the fatal car crash. After the crash, there weren't any experimental studies published that year in USA. So, the fatal crash with the automated vehicle might have an effect on the amount of published papers in USA. In the same Figure it is also seen that published papers from UK also dipped and the cause haven't been found.

In Section 3.1.2 results were compared with the Dutch driver demographics. It was chosen to compare participants demographics with the Dutch, due to its online accessibility. According to a Wikipedia page about the demographics of the world, the Netherlands has similar demographics than most western countries. Moreover, the majority of the experimental studies contain participants that don't reflect Dutch driver demographics, which means that behaviour results could be less accurate reflecting the average Dutch driver, as age and sex has an influence on driver behaviour (Reason, Manstead, stephen stradling, Baxter, & Campbell, 1990).

As told in Section 2.1.2, nearly all the boxplots in Figure 16 contain significant percentage of undefined values, such as the mean, standard deviation (SD) and % female participant. The undefined values come from papers that use a different categories or doesn't use at all. For example, the majority of papers use the mean and SD to show the distribution of participants ages, other pages use the minimum and maximum of the participant age. Some papers don't mention the sex distribution of their participants. It is hypothesized that many of these experiments are all male participant experiments. So that means that the values % of female participants in the boxplots could be lower. To research if this hypothesis is true, the authors of the experimented could be contacted and asked to the sex distribution of the experiment's participants.

In Figures 10b & 17 it is seen that the amount of patents dipped in 2017. At Section 2.2 five most mentioned IPC are precisely analyzed. Even with these IPCs, there wasn't correlation found why the dip happened. In this systematic review 0.9% of the total 555 IPC are precisely analyzed, even the most common IPC got mentioned with 30%. It is recommended to analyzed a bigger fraction of IPC to find a the dip's correlation.

5 Conclusion & Recommendation

This systematic review analyzed 340 papers and found that according to the amount of published papers per year and the popularity trend from Google, the interests of scientist represents the interests of the general public. However, it was also discussed that popularity trend from Google is complicated to reproduce, due to its scaling of results. It is also found that number of publications is effected by technological developments.

Experimental studies had an advantageous influence by the cost of computer performance, which increased the amount of published experimental studies and made it the most popular study in recent years. However, in 2018 the amount of published experimental studies declined, due to societal events, but the amount of published patents and theoretical studies grew. In short, experimental studies are the most popular type of paper, patents were the second and theoretical studies the third.

Furthermore, the mentioning of SAE level 3 increased significantly since the introduction of the SAE levels in 2014 and was in the last two year the most mentioned level. SAE levels 4 & 5 also had a significant growth. Lower SAE levels, like level 0, 1 & 2, are less mentioned compared to the total number of published papers. Lastly, the same trend has been found in experimental studies, patents and theoretical studies. In conclusion, the mentioning of SAE level 3 had a significant growth and is the most mentioned level in papers and in all other type of studies.

Looking at countries it was found that Germany published the most papers and mentions the higher SAE level. Other countries focused more on lower SAE levels. Additionally, European countries focus more on simulator experiments and USA focuses on real driving experiments. Remarkably, at theoretical studies the other non-top5 countries shift publishes more papers and focus more on higher SAE levels. There was also a discussion about the over representation of western countries in the research, due to absence of non-English paper. It is recommended that these papers should be translated and be analyzed with the same methodology.

Further, it was found that the very low to mid fidelity simulator were more common due to its cost difference with the higher fidelity simulators. Higher fidelity simulators had also better participant demographics than lower fidelity simulator. Additionally, real driving experiments had significantly older and less participants than simulator studies. Lastly, only 4.1% of the fidelity and real driving experiments use participants which reflect the Dutch driver demographics.

Additionally, metrics were also analyzed. Objective metrics were more common than subjective metrics. Reaction time was the most common objective metric. It was also found that some metrics were more common at some SAE levels, fidelities and interactions.

Lastly, it was found, in the recent years, inventors apply their patents on more domains.

It was discussed that the use of NOT-operators and construct proliferation could not lead to data loss. However, a lack of inter-rater reliability check and a lack of description of the classification of automation made the filtering and categorization process less reliable.

This systematic review categorized papers on 20 different categories. However, more categories might be studied to explain, for example why real driving experiments have older and less participants than simulator experiments. Moreover, with 340 papers found in the paper filtering progress, there are still some undiscovered papers that are not written in English and could provide viable work this research. Furthermore, with the 555 different IPC found, there is also still no explanation to some trend behaviours in patents, such as a decline in 2017 as seen in Figure 17.

It is evident from the results presented in this paper, that SAE level 3 and higher are still understudied topics and are studies on participants that don't reflect the Dutch driver demographics. It is recommended to investigate these levels on participants that reflect the driver demographics, in order to be ahead of the vehicle market, who are currently actively aiming to deploy SAE level 3 and higher on the market ("40+ Corporations Working On Autonomous Vehicles", 2019) .

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Appendix A: Query results

Query	Number of results
"Human machine interaction" AND ("Automated Vehicle" OR "Automated Vehicles") NOT (pedestrian wheelchair military business)	364
"Human machine interaction" AND ("Automated car" OR "Automated carsNOT (pedestrian wheelchair military business)	74
"Human machine interaction" AND ("Automated pod" OR "Automated podsNOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("Automated shuttle" OR "Automated shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("Automated driving" OR "Automated drivings") NOT (pedestrian wheelchair military business)	346
"Human machine interaction" AND ("Automated transport" "Automated transit" "Automated transports" "Automated transits") NOT (pedestrian wheelchair military business)	13
"Human machine interaction" AND ("Automated bus" OR "Automated buses") NOT (pedestrian wheelchair military business)	5
"Human machine interaction" AND ("Autonomous Vehicle" OR "Autonomous Vehicles") NOT (pedestrian wheelchair military business)	628
"Human machine interaction" AND ("Autonomous car" OR "Autonomous cars") NOT (pedestrian wheelchair military business)	151
"Human machine interaction" AND ("Autonomous pod" OR "Autonomous pods") NOT (pedestrian wheelchair military business)	2
"Human machine interaction" AND ("Autonomous shuttle" OR "Autonomous shuttles") NOT (pedestrian wheelchair military business)	1
"Human machine interaction" AND ("Autonomous driving" OR "Autonomous drivings") NOT (pedestrian wheelchair military business)	369
"Human machine interaction" AND ("Autonomous transport" "Autonomous transit" "Autonomous transports" "Autonomous transits") NOT (pedestrian wheelchair military business)	9
"Human machine interaction" AND ("Autonomous bus" OR "Autonomous buses") NOT (pedestrian wheelchair military business)	1
"Human machine interaction" AND ("self-driving Vehicle" OR "self-driving Vehicles") NOT (pedestrian wheelchair military business)	72
"Human machine interaction" AND ("self-driving car" OR "self-driving cars") NOT (pedestrian wheelchair military business)	151
"Human machine interaction" AND ("self-driving pod" OR "self-driving pods") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("self-driving shuttle" OR "self-driving shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("self-driving driving" OR "self-driving drivings") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("self-driving transport" "self-driving transit" "self-driving transports" "self-driving transits") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("self-driving bus" OR "self-driving buses") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("cooperative Vehicle" OR "cooperative Vehicles") NOT (pedestrian wheelchair military business)	55
"Human machine interaction" AND ("cooperative car" OR "cooperative cars") NOT (pedestrian wheelchair military business)	5
"Human machine interaction" AND ("cooperative pod" OR "cooperative pods") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("cooperative shuttle" OR "cooperative shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("cooperative driving" OR "cooperative drivings") NOT (pedestrian wheelchair military business)	78
"Human machine interaction" AND ("cooperative transport" "cooperative transit" "cooperative transports" "cooperative transits") NOT (pedestrian wheelchair military business)	16
"Human machine interaction" AND ("cooperative bus" OR "cooperative buses") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("driverless Vehicle" OR "driverless Vehicles") NOT (pedestrian wheelchair military business)	33
"Human machine interaction" AND ("driverless car" OR "driverless cars") NOT (pedestrian wheelchair military business)	63
"Human machine interaction" AND ("driverless pod" OR "driverless pods") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("driverless shuttle" OR "driverless shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interaction" AND ("driverless driving" OR "driverless drivings") NOT (pedestrian wheelchair military business)	13
"Human machine interaction" AND ("driverless transport" "driverless transit" "driverless transports" "driverless transits") NOT (pedestrian wheelchair military business)	3
"Human machine interaction" AND ("driverless bus" OR "driverless buses") NOT (pedestrian wheelchair military business)	1
"Human Computer interaction" AND ("Automated Vehicle" OR "Automated Vehicles") NOT (pedestrian wheelchair military business)	436
"Human Computer interaction AND ("Automated car" OR "Automated cars") NOT (pedestrian wheelchair military business)	129
"Human Computer interaction" AND ("Automated pod" OR "Automated pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interaction" AND ("Automated shuttle" OR "Automated shuttles") NOT (pedestrian wheelchair military business)	4
"Human Computer interaction" AND ("Automated driving" OR "Automated drivings") NOT (pedestrian wheelchair military business)	381
"Human Computer interaction" AND ("Automated transport" "Automated transit" "Automated transports" "Automated transits") NOT (pedestrian wheelchair military business)	25
"Human Computer interaction" AND ("Automated bus" OR "Automated buses") NOT (pedestrian wheelchair military business)	2
"Human Computer interaction" AND ("Autonomous Vehicle" OR "Autonomous Vehicles") NOT (pedestrian wheelchair military business)	1182[1]
"Human Computer interaction" AND ("Autonomous car" OR "Autonomous cars") NOT (pedestrian wheelchair military business)	314
"Human Computer interaction" AND ("Autonomous pod" OR "Autonomous pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interaction" AND ("Autonomous shuttle" OR "Autonomous shuttles") NOT (pedestrian wheelchair military business)	6
"Human Computer interaction" AND ("Autonomous driving" OR "Autonomous drivings") NOT (pedestrian wheelchair military business)	575

[1] Query was split in two time domains

”Human Computer interaction” AND (”Autonomous transport” ”Autonomous transit” ”Autonomous transports” ”Autonomous transits”) NOT (pedestrian wheelchair military business)	15
”Human Computer interaction” AND (”Autonomous bus” OR ”Autonomous buses”) NOT (pedestrian wheelchair military business)	4
”Human Computer interaction” AND (”self-driving Vehicle” OR ”self-driving Vehicles”) NOT (pedestrian wheelchair military business)	112
”Human Computer interaction” AND (”self-driving car” OR ”self-driving cars”) NOT (pedestrian wheelchair military business)	353
”Human Computer interaction” AND (”self-driving pod” OR ”self-driving pods”) NOT (pedestrian wheelchair military business)	0
”Human Computer interaction” AND (”self-driving shuttle” OR ”self-driving shuttles”) NOT (pedestrian wheelchair military business)	2
”Human Computer interaction” AND (”self-driving driving” OR ”self-driving drivings”) NOT (pedestrian wheelchair military business)	0
”Human Computer interaction” AND (”self-driving transport” ”self-driving transit” ”self-driving transports” ”self-driving transits”) NOT (pedestrian wheelchair military business)	0
”Human Computer interaction” AND (”self-driving bus” OR ”self-driving buses”) NOT (pedestrian wheelchair military business)	1
”Human Computer interaction” AND (”cooperative Vehicle” OR ”cooperative Vehicles”) NOT (pedestrian wheelchair military business)	47
”Human Computer interaction” AND (”cooperative car” OR ”cooperative cars”) NOT (pedestrian wheelchair military business)	3
”Human Computer interaction” AND (”cooperative pod” OR ”cooperative pods”) NOT (pedestrian wheelchair military business)	0
”Human Computer interaction” AND (”cooperative shuttle” OR ”cooperative shuttles”) NOT (pedestrian wheelchair military business)	0
”Human Computer interaction” AND (”cooperative driving” OR ”cooperative drivings”) NOT (pedestrian wheelchair military business)	58
”Human Computer interaction” AND (”cooperative transport” ”cooperative transit” ”cooperative transports” ”cooperative transits”) NOT (pedestrian wheelchair military business)	22
”Human Computer interaction” AND (”cooperative bus” OR ”cooperative buses”) NOT (pedestrian wheelchair military business)	0
”Human Computer interaction” AND (”driverless Vehicle” OR ”driverless Vehicles”) NOT (pedestrian wheelchair military business)	66
”Human Computer interaction” AND (”driverless car” OR ”driverless cars”) NOT (pedestrian wheelchair military business)	134
”Human Computer interaction” AND (”driverless pod” OR ”driverless pods”) NOT (pedestrian wheelchair military business)	0
”Human Computer interaction” AND (”driverless shuttle” OR ”driverless shuttles”) NOT (pedestrian wheelchair military business)	4
”Human Computer interaction” AND (”driverless driving” OR ”driverless drivings”) NOT (pedestrian wheelchair military business)	6
”Human Computer interaction” AND (”driverless transport” ”driverless transit” ”driverless transports” ”driverless transits”) NOT (pedestrian wheelchair military business)	8
”Human Computer interaction” AND (”driverless bus” OR ”driverless buses”) NOT (pedestrian wheelchair military business)	2
”Human machine interface” AND (”Automated Vehicle” OR ”Automated Vehicles”) NOT (pedestrian wheelchair military business)	937
”Human machine interface” AND (”Automated car” OR ”Automated cars”) NOT (pedestrian wheelchair military business)	140
”Human machine interface” AND (”Automated pod” OR ”Automated pods”) NOT (pedestrian wheelchair military business)	0
”Human machine interface” AND (”Automated shuttle” OR ”Automated shuttles”) NOT (pedestrian wheelchair military business)	12
”Human machine interface” AND (”Automated driving” OR ”Automated drivings”) NOT (pedestrian wheelchair military business)	839
”Human machine interface” AND (”Automated transport” ”Automated transit” ”Automated transports” ”Automated transits”) NOT (pedestrian wheelchair military business)	47
”Human machine interface” AND (”Automated bus” OR ”Automated buses”) NOT (pedestrian wheelchair military business)	18
”Human machine interface” AND (”Autonomous Vehicle” OR ”Autonomous Vehicles”) NOT (pedestrian wheelchair military business)	2054[2]
”Human machine interface” AND (”Autonomous car” OR ”Autonomous cars”) NOT (pedestrian wheelchair military business)	206
”Human machine interface” AND (”Autonomous pod” OR ”Autonomous pods”) NOT (pedestrian wheelchair military business)	0
”Human machine interface” AND (”Autonomous shuttle” OR ”Autonomous shuttles”) NOT (pedestrian wheelchair military business)	3
”Human machine interface” AND (”Autonomous driving” OR ”Autonomous drivings”) NOT (pedestrian wheelchair military business)	1335[1]
”Human machine interface” AND (”Autonomous transport” ”Autonomous transit” ”Autonomous transports” ”Autonomous transits”) NOT (pedestrian wheelchair military business)	49
”Human machine interface” AND (”Autonomous bus” OR ”Autonomous buses”) NOT (pedestrian wheelchair military business)	5
”Human machine interface” AND (”self-driving Vehicle” OR ”self-driving Vehicles”) NOT (pedestrian wheelchair military business)	216
”Human machine interface” AND (”self-driving car” OR ”self-driving cars”) NOT (pedestrian wheelchair military business)	169
”Human machine interface” AND (”self-driving pod” OR ”self-driving pods”) NOT (pedestrian wheelchair military business)	1
”Human machine interface” AND (”self-driving shuttle” OR ”self-driving shuttles”) NOT (pedestrian wheelchair military business)	1
”Human machine interface” AND (”self-driving driving” OR ”self-driving drivings”) NOT (pedestrian wheelchair military business)	0
”Human machine interface” AND (”self-driving transport” ”self-driving transit” ”self-driving transports” ”self-driving transits”) NOT (pedestrian wheelchair military business)	0
”Human machine interface” AND (”self-driving bus” OR ”self-driving buses”) NOT (pedestrian wheelchair military business)	2
”Human machine interface” AND (”cooperative Vehicle” OR ”cooperative Vehicles”) NOT (pedestrian wheelchair military business)	160
”Human machine interface” AND (”cooperative car” OR ”cooperative cars”) NOT (pedestrian wheelchair military business)	12
”Human machine interface” AND (”cooperative pod” OR ”cooperative pods”) NOT (pedestrian wheelchair military business)	0
”Human machine interface” AND (”cooperative shuttle” OR ”cooperative shuttles”) NOT (pedestrian wheelchair military business)	0
”Human machine interface” AND (”cooperative driving” OR ”cooperative drivings”) NOT (pedestrian wheelchair military business)	215
”Human machine interface” AND (”cooperative transport” ”cooperative transit” ”cooperative transports” ”cooperative transits”) NOT (pedestrian wheelchair military business)	6
”Human machine interface” AND (”cooperative bus” OR ”cooperative buses”) NOT (pedestrian wheelchair military business)	0

[2] Query was split in three time domains

[1] Query was split in two time domains

"Human machine interface" AND ("driverless Vehicle" OR "driverless Vehicles") NOT (pedestrian wheelchair military business)	121
"Human machine interface" AND ("driverless car" OR "driverless cars") NOT (pedestrian wheelchair military business)	78
"Human machine interface" AND ("driverless pod" OR "driverless pods") NOT (pedestrian wheelchair military business)	1
"Human machine interface" AND ("driverless shuttle" OR "driverless shuttles") NOT (pedestrian wheelchair military business)	1
"Human machine interface" AND ("driverless driving" OR "driverless drivings") NOT (pedestrian wheelchair military business)	9
"Human machine interface" AND ("driverless transport" "driverless transit" "driverless transports" "driverless transits") NOT (pedestrian wheelchair military business)	5
"Human machine interface" AND ("driverless bus" OR "driverless buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("Automated Vehicle" OR "Automated Vehicles") NOT (pedestrian wheelchair military business)	25
"Human Computer interface" AND ("Automated car" OR "Automated cars") NOT (pedestrian wheelchair military business)	12
"Human Computer interface" AND ("Automated pod" OR "Automated pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("Automated shuttle" OR "Automated shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("Automated driving" OR "Automated drivings") NOT (pedestrian wheelchair military business)	17
"Human Computer interface" AND ("Automated transport" "Automated transit" "Automated transports" "Automated transits") NOT (pedestrian wheelchair military business)	4
"Human Computer interface" AND ("Automated bus" OR "Automated buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("Autonomous Vehicle" OR "Autonomous Vehicles") NOT (pedestrian wheelchair military business)	175
"Human Computer interface" AND ("Autonomous car" OR "Autonomous cars") NOT (pedestrian wheelchair military business)	22
"Human Computer interface" AND ("Autonomous pod" OR "Autonomous pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("Autonomous shuttle" OR "Autonomous shuttles") NOT (pedestrian wheelchair military business)	1
"Human Computer interface" AND ("Autonomous driving" OR "Autonomous drivings") NOT (pedestrian wheelchair military business)	46
"Human Computer interface" AND ("Autonomous transport" "Autonomous transit" "Autonomous transports" "Autonomous transits") NOT (pedestrian wheelchair military business)	4
"Human Computer interface" AND ("Autonomous bus" OR "Autonomous buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("self-driving Vehicle" OR "self-driving Vehicles") NOT (pedestrian wheelchair military business)	12
"Human Computer interface" AND ("self-driving car" OR "self-driving cars") NOT (pedestrian wheelchair military business)	29
"Human Computer interface" AND ("self-driving pod" OR "self-driving pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("self-driving shuttle" OR "self-driving shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("self-driving driving" OR "self-driving drivings") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("self-driving transport" "self-driving transit" "self-driving transports" "self-driving transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("self-driving bus" OR "self-driving buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("cooperative Vehicle" OR "cooperative Vehicles") NOT (pedestrian wheelchair military business)	6
"Human Computer interface" AND ("cooperative car" OR "cooperative cars") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("cooperative pod" OR "cooperative pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("cooperative shuttle" OR "cooperative shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("cooperative driving" OR "cooperative drivings") NOT (pedestrian wheelchair military business)	6
"Human Computer interface" AND ("cooperative transport" "cooperative transit" "cooperative transports" "cooperative transits") NOT (pedestrian wheelchair military business)	2
"Human Computer interface" AND ("cooperative bus" OR "cooperative buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("driverless Vehicle" OR "driverless Vehicles") NOT (pedestrian wheelchair military business)	10
"Human Computer interface" AND ("driverless car" OR "driverless cars") NOT (pedestrian wheelchair military business)	14
"Human Computer interface" AND ("driverless pod" OR "driverless pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("driverless shuttle" OR "driverless shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("driverless driving" OR "driverless drivings") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("driverless transport" "driverless transit" "driverless transports" "driverless transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interface" AND ("driverless bus" OR "driverless buses") NOT (pedestrian wheelchair military business)	1
"Human machine interactions" AND ("Automated Vehicle" OR "Automated Vehicles") NOT (pedestrian wheelchair military business)	55
"Human machine interactions" AND ("Automated car" OR "Automated cars") NOT (pedestrian wheelchair military business)	11
"Human machine interactions" AND ("Automated pod" OR "Automated pods") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("Automated shuttle" OR "Automated shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("Automated driving" OR "Automated drivings") NOT (pedestrian wheelchair military business)	54
"Human machine interactions" AND ("Automated transport" "Automated transit" "Automated transports" "Automated transits") NOT (pedestrian wheelchair military business)	9
"Human machine interactions" AND ("Automated bus" OR "Automated buses") NOT (pedestrian wheelchair military business)	1
"Human machine interactions" AND ("Autonomous Vehicle" OR "Autonomous Vehicles") NOT (pedestrian wheelchair military business)	108
"Human machine interactions" AND ("Autonomous car" OR "Autonomous cars") NOT (pedestrian wheelchair military business)	27
"Human machine interactions" AND ("Autonomous pod" OR "Autonomous pods") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("Autonomous shuttle" OR "Autonomous shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("Autonomous driving" OR "Autonomous drivings") NOT (pedestrian wheelchair military business)	55
"Human machine interactions" AND ("Autonomous transport" "Autonomous transit" "Autonomous transports" "Autonomous transits") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("Autonomous bus" OR "Autonomous buses") NOT (pedestrian wheelchair military business)	0

"Human machine interactions" AND ("self-driving Vehicle" OR "self-driving Vehicles") NOT (pedestrian wheelchair military business)	9
"Human machine interactions" AND ("self-driving car" OR "self-driving cars") NOT (pedestrian wheelchair military business)	29
"Human machine interactions" AND ("self-driving pod" OR "self-driving pods") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("self-driving shuttle" OR "self-driving shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("self-driving driving" OR "self-driving drivings") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("self-driving transport" "self-driving transit" "self-driving transports" "self-driving transits") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("self-driving bus" OR "self-driving buses") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("cooperative Vehicle" OR "cooperative Vehicles") NOT (pedestrian wheelchair military business)	3
"Human machine interactions" AND ("cooperative car" OR "cooperative cars") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("cooperative pod" OR "cooperative pods") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("cooperative shuttle" OR "cooperative shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("cooperative driving" OR "cooperative drivings") NOT (pedestrian wheelchair military business)	10
"Human machine interactions" AND ("cooperative transport" "cooperative transit" "cooperative transports" "cooperative transits") NOT (pedestrian wheelchair military business)	2
"Human machine interactions" AND ("cooperative bus" OR "cooperative buses") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("driverless Vehicle" OR "driverless Vehicles") NOT (pedestrian wheelchair military business)	6
"Human machine interactions" AND ("driverless car" OR "driverless cars") NOT (pedestrian wheelchair military business)	11
"Human machine interactions" AND ("driverless pod" OR "driverless pods") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("driverless shuttle" OR "driverless shuttles") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("driverless driving" OR "driverless drivings") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("driverless transport" "driverless transit" "driverless transports" "driverless transits") NOT (pedestrian wheelchair military business)	0
"Human machine interactions" AND ("driverless bus" OR "driverless buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("Automated Vehicle" OR "Automated Vehicles") NOT (pedestrian wheelchair military business)	13
"Human Computer interactions" AND ("Automated car" OR "Automated cars") NOT (pedestrian wheelchair military business)	3
"Human Computer interactions" AND ("Automated pod" OR "Automated pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("Automated shuttle" OR "Automated shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("Automated driving" OR "Automated drivings") NOT (pedestrian wheelchair military business)	12
"Human Computer interactions" AND ("Automated transport" "Automated transit" "Automated transports" "Automated transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("Automated bus" OR "Automated buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("Autonomous Vehicle" OR "Autonomous Vehicles") NOT (pedestrian wheelchair military business)	55
"Human Computer interactions" AND ("Autonomous car" OR "Autonomous cars") NOT (pedestrian wheelchair military business)	15
"Human Computer interactions" AND ("Autonomous pod" OR "Autonomous pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("Autonomous shuttle" OR "Autonomous shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("Autonomous driving" OR "Autonomous drivings") NOT (pedestrian wheelchair military business)	28
"Human Computer interactions" AND ("Autonomous transport" "Autonomous transit" "Autonomous transports" "Autonomous transits") NOT (pedestrian wheelchair military business)	1
"Human Computer interactions" AND ("Autonomous bus" OR "Autonomous buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("self-driving Vehicle" OR "self-driving Vehicles") NOT (pedestrian wheelchair military business)	6
"Human Computer interactions" AND ("self-driving car" OR "self-driving cars") NOT (pedestrian wheelchair military business)	23
"Human Computer interactions" AND ("self-driving pod" OR "self-driving pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("self-driving shuttle" OR "self-driving shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("self-driving driving" OR "self-driving drivings") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("self-driving transport" "self-driving transit" "self-driving transports" "self-driving transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("self-driving bus" OR "self-driving buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("cooperative Vehicle" OR "cooperative Vehicles") NOT (pedestrian wheelchair military business)	3
"Human Computer interactions" AND ("cooperative car" OR "cooperative cars") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("cooperative pod" OR "cooperative pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("cooperative shuttle" OR "cooperative shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("cooperative driving" OR "cooperative drivings") NOT (pedestrian wheelchair military business)	4
"Human Computer interactions" AND ("cooperative transport" "cooperative transit" "cooperative transports" "cooperative transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("cooperative bus" OR "cooperative buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("driverless Vehicle" OR "driverless Vehicles") NOT (pedestrian wheelchair military business)	4
"Human Computer interactions" AND ("driverless car" OR "driverless cars") NOT (pedestrian wheelchair military business)	8
"Human Computer interactions" AND ("driverless pod" OR "driverless pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("driverless shuttle" OR "driverless shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("driverless driving" OR "driverless drivings") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("driverless transport" "driverless transit" "driverless transports" "driverless transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interactions" AND ("driverless bus" OR "driverless buses") NOT (pedestrian wheelchair military business)	0

”Human machine interfaces” AND (”Automated Vehicle” OR ”Automated Vehicles”) NOT (pedestrian wheelchair military business)	175
”Human machine interfaces” AND (”Automated car” OR ”Automated cars”) NOT (pedestrian wheelchair military business)	38
”Human machine interfaces” AND (”Automated pod” OR ”Automated pods”) NOT (pedestrian wheelchair military business)	1
”Human machine interfaces” AND (”Automated shuttle” OR ”Automated shuttles”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”Automated driving” OR ”Automated drivings”) NOT (pedestrian wheelchair military business)	161
”Human machine interfaces” AND (”Automated transport” ”Automated transit” ”Automated transports” ”Automated transits”) NOT (pedestrian wheelchair military business)	9
”Human machine interfaces” AND (”Automated bus” OR ”Automated buses”) NOT (pedestrian wheelchair military business)	4
”Human machine interfaces” AND (”Autonomous Vehicle” ”Autonomous Vehicles”) NOT (pedestrian wheelchair military business)	343
”Human machine interfaces” AND (”Autonomous car” OR ”Autonomous cars”) NOT (pedestrian wheelchair military business)	51
”Human machine interfaces” AND (”Autonomous pod” OR ”Autonomous pods”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”Autonomous shuttle” OR ”Autonomous shuttles”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”Autonomous driving” OR ”Autonomous drivings”) NOT (pedestrian wheelchair military business)	206
”Human machine interfaces” AND (”Autonomous transport” ”Autonomous transit” ”Autonomous transports” ”Autonomous transits”) NOT (pedestrian wheelchair military business)	9
”Human machine interfaces” AND (”Autonomous bus” OR ”Autonomous buses”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”self-driving Vehicle” OR ”self-driving Vehicles”) NOT (pedestrian wheelchair military business)	40
”Human machine interfaces” AND (”self-driving car” OR ”self-driving cars”) NOT (pedestrian wheelchair military business)	46
”Human machine interfaces” AND (”self-driving pod” OR ”self-driving pods”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”self-driving shuttle” OR ”self-driving shuttles”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”self-driving driving” OR ”self-driving drivings”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”self-driving transport” ”self-driving transit” ”self-driving transports” ”self-driving transits”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”self-driving bus” OR ”self-driving buses”) NOT (pedestrian wheelchair military business)	1
”Human machine interfaces” AND (”cooperative Vehicle” OR ”cooperative Vehicles”) NOT (pedestrian wheelchair military business)	24
”Human machine interfaces” AND (”cooperative car” OR ”cooperative cars”) NOT (pedestrian wheelchair military business)	3
”Human machine interfaces” AND (”cooperative pod” OR ”cooperative pods”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”cooperative shuttle” OR ”cooperative shuttles”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”cooperative driving” OR ”cooperative drivings”) NOT (pedestrian wheelchair military business)	40
”Human machine interfaces” AND (”cooperative transport” ”cooperative transit” ”cooperative transports” ”cooperative transits”) NOT (pedestrian wheelchair military business)	9
”Human machine interfaces” AND (”cooperative bus” OR ”cooperative buses”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”driverless Vehicle” OR ”driverless Vehicles”) NOT (pedestrian wheelchair military business)	12
”Human machine interfaces” AND (”driverless car” OR ”driverless cars”) NOT (pedestrian wheelchair military business)	27
”Human machine interfaces” AND (”driverless pod” OR ”driverless pods”) NOT (pedestrian wheelchair military business)	0
”Human machine interfaces” AND (”driverless shuttle” OR ”driverless shuttles”) NOT (pedestrian wheelchair military business)	1
”Human machine interfaces” AND (”driverless driving” OR ”driverless drivings”) NOT (pedestrian wheelchair military business)	2
”Human machine interfaces” AND (”driverless transport” ”driverless transit” ”driverless transports” ”driverless transits”) NOT (pedestrian wheelchair military business)	9
”Human machine interfaces” AND (”driverless bus” OR ”driverless buses”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”Automated Vehicle” OR ”Automated Vehicles”) NOT (pedestrian wheelchair military business)	34
”Human Computer interfaces” AND (”Automated car” OR ”Automated cars”) NOT (pedestrian wheelchair military business)	15
”Human Computer interfaces” AND (”Automated pod” OR ”Automated pods”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”Automated shuttle” OR ”Automated shuttles”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”Automated driving” OR ”Automated drivings”) NOT (pedestrian wheelchair military business)	23
”Human Computer interfaces” AND (”Automated transport” ”Automated transit” ”Automated transports” ”Automated transits”) NOT (pedestrian wheelchair military business)	3
”Human Computer interfaces” AND (”Automated bus” OR ”Automated buses”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”Autonomous Vehicle” OR ”Autonomous Vehicles”) NOT (pedestrian wheelchair military business)	114
”Human Computer interfaces” AND (”Autonomous car” OR ”Autonomous cars”) NOT (pedestrian wheelchair military business)	13
”Human Computer interfaces” AND (”Autonomous pod” OR ”Autonomous pods”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”Autonomous shuttle” OR ”Autonomous shuttles”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”Autonomous driving” OR ”Autonomous drivings”) NOT (pedestrian wheelchair military business)	50
”Human Computer interfaces” AND (”Autonomous transport” ”Autonomous transit” ”Autonomous transports” ”Autonomous transits”) NOT (pedestrian wheelchair military business)	4
”Human Computer interfaces” AND (”Autonomous bus” OR ”Autonomous buses”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”self-driving Vehicle” OR ”self-driving Vehicles”) NOT (pedestrian wheelchair military business)	6
”Human Computer interfaces” AND (”self-driving car” OR ”self-driving cars”) NOT (pedestrian wheelchair military business)	15
”Human Computer interfaces” AND (”self-driving pod” OR ”self-driving pods”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”self-driving shuttle” OR ”self-driving shuttles”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”self-driving driving” OR ”self-driving drivings”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”self-driving transport” ”self-driving transit” ”self-driving transports” ”self-driving transits”) NOT (pedestrian wheelchair military business)	0
”Human Computer interfaces” AND (”self-driving bus” OR ”self-driving buses”) NOT (pedestrian wheelchair military business)	0

"Human Computer interfaces" AND ("cooperative Vehicle" OR "cooperative Vehicles") NOT (pedestrian wheelchair military business)	4
"Human Computer interfaces" AND ("cooperative car" OR "cooperative cars") NOT (pedestrian wheelchair military business)	1
"Human Computer interfaces" AND ("cooperative pod" OR "cooperative pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("cooperative shuttle" OR "cooperative shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("cooperative driving" OR "cooperative drivings") NOT (pedestrian wheelchair military business)	4
"Human Computer interfaces" AND ("cooperative transport" "cooperative transit" "cooperative transports" "cooperative transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("cooperative bus" OR "cooperative buses") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("driverless Vehicle" OR "driverless Vehicles") NOT (pedestrian wheelchair military business)	7
"Human Computer interfaces" AND ("driverless car" OR "driverless cars") NOT (pedestrian wheelchair military business)	4
"Human Computer interfaces" AND ("driverless pod" OR "driverless pods") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("driverless shuttle" OR "driverless shuttles") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("driverless driving" OR "driverless drivings") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("driverless transport" "driverless transit" "driverless transports" "driverless transits") NOT (pedestrian wheelchair military business)	0
"Human Computer interfaces" AND ("driverless bus" OR "driverless buses") NOT (pedestrian wheelchair military business)	0
Total	15,445

Appendix B1: Experimental studies

Table 18. This Table shows the experimental studies and their experiments sorted on alphabetical order. The experimental studies are categorized in this Table categorized in year, country, SAE level, Simulator's Immersion, Simulator's Configuration, Simulator's software and Simulator's Hardware. The countries are coded in ISO 3166-1 alpha-2. Some studies published multiple experiments. The rows under these studies are used to categorize its experiments and doesn't show the number of the study, the author, the publishing year and tha publishing country. For example, Blanco published in 2016 a study with 3 experiments, so the study has 3 rows in the table.

#	Author	Year	Country	SAE level						Simulator			
				0	1	2	3	4	5	Immersion	Configuration	Software	Hardware
1	Ahmed, Gaweesh & Yang	2019	US	x						SIVR<180	3DOF		
2	Albert, Lange, Schmidt, Wimmer & Bengler	2015	DE				x			Live simulation			Audi A7
3	Ariansyah, Caruso, Ruscio & Bordegoni	2018	IT	x						SIVR<180	FB	Unity 3D	
4	Bauerfeind et al	2017	DE				x			SIVR<180	FB	Virtual Test Drive	Audi mockup
5	Befelein, Boschet & Neukum	2018	DE				x			SIVR>180	FB	SILAB	Opel Insignia (mockup)
6	Beggiato & Krems	2013	DE		x					SIVR<180	FB	STISIM Drive	BMW 350i (mockup)
7	Beggiato et al	2015	DE	x		x		x		SIVR>180	FB	SILAB	Dikablis
8	Benloucif et al	2016	FR				x			SIVR>180	6DOF		Peugeot 206 (mockup)
9	Biondi, Goethe, Cooper & Strayer	2017	US			x				Live simulation			Honda Accord XL (2016)
10	Biondi, Leo, Gastaldi, Rossi & Mulatti	2017	US	x									
				x									
11	Biondi, Strayer, Rossi, Gastaldi & Mulatti	2017	GB IT US	x						SIVR>180	FB		PatrolSim
				x						SIVR>180	FB		PatrolSim
12	Blanco et al	2016	US			x				Live simulation			Chevrolet Malibu (2007)
						x				Live simulation			Cadillac SRX (2010)
							x			Live simulation			Lexus (2012)
13	Blanco et al	2015	US			x				Live simulation			Chevrolet Malibu (2009)
						x				Live simulation			Cadillac SRX (2010)
							x			Live simulation			Lexus RX450h (2012)
14	Blömacher, Nöcker & Huff	2018	DE				x			NIVR	FB		
15	Bouquier	2016	FR	x						NIVR	FB		
16	Bout, Brenden, Klingegård, Habibovic & Böckle	2017	SE						x	TIVR	FB	Unity 3D	HTC VIVE
17	Brandt, Sattel & Bohm	2007	DE	x						SIVR<180	FB	C++	Force Feedback wheel
18	Braunagel, Rosenstiel & Kasneci	2017	DE				x			TIVR	6DOF		Mercedes-Benz E-class W212 (mockup), Dikablis
19	Brockmann, Allgaier, Timofeev & Becker	2016	DE	x						SIVR>180	FB		
20	Butmee & Lansdown	2017	GB	x	x	x				NIVR	FB		
21	Clark, Stanton & Revell	2018	GB				x	x		SIVR<180	FB		
22	Cramer & Klohr	2019	DE			x				Live simulation			Audi A5 (2012)
23	Damböck, Kienle, Bengler & Bubb	2011	DE	x		x	x			NIVR	FB	SILAB	
24	De Nijs	2011	NL	x						NIVR	FB		
25	Diels & Thompson	2017	GB					x		NIVR	FB		Vehicle mockup
26	Dogan et al	2017	FR			x				SIVR<180	FB	SCANeR© II	Facelab eye tracker, Vehicle mockp
27	Dziennus, Kelsch & Schieben	2016	DE	x						SIVR>180	FB		LED strip
28	Ekman, Johansson & Sochor	2018	SE			x							
29	Ekman, Johansson & Sochor	2016	SE				x			Live simulation			
30	Eom	2015	KR			x				SIVR<180	FB	PreScan	Logitech G27
31	Ercan, Carvalho, Gokasan & Borrelli	2017	TR	x									
32	Eriksson & Stanton	2017	GB				x			SIVR<180	FB	STISIM Drive Version 3	Jaguar XJ 350 (Mockup)
33	Fagerlönn, Lindberg & Sirkka	2015	SE	x									
34	Faltaous, Baumann, Schneegass & Chuang	2018	DE				x			SIVR<180		Unity3D	LED strip
35	Farah /& Koutsopoulos	2012	SE	x						Live simulation			Audi A4
36	Farooq et al	2014	FI	x						Live simulation			Volvo XC60
37	Feenstra	2006	NL		x					SIVR>180	moving		
38	Feldhütter, Gold, Hüger & Bengler	2016	DE					x	x	SIVR>180	FB		BMW 6 series (mockup)
39	Feldhütter, Gold, Schneider & Bengler	2017	DE				x			SIVR>180	FB		Vehicle mockup
40	Feldhütter, Härtwig, Kurpiers, Hernandez & Bengler	2018	DE			x	x			SIVR>180	FB		BMW 5 series (half-mockup), Dikablis Essentials
41	Feldhütter, Segler & Bengler	2017	DE			x	x			NIVR	FB	Unity3D	
42	Feuerstack, Wortelen, Kettwich & Schieben	2016	DE		x								
43	Flemisch et al	2008	DE				x			SIVR>180	6DOF		
44	Forster et al	2019	DE			x	x			SIVR>180	6DOF		BMW 5 series (mockup)
45	Forster, Naujoks & Neukum	2017	DE				x			SIVR>180	6DOF	SILAB	BMW 520i (half-mockup)
46	Forster, Naujoks & Neukum	2016	DE				x			SIVR<180	FB	SILAB	
47	Forster, Naujoks, Neukum & Huestegged	2017	DE				x			SIVR>180	6DOF	SILAB	BMW 520i (mockup)
48	Forsyth & MacLean	2006	CA	x									
49	Frison, Wintersberger, Liu & Riener	2019	DE					x			moving	IPG CarMaker	
50	Gauerhof, Kürzl & Lienkamp	2015	DE	x						SIVR<180	FB	SILAB 4.0	Epson Moverio BT-200
51	Gold, Körber, Hohenberger, Lechner & Bengler	2015	DE				x			SIVR>180	FB		BMW 6 series (mockup)
52	Govindarajan & Bajcsy	2017	US	x						SIVR<180	FB	PreScan	
53	Griffiths & Gillespie	2004	US	x						NIVR	FB		
				x						NIVR	FB		
54	Guo et al	2017	FR				x			SIVR<180			
55	Habibovic, Andersson, Nilsson, Nilsson & Edgren	2017	US					x		SIVR<180	FB		
56	Haspiel et al	2018	US				x			SIVR>180	FB		Nissan Versa (mockup)
57	Häuslschmid, von Buelow, Pfleging & Butz	2017	DE						x	NIVR	FB		Volkswagen Pasat (mockup)
58	Hernandez	2018	BR	x						SIVR<180	FB	Blender	G27 joystick
59	Hesse et al	2013	DE				x			SIVR>180	6DOF		Volkswagen Golf (mockup)
				x						Live simulation			Volkswagen Pasat
							x			0	6DOF		Volkswagen Golf (mockup)
60	Hirokawa, Uesugi, Furugori, Kitagawa & Suzuki	2012	JP	x						SIVR>180	FB		1/10 scaled robot car (ZMP corparation)
61	Hirsch, Diederichs, Widlroither, Graf & Bischoff	2017	DE				x			SIVR>180	FB	SILAB	Porsche Macan (mockup)
62	Hoc et al	2006	FR	x	x					Live simulation			Renault Scenic
				x	x					Live simulation			Renault Scenic
63	Hock, Kraus, Walch, Lang & Baumann	2016	DE				x			TIVR	FB	Unity3D	Oculus Rift DK2, Logitech G27
64	Hofauer et al	2018	DE	x	x					SIVR<180	FB		
65	Holländer & Pfleging	2018	DE				x			NIVR	FB	OpenDS	Logitech G27

66	Howard et al	2013	US	x						SIVR>180	FB		
67	Jiménez et al	2018	ES				x			NIVR	FB		The Model 504 Ocular system log
				x						Live simulation			Tobii Pro Glasses 2
68	Johns, Mok, Talamonti, Sibi & Ju	2017	US			x				SIVR>180			LED strip
69	Karatas, Tamura, Fushiki & Okada	2018	JP					x		SIVR<180	FB	UC-win Road	
70	Katzourakis, Velenis, Holweg & Happee	2014	SE & NL	x						Live simulation			Opel Astra
71	Kelsch, Dziennus & Köster	2015	DE	x						SIVR>180	FB		
72	Kerschbaum, Lorenz & Bengler	2015	DE				x			SIVR>180	moving		BMW 5 series (mockup)
73	Kienle, Damböck, Bubb & Bengler	2013	DE	x						NIVR	6DOF	SILAB	Vehicle mockup
74	Kim, Jeong, Yang, Oh & Kim	2017	KR			x	x			NIVR	FB	Matlab	Logitech G27
75	Kim, Kim & Han	2016	KR				x						
76	Kuehn, Vogelpohl & Vollrath	2017	DE				x			SIVR>180	FB	SILAB	
77	Langlois, Nguyen & Mermillod	2016	FR	x						SIVR>180			Vehicle mockup
78	Langner et al	2016	DE	x						Live simulation			SMI glasses
79	Lapoehn et al	2016	DE					x		TIVR			Volkswagen Pasat (mockup)
80	Large, Banks, Burnett, Baverstock & Skrypchuk	2017	GB	x		x	x			NIVR	FB		Honda Civic
81	Lau, Harbluk, Burns & Yue El-Hage	2018	CA				x			SIVR<180	FB		NANDS
82	Lee & Eom	2015	KR		x						FB	TNO PreScan	Logitech G27
83	Lee et al	2016	KR			x				Live simulation			Kia K7
84	Li, Blythe, Guo, Namdeo	2018	GB				x			SIVR>180	FB		
85	Llaneras, Cannon & Green	2017	US			x				Live simulation			Cadillac SRX 2010
86	Manawadu et al	2018	JP				x			SIVR>180	FB		
87	Manawadu, Hayashi, Kamezaki & Sugano	2017	JP				x			SIVR>180	FB		
88	McCall & Trivedi	2007	US	x						Live simulation			
89	Merat & Jamson	2009	GB	x		x				SIVR>180	8DOF		
90	Mok, Johns, Yang & Ju	2017	US			x				SIVR>180	FB		Toyota Avalon (mock up), Led strip
91	Morgan, Voinescu, Alford & Caleb-Solly	2018	GB					x	x	NIVR	FB		Lutz Pod (half mockup)
92	Mueller, Ogrizek, Bier & Abendroth	2018	DE				x			SIVR>180	FB	SILAB 5.1	Chevrolet Avero (mockup)
							x			SIVR>180	FB	SILAB 5.1	Chevrolet Avero (mockup)
							x			SIVR>180	FB	SILAB 5.1	Chevrolet Avero (mockup)
93	Mulder, Abbink & Boer	2012	NL		x					NIVR	FB		
94	Naujoks, Forster, Wiedemann & Neukum	2017	DE				x			SIVR<180	FB	SILAB	
95	Naujoks, Forster, Wiedemann & Neukum	2017	DE				x			SIVR>180	6DOF	SILAB	BMW 520i (half-mockup)
96	Naujoks, Forster, Wiedemann & Neukum	2016	DE					x	x		moving	SILAB	
97	Naujoks, Höfling, Purucker & Zeeb	2018	DE			x		x		SIVR>180	6DOF	SILAB	BMW 520i (half-mockup)
98	Naujoks, Mai & Neukum	2014	DE				x			SIVR>180	6DOF		
99	Nilsson, Strand, Falcone & Vinter	2013	SE		x					NIVR	6DOF		Volvo S80 (cabin)
100	Niu, Terken & Eggen	2018	CN					x		SIVR>180	FB	Greendino	
101	Olaverri-Monreal, Kumar, Dìaz-Àlvarez	2018	AT				x						
102	Othersen, Petermann-Stock, Schoemig & Fuest	2018	DE				x				FB		
103	Payre & Diels	2017	GB	x									
104	Payre, Cestac & Delhomme	2016	FR				x			TIVR	FB		Vehicle mockup
105	Petchbordee	2016	KR				x			NIVR	FB		Logitech Momo
106	Petermeijer	2017	DE	x						SIVR<180	FB		Vibrotactil seat
							x			SIVR>180	FB	SILAB	Vibrotactile seat, BMW 5 Series (mockup)
							x			SIVR>180	FB	SILAB	Vibrotactile seat, BMW 6 Series (mockup)
							x			SIVR>180	FB	SILAB	Vibrotactile seat, BMW 5 Series (mockup)
							x			SIVR>180	FB	SILAB	Vibrotactile seat, BMW 6 Series (mockup)
107	Petermeijer, Doubek & de Winter	2017	DE				x			SIVR>180	FB	SILAB	BMW 6 series (mockup)
108	Pfleging	2017	DE	x						Live simulation			
						x				NIVR	FB	CARS, OpenDS	Logitech G27
						x				NIVR	FB	CARS, OpenDS	Logitech G27
109	Politis, Brewster & Pollick	2017	GB				x			NIVR	FB		Logitech G27
110	Preuk, Stemmler & Jipp	2016	DE	x						SIVR<180	FB		Vehicle mockup
111	Rezvani et al	2016	US				x	x		SIVR<180	4DOF	PreScan	
112	Risto & Martens	2013	NL		x					Live simulation			Toyota Prius
113	Rittger & Götze	2018	DE	x									
				x							FB		
				x						SIVR>180	FB		
				x									
				x						NIVR	FB		BMW X5 (mockup)
				x									
				x						SIVR>180	FB		
114	Rittger, Schmidt, Wiedemann, Schömig & Green	2017	DE			x				Live simulation			Opel Insignia
						x				Live simulation			Opel Insignia
115	Ruijten, Terken & Chandramouli	2018	NL					x		SIVR<180	FB		
116	Sadeghian Borojeni, Boll, Heuten, Bülthoff & Chuang	2018	DE				x			SIVR<180	8DOF	CarSIM	
117	Saffarian, Happee, Abbink & Mulder	2010	NL		x					SIVR>180	FB		
					x					SIVR>180	FB		
118	Sandhaus & Hornecker	2018	DE						x	Live simulation			Nissan Cube, Android tablet, LED strip
119	Sbîrcea	2017	GB						x	NIVR	FB	OpenDS	
120	Schartmüller, Riener & Wintersberger	2018	DE				x			NIVR	6DOF		
121	Schwalk, Kalogerakis & Maier	2015	DE	x						SIVR<180	FB	LabView	Vibrotactile seat,
122	Sentouh, Popieul, Debernard & Boverie	2014	FR	x	x	x							
123	Seppelt & Lee	2019	GB		x					SIVR<180	FB		
				x	x					SIVR<180	FB		
124	Shakeri, Williamson & Brewster	2018	GB	x						NIVR	FB	OpenDS	ogitech steeringwheel
125	Shen	2016	US			x				SIVR<180	FB		Minsim
				x		x				SIVR<180	FB		Minsim
				x		x				TIVR	13DOF		Minsim
126	Siebert, Oehl, Höger & Pfister	2013	DE					x	x				
127	Sonoda & Wada	2017	JP					x	x	SIVR<180	FB	Unity3D	DIY Torque wheel,
128	Staubach et al	2012	DE	x						SIVR>180	6DOF		
129	Steinberger, Schroeter, Foth & Johnson	2017	AU	x						SIVR>180	6DOF		
				x						SIVR>180	6DOF		
				x						SIVR>180	6DOF		
130	Strand	2014	SE	x	x	x							
					x								
					x					SIVR<180	6DOF		Chalmers
					x	x				SIVR>180	8DOF		VTI's Sim IV
131	Takada, Boer & Sawaragi	2017	US	x						Live simulation			Nissan (mockup)

132	Talamonti	2017	US	x		x	x			SIVR>180	6DOF		
				x	x					SIVR>180	6DOF	Blue Newt Software	Ford Edge 2007 (mockup)
				x	x					SIVR>180	6DOF	Blue Newt Software	Ford Edge 2007 (mockup)
						x				SIVR>180	6DOF	Blue Newt Software	Ford Edge 2007 (mockup)
				x		x				SIVR>180	6DOF	Blue Newt Software	Ford Edge 2007 (mockup)
133	Talamonti et al	2017	US		x					SIVR>180	6DOF	Blue Newt Software	Ford Edge 2007 (mockup)
134	Telpaz et al	2017	IL				x			SIVR<180	FB		NADS
135	Tijerina & Curry	2014	US	x	x					SIVR>180	6DOF		Ford VIRTTEX, Ford mockup
136	Toyoda, Domeyer & Lenneman	2017	US				x			Live simulation			
137	Tscharn, Latoschik, Löffler & Hurtienne	2017	DE					x		SIVR<180	FB	Unity 3D	
138	van der Heiden et al	2018	NL	x				x		NIVR	FB	OpenDS	Logitech G27
139	van Veen, Karjanto & Terken	2017	NL	x						Live simulation			AmbiGlasses, eye-q
140	Vlakveld et al	2018	NL				x			SIVR>180	FB		
141	Vogelpohl, Kühn, Hummel & Vollrath	2018	DE				x			SIVR>180	FB	SILAB 5	
142	Voinescu, Morgan, Alford & Caleb-Solly	2018	GB						x				
143	Walch, Lange, Baumann & Weber	2015	DE				x			SIVR<180	FB		Logitech G27
144	Walch, Sieber, Hock, Baumann & Weber	2016	DE				x			SIVR<180	FB	Unity3D	Logitech G27
145	Wandtner, Schömig & Schmidt	2018	DE				x			SIVR>180	6DOF		
146	Wandtner, Schömig & Schmidt	2018	DE				x			SIVR>180	6DOF		
147	Wang et al	2014	CN	x						SIVR<180	FB	UC-Win/Road Ver.8 Standard	
148	Wang, Zheng, Kaizuka & Nakano	2017	JP	x						SIVR<180	6DOF		
149	Wang, Zheng, Kaizuka, Shimono & Nakano	2016	JP	x						SIVR<180	6DOF		
150	Wiedemann et al	2018	DE				x			SIVR>180	moving	SILAB	BMW 520i (mockup)
151	Wulf, Rimini-Döring, Arnon & Gauterin	2015	DE			x				SIVR>180	FB		Half vehicle mockup
152	Wulf, Zeeb, Rimini-Döring, Arnon & Gauterin	2013	DE				x			SIVR>180	FB		vehicle half mockup
153	Yan, Weber & Luedtke	2014	DE			x							
154	Young & Stanton	2007	GB	x	x	x				NIVR	FB		Ford Orion (half mockup)
	Total			**73**	**25**	**39**	**69**	**18**	**10**				
	Total in %			**38**	**13**	**20**	**36**	**9.3**	**5.2**				

Table 19. This Table is an extension of Table 18 and shows the experimental studies and their experiments categorized in interaction and variables. The experimental studies have the same number as in Table 18.

#	Interaction					Variables						Experiment type
	Visual	Auditory	Vibrotactile	Haptic	Other	HMI types	NDT	Automation	Environment	Participant Types	Other	
1	x					x						Simulation
2	x					x						Test Track Study
3									x			Simulation
4						x				x		Simulation
5	x	x					x					Simulation
6									x			Simulation
7	x	x						x				Simulation
8							x	x				Simulation
9	x							x				Field Test
10	x	x	x			x	x					Simulation
		x	x			x	x					Simulation
11		x	x			x					x	Simulation
						x					x	Simulation
12	x	x	x			x						Test Track Study
	x	x	x			x						Test Track Study
						x						Test Track Study
13	x			x		x						Test Track Study
	x			x		x						Test Track Study
	x	x				x						Test Track Study
14									x			Simulation
15	x					x						Simulation
16						x						PR
17	x			x				x	x			Simulation
18	x	x						x	x			Simulation
19	x	x		x				x	x			Simulation
20	x							x				Simulation
21		x							x			Simulation
22					x	x						Test Track Study
23	x			x		x						Simulation
24	x			x		x			x			Simulation
25	x							x				Simulation
26	x	x				x						Simulation
27	x					x			x			Simulation
28						x						Simulation
29	x					x						WoO
30	x							x				Simulation
31				x		x				x		Simulation
32	x						x					Simulation
33	x	x				x						Simulation
34	x								x			Simulation
35	x							x				Field Test
36	x	x	x		x	x						
37	x			x		x		x				Simulation
38	x										x	Simulation
39		x					x					Simulation
40	x							x				Simulation
41	x					x						Simulation
42	x					x						Simulation
43				x				x				Simulation
44	x							x				Simulation
45	x	x				x						Simulation
46	x					x						Simulation
47	x	x				x						Simulation
48				x		x			x			Simulation
49	x								x			Simulation
50	x							x	x		x	Simulation
51	x	x							x	x		Simulation
52									x			Simulation
53				x				x				Simulation
				x				x				Simulation
54	x								x			Simulation
55	x					x						WoO
56						x						Simulation
57	x					x						Simulation
58		x						x				Simulation
59	x			x				x				Simulation
				x		x		x				Test Track Study
				x		x						Simulation
60								x				Simulation
61	x	x									x	Simulation
62	x							x				Test Track Study
		x		x				x				Test Track Study
63	x	x				x			x			Simulation
64	x					x						Simulation
65	x					x						Simulation
66	x		x			x						Simulation
67							x					Simulation
									x			Field Test
68	x			x		x						Simulation
69	x					x						Simulation
70				x		x						Test Track Study
71	x								x			Simulation
72						x			x			Simulation
73	x			x		x		x				Simulation
74	x					x						Simulation

75			x							x	Simulation
76	x	x				x					Simulation
77	x				x						Simulation
78	x				x						
79	x	x			x						Simulation
80	x					x	x				Simulation
81	x	x			x						Simulation
82					x						Simulation
83									x		Field Test
84	x	x						x	x		Simulation
85	x	x		x	x				x		Test Track Study
86	x			x	x						Simulation
87	x			x	x						Simulation
88											Field Test
89	x	x					x				Simulation
90	x	x			x						WoO
91		x						x			Simulation
92			x		x						Simulation
	x				x						Simulation
	x	x	x		x						Simulation
93				x			x		x		Simulation
94	x				x						Simulation
95	x	x							x		Simulation
96	x	x			x						Simulation
97	x					x	x				Simulation
98	x	x			x			x		x	Simulation
99										x	Simulation
100	x				x						Simulation
101	x	x			x						Simulation
102	x					x		x			Simulation
103	x				x						Simulation
104	x	x			x			x			Simulation
105	x	x			x				x		Simulation
106			x		x						Simulation
	x	x	x		x						Simulation
	x	x	x		x						Simulation
			x		x	x					Simulation
	x		x		x						Simulation
107	x	x	x		x						Simulation
108								x			Field Test
										x	Simulation
										x	Simulation
109	x	x			x						Simulation
110					x						Simulation
111	x	x			x						Simulation
112	x	x						x			Field Test
113	x							x			Simulation
					x						Simulation
	x				x						Simulation
	x			x	x						Simulation
	x				x						Simulation
	x			x	x						Simulation
	x				x						Simulation
114	x				x						WoO
	x				x						WoO
115	x				x						Simulation
116	x	x			x			x			Simulation
117	x			x	x			x			Simulation
	x				x						Simulation
118	x				x						WoO
119	x									x	WoO
120	x	x			x						Simulation
121			x		x				x		Simulation
122	x	x		x			x				Simulation
123	x	x			x						Simulation
	x	x			x						Simulation
124	x	x			x						Simulation
125	x						x				Simulation
	x					x	x				Simulation
	x	x			x	x	x				Simulation
126								x			Simulation
127	x		x		x						Simulation
128	x			x	x						Simulation
129	x				x						Simulation
	x				x						Simulation
	x				x						Simulation
130									x		Simulation
								x			Simulation
										x	Simulation
										x	Simulation
131				x			x				Test Track Study
132	x	x			x						Simulation
				x			x				Simulation
				x			x				Simulation
	x	x		x		x	x				Simulation
	x	x		x			x				Simulation
133				x	x						Simulation
134	x	x	x		x						Simulation
135	x	x			x						Simulation
136	x						x				Test Track Study
137	x									x	WoO

138		x				x						Simulation
139	x					x						WoO
140	x	x									x	Simulation
141	x	x						x			x	Simulation
142	x					x						Simulation
143	x	x				x						Simulation
144	x	x				x						Simulation
145	x	x				x						Simulation
146	x					x						Simulation
147	x	x				x						Simulation
148				x		x						Simulation
149				x		x						Simulation
150	x	x									x	Simulation
151	x					x						Simulation
152	x					x	x		x			Simulation
153		x									x	Simulation
154										x		Simulation
Total	**131**	**65**	**19**	**36**	**2**	**116**	**16**	**39**	**33**	**12**	**18**	
Total in %	**68**	**34**	**9.8**	**19**	**1.0**	**60**	**8.3**	**20**	**17**	**6.2**	**9.3**	

Table 20. This Table is an extension of Table 18 and shows the experimental studies and their experiments categorized in Participants' data and environment. The experimental studies have the same number as in Table 18.

#	Participants							Environment						
	Amount			Age										
	Total	Male	Female	Mean	SD	Min	Max	HW[lanes]	Rural	Urban	Track	PR	LC	Other
1	23							x						
2	37	31	6	32.47	5.41	25	46	x			x		x	
3	14	13	1	25.9	4.4				x					
4	47	27	20	38.6	15.4	22	59	x					x	
5	58	30	28	32.3	9.7	19	54	x						
6	51	25	26	24	2.37			2					x	Bad Weather
7	20	9	11	30	7.1	25	47	x					x	
8	9	7	2						x					
9	10	1	9	25	3							x		
10	18			23	3									
	26	10	16	20	1.5									
11	22			25	6			4						
	22	6	16	27	8.9									
12	25										x			
	56										x			
	25										x			
13	25	16	9	44.3	19.24	18	72				x			
	56	28	28	41	16.3	18	72				x			
	25	17	8	38.8	13.77	18	69				x			
14	119	51	68	39.4	11.78	19	65	x					x	
15														
16	12	10	2						x					
17	16	8	8	35		18	60						x	
18	81	45	36	38	11	20	58	3					x	
19	24	12	12	41.6	11.3	24	59	3						
20	160								x				x	
21	40	29	11	31.1	10.07	18	61	x						
22	39	20	19	35.1	9.1	24	63				x			Oval Track
23	16	13	3	29.5	5.3				x					
24	12	10	2	24	2.6									
25	38							x	x	x			x	
26	28	20	8	38.5	12.8			2						
27	41	20	21	36.8	14.13	19	64	3						
28	9	5	4			22	55							
29	8	7	1			19	28				x			
30	40	30	10	36.54	13.67	20	65			x				
31	5					25	30							
32	26	16	10	30.27	8.52	20	52	3						
33	18	10	8	38.5	11.8	25	66							
34	20	14	6	29.65	8.86	19	57		x				x	
35	35	20	15					x						
36	8	6	2											
37	32							3					x	
38	28	14	14	24.04	2.08	21	28							
39	30	16	14	24.17	2.09	21	28	3						
40	45	35	10	39.04	5.98			2					x	
41	49	34	15	34.65	9.92			3					x	
42	12	6	6			23	49			x				
43	10	5	5	32.7		18	59	x						Automation Failure
44	55	41	14	31.64	9.97	20	62	3					x	
45	17	10	7	29	8.12	22	56	3					x	
46	6	3	3	29.5	4.2			3					x	
47	17	10	7	29	8.12	22	56	3						Bad Weather
48	18	12	6			19	33							
49	30	21	9	26.87	3.98			3	x	x				
50	23			25.4	1.79	21	28	x		x			x	Oval Track
51	69			44.97	22.16			x		x			x	
52	6	3	3			23	36			x				
53	11	9	2			20	63	x					x	
	11	9	2			20	63							
54	22			41.3		24	61	2						
55	17	9	8											
56	8	3	5	25.7	2.36									
57	30	28	12	26	5.9					x				
58	20	13	7	27.2	3.65			2					x	
59	40								x				x	
	45	27	18	30.4	9.9					x			x	
	57								x				x	
60	8	7	1			12	30			x				
61	44	24	20	37.59	14.58	20	72	x					x	
62	12	10	2								x			
	20			34		24	50				x			
63	38	13	25	24	3.54				x					
64	19									x				
65	24	13	11	29.58	11.87	21	64	x	x					
66	4							x						
67	21	8	13	23.95	5.72									
	8											x		
68	60	40	20	43.3	21.52			2					x	
69	22	19	3	24.82	6.31	19	40			x				
70	17	15	2	33.1	6.6						x			
71	8	4	4	32	14.8			2					x	
72	67	48	17	31	8.2	21	60	3					x	
73	18	13	5	30.33	7.8				x					
74	57	36	21											

75														
76	60	38	22			20	76	2						
77	24	18	6	36	9	24	55	3						
78										x				
79	33	17	16	26	10.49	18	64	3					x	
80	30	18	12	35.9				3						
81	32	14	18	34.5	9.27	20	58	2					x	
82	40					20	65			x				
83	6	3	3	34.2	11.3	25	58					x		
84	76	43	33	49.21	23.32	20	81		x				x	
85	25	13	12			22	25				x			
86	11	6	5	28.6	4.2					x			x	
87	11	6	5	28.6	4.2					x				
88	28								x	x		x		
89	39	20	19	41		23	63			x				
90	56	29	27	29.3	11.1	18	75		x					
91	31			67.52	7.29	47	88		x	x				
92	21	15	6	27.3	9.5			x		x				
	19	14	5	24.7	5.7			x						
	30	22	8	33.2	6.8			x						
93	34					20	75		x					
94	6	3						3						
95	17	10	7	29	8.1	22	56	3					x	
96	20			29	8.1	22	56	3					x	
97	64	34	30	33	10			3						
98	16												x	
99	48			40.5	9.83	25	59	x						
100	39	24	15	27.21	7.22									
101	24	15	9	27.32	9.6								x	
102	64	41	23	36				3						
103	21	13	8	22.5	5.4									
104	69	37	32	38.5	14.9	20	75		x					
105	12					24	30	3						
106	12	7	5	24.2	3.1	19	31							
	101	70	31	24.7		17	39							
	24	16	8	27.9	3	24	35						x	
	18	13	5	43	15.2	22	78						x	
	25	14	11	25.7	3.9	19	36						x	
107	101	70	31	24.7		17	39	2					x	
108	10	7	3	35.6	9.06	23	57					x		
	12	10	2	28.2	6.58	20	39	2					x	
	16	16	0	23.8	2.35	21	29							
109	20	13	7	25.25	5.67	20	45	3					x	
110	60	40	20	30.6	10.8	20	78			x				
111	10	6	4			18	61		x				x	
112	13	11	2	52.9	10.8	27	66	2 & 3				x		
113	32									x				
	36									x				
										x				
										x				
	30									x				
										x				
	30			25	4					x				
114	24	11	13	38.8	10.6						x			
	24	12	12	40.5	12.9						x			
115	57	44	13	24.5	1.96	20	30			x				
116	16	11	5	29.56	5.88	23	44				x			
117	20	10	10	20.7	1.4			2	x					
	20	12	8	23.9	3.6				x					
118	12													
119	15	5	10	25.6	3.45	22	34	x						
120	14	11	3	31.46	11.39			3					x	
121	24	10	14	35.6	16.4	22	82	5						
122														
123	48	21	27	30.08	4.53	25	40	x		x				
	12	3	9	29	2.52									
124	17	8	9	28.6	6.8	19	40	5					x	
125	36			21.19	2.99	18	25							Automation Failure
	48	24	24	21.17	1.91	18	25	x						Automation Failure
	48	24	24	20.07	1.6	18	25							Automation Failure
126	32	11	21	22.97	2.9			x	x					
127	10	10	0			21	23			x			x	
128	24	12	12	41.8	16.7	22	70							
129	24	24	0	20.25	1.82			x		x				
	10			29	4.42									
	24			23.8	3.32									
130	18	17	1											
	87	78	9	53.18	10.69	31	76							
	48	33	15	40.5	9.83	25	59		x					Automation Failure
	36	28	8	43.2	9.6	25	64						x	
131	12					19	43				x			
132	64	32	32	38.73	12.82	18	62		x				x	
	32	16	16			18	63		x				x	
	32	16	16			18	63	2	x					
	63	32	31	43.36	11.18	22	65	2	x					
	64	37	27	37.22	13.68	19	67	x					x	
133	32	16	16			18	63	2					x	
134	26	14	12	30	10.6			2 & 5					x	
135	80	40	40	47.5		25	65	x						
136	15	12	3	32	8.7						x			
137	38	16	22	22.3	3.05			x		x			x	

138	18	7	11	22.06	1.39	20	25	2						
139	12			40.3	9.9	22	56		x	x				
140	43	35	8	44.2	14.9	23	65	x	x	x				
141	60	38	22	41.3	21.1	18	87	3						
142	31			67.52	7.29	47	83							
143	30	21	9	24.9	3.42	20	36	x					x	
144	32	22	10	25.16	3.47				x				x	Traffic Rule violation
145	30	15	15	29.17	6.38									
146	20	10	10	27.6	6.2	20	44	2						
147	24			24.2	2.84	20	29	3						
148	12	12	0	24.3	2.4	22	31		x					
149	12			25.8	5.3	22	41		x					
150	36	19	17	33	9.22			3					x	
151	135							x					x	
152	90			36.4	9.075	18	60							
153	5			30.2	2.28			2					x	
154	114	38	16	29.3	15.7									
Total	**5,953**	**2,718**	**1,754**					**81**	**33**	**35**	**18**	**6**	**57**	**10**
Total in %								**42**	**17**	**18**	**9.3**	**3.1**	**30**	**5.2**

Table 21. This Table is an extension of Table 18 and shows the experimental studies and their experiments categorized in objective metrics. The experimental studies have the same number as in Table 18.

#	RT	GB	NDTP	Vehicle metrics							
				Longitudinal				Lateral			Other
				Headway	Speed	Acceleration	Other longitudinal metrics	Steer	Lane Keeping	Other lateral metrics	
1											
2											
3								x	x		
4		x									
5	x										
6											
7		x									
8								Reversal	SD, mean		
9											
10	x										
11	x										
	x										
12	x										
	x	x	x								
	x	x	x								
13	x	x									
	x	x									
	x	x									
14											
15		x									
16											
17									x	CA	
18	x			x					max,	1ˆst brake, 1ˆst steer, TTLC	
19	x										
20		x	x	x	x				position		
21											
22											
23											
24								Reversal, Force(mean, SD)	position,	TTLC	
25											
26	x	x							mean		
27											
28											
29											
30		x									
31								Torque, angle	x		
32									mean	Angle(SD)	
33	x										
34											
35				x	mean, profile	x			x		
36											
37				Time							
38											
39	x			x(TTC)							
40		x									
41	x	x									
42		x									
43			x		mean				SD		
44	x		x								
45											
46											
47	x	x									
48								Force(mean)	MSE		
49											
50											
51		x									
52											
53		x							SD	Object collsions	
	x								SD	Object collsions, Accuracy	
54	x										
55											
56											
57											
58					x		brake				crashes
59									mean, max, SD		
									Max, SD,mean	Collsions	
									Max, SD,mean	Collsions	
60											
61	x			mean	mean(change)			Mean			
62	x				x			angle			
	x										
63	x										
64											
65	x										Driving quality
66											
67	x	x									
		x	x								
68	x								max		
69											
70					x	x	yaw rate, slip angle	angle, Torque			

71											
72		x				x				accel	
73									mean(SD)		
74	x										
75											
76	x	x									
77				x							
78	x	x									
79	x					x					max Acceleration
80		x	x								
81	x										
82		x									
83											
84	x			TTC		mean		angle		Collsion Avoidance	
85		x									
86	x				max error			max angle error			
87	x										
88					x	x	brake pressure, accelerator position				
89	x										
90								angle	SD		
91											
92											
	x										
	x										
93											
94											
95		x	x								
96		x	x								
97	x		x								
98	x								max,SD		
99				TTC	Speed Limit violation	x					
100											
101	x					x		angle		Collsions	
102	x										
103											
104	x										
105	x										
106											
	x	x									
	x										
	x										
		x			x			x	x		
107	x										
108				x	x						
									x		
109	x								x		
110					mean, min, SD						
111	x					x					
112											
113		x	x		x						
					x						
	x										
	x				x				x		
					x						
114											
									x		
115											
116	x		x						mean		
117					err						
	x					x					
118											
119											
120	x							mean, SD			
121											
122								Torque			
123	x			TTC							
	x			TTC							
124		x	x						x		
125	x							Angle, SD	max		
	x		x					max	time		
	x		x					max	time		
126											
127											
128	x					x					
129											
		x			mean						
130											
											Driver behaviour
	x			min			TTC				
131								Angle, Torque			
132	x						TTC				Response type
	x										
							TTC				
							TTC				Driver behaviour, Response

	x										Response type
133											
134	x	x			x		Force, Brake				
135	x										
136		x									
137	x										
138	x										
139			x								
140		x									
141	x	x									
142											
143	x						Braking				
144											
145	x										
146	x	x	x								
147	x		x		x				mean		
148									x, TTLC		
149									SD, TTLC		
150	x			min	max,min	x	TTC	angle,velocity	SD, TTLC	Accel	
151	x	x								Lane crossings, Collsions	
152	x										
153	x										
154		x	x	instability	instability				excursions, out of lane time		
Total	**79**	**39**	**17**	**15**	**23**	**12**	**10**	**19**	**37**	**13**	**8**
Total in %	**40**	**20**	**8.8**	**7.8**	**12**	**6.2**	**5.2**	**9.8**	**19**	**6.7**	**4.1**

Table 22. This Table is an extension of Table 18 and shows the experimental studies and their experiments categorized in subjective metrics. The experimental studies have the same number as in Table 18.

#	Usefullness	Trust	Workload	Comfort	Acceptance	Understandable	Situation awareness	Other	Number of references
1	x		RSME			x		1	6
2		x			x			4	24
3		x	BVP,NASA-TLX, HR						50
4		x							12
5								6	13
6		x	x		x		1	1	43
7		x						1	26
8				x			x	2	17
9	x	x			x			3	11
10	x								25
			NASA-TLX						
11			NASA-TLX					1	53
			NASA-TLX						
12									1
13		x						1	26
		x							
		x		x					
14		x			x		SAGAT	1	42
15									
16							SART		11
17								1	18
18									28
19					x			5	7
20			RSME						11
21	SUS		NASA-TLX				x	3	80
22			x	x	x	x		6	66
23	x			x				4	10
24			x						26
25								1	6
26									33
27	x			x				9	17
28							x		27
29		x						1	16
30									32
31									28
32									53
33								1	12
34								3	42
35									28
36								3	38
37	x		RSME					1	12
38	x	x		x				1	18
39								1	20
40							x	2	11
41									15
42	x			x					11
43			NASA-TLX					1	19
44	SUS							1	58
45	SUS	x			x			1	31
46	x							3	20
47	SUS						1		41
48								4	20
49	x	x		x			x	7	56
50	x	x	NASA-TLX	x				3	23
51	x	x						3	28
52									47
53									11
54						x		1	33
55	x					x		5	11
56		x						2	10
57		x				x		6	40
58									140
59									8
60									22
61			DALI					1	32
62		x			x			1	38
63		x			x			3	36
64	x							1	12
65	SUS		DALI					1	36
66							x		47
67									69
68									21
69								5	22
70			NASA-TLX						39
71								1	16
72								1	12
73			NASA-TLX		x			1	21
74	x		NASA-TLX						32

75									8
76									15
77									15
78									24
79	x				x			4	15
80			NASA-TLX				SART		47
81	x		x			x		2	22
82									9
83		x							37
84									41
85									19
86			x						14
87			x						7
88									31
89								1	11
90								1	58
91	x	x	NASA-TLX				SART	1	54
92								1	17
	x			x				2	
	x			x				2	
93									52
94	SUS					x		3	26
95			x		x			3	61
96	x		x		x				10
97			x					6	53
98									31
99									26
100		x						4	55
101								4	22
102									16
103								1	9
104		x			x				42
105				x				6	12
106		x				x		2	82
	x							1	
	x							2	
								1	
	x		NASA-TLX					1	
107	x						x	1	22
108								1	306
	x				x			1	
	SUS		DALI					3	
109								2	36
110	x							2	52
111		x						1	31
112								1	19
113								1	43
	)							3	
			NASA-TLX					1	
			NASA-TLX					1	
	PSSUQ								
	SUS								
	SUS		NASA-TLX						
114								1	12
	x							3	
115		x						3	82
116			NASA-TLX					3	51
117								2	12
			RSME						
118		x						1	16
119		x				x		3	48
120								1	20
121			NASA-TLX					2	11
122			x						13
123		x				x		2	86
		x				x		2	
124			x						48
125		x			x			2	104
		x			x			3	
		x			x				
126				x	x			6	
127		x		x			x	3	25
128									17
129								3	88
	SUS							1	
								2	
130	x	x						4	30
	x	x			x			7	
				x		x		3	
131									58
132									76
					x			1	
133					x			2	37
134								1	27
135									11
136									7
137	QUESI		SMEQ,NASA-TLX						44

138								1	48
139				x		x	x	3	22
140		x						1	30
141							x		72
142		x						2	66
143	x	x		TOR				3	14
144	x	x						3	18
145			NASA-TLX		x			2	41
146						x		2	32
147									27
148								1	18
149									23
150								1	58
151							x	1	50
152			x		x		SAGAT	1	29
153								1	8
154									62
Total	**44**	**41**	**40**	**17**	**24**	**14**	**17**	**259**	
Total in %	**23**	**21**	**21**	**8.8**	**12**	**7.3**	**8.8**		

Appendix B2: References from experimental studies

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Appendix C1: Patents

Table 23. This Table shows all the patents sorted by alphabetical order. The columns of this table show the year of publishing, mentioned SAE level, mentioned IPCs and number of IPC used. The mentioned IPCs column shows the IPCs that got at least 10 mentions.

Author	Year	SAE level						IPC											Number of IPCs
								B60									G05		
		0	1	2	3	4	5	K35	W10		W2050	W2520	W2554	W50			D01	D2201	
								/00	/18	/20	/146	/10	/00	/08	/10	/14	/0061	/0213	
Altmannshofer & Takahashi	2018	x	x	x							x	x				x			24
Aoki & Hashimoto	2018				x	x	x												8
Arai & Nakai	2018	x			x	x		x			x					x	x		14
Bertollini, Szczerba & Mathieu	2017			x	x	x	x				x					x			9
Boule, Chick, Powell & Schubert	2018			x	x	x	x				x					x		x	8
Canac & Lajara	2015	x																	3
Christian & Mueller	2016	x	x	x	x	x		x											17
Cooprider, Shen & Ibrahim	2012	x									x	x				x			9
Ebina	2018			x	x						x								14
Engstrom & Larsson	2006	x																	3
Fairgrieve, Hemes, Kelly, Dennehy & Anker	2015					x	x	x						x					20
Fairgrieve, Hemes, Kelly, Dennehy & Anker	2017			x	x	x		x						x					22
Feit, Miller & Champi	2018	x	x	x				x						x					14
Gall	2015	x						x											11
Gordh & Vahtra	2013	x	x	x															6
Hahne	2015	x	x	x	x				x	x						x	x	x	9
Hashimoto, Torii & Taira	2016				x											x	x	x	6
Heckmann & Wersing	2015	x	x	x										x	x	x			8
Hongsoo, Jaeseung & Kim	2017	x						x											13
Hoye, Lambert & Sutton	2016	x									x	x	x			x			8
Huang	2018					x	x		x	x					x				11
Iguchi	2018					x	x	x			x								15
Imai et al	2018		x	x	x				x	x	x					x	x	x	21
Jablonski	2018		x	x	x	x	x	x											13
Jerusalem, Huth & Schmidt	2013	x	x	x	x														1
Jones, Dacko & Kirby	2019			x	x	x			x	x							x	x	20
Kashiba & Matsubara	2016				x				x	x								x	15
Kato & Fujii	2018	x																	2
Kim	2015	x																	14
Kim	2018	x	x	x						x	x	x	x			x			15
Ko, Choi & Jeon	2019	x							x		x		x			x			19
Konet et al	2016	x						x											29
Kornhaas	2015	x	x	x															19
Korthauer & Placke	2010	x																	1
Kozman & Massoud	2018						x												13
Kumagai	2016	x						x											13
Kurt, Redmill, Thomas & Ozguner	2018	x																x	14
Lavoie, Bahena & Hochrein	2016	x		x															3
Lee	2015					x	x											x	4
Levin, Westervall, Markkula, Kronberg & Victor	2015	x																	9
Liu, Sun, Yan & Zhang	2019				x	x	x		x	x			x		x	x	x	x	25
Lo	2008	x																	2
Makke & Kadry	2018	x										x							13
Matsumoto	2016		x							x		x	x	x	x				26
Matsumura	2015	x																	3
McCarthy, Uhlmann & Lynam	2004	x																	17
McNew & Vladimerou	2016			x												x			4
Miller & Tascillo	2004	x																	2
Miyahara et al	2018				x			x			x					x	x	x	24
Mohr, Gariepy & Kaynama	2016					x	x												8
Munaoka & Banno	2017	x										x							21
Nagy, Becker & Dechant	2018		x	x	x			x			x			x		x			16
Nelson	2015	x										x	x						7
Nogimori	2018	x									x		x			x			16
Noh	2014	x		x						x	x		x						9
Okuda	2014	x										x				x			13
Oooka, Narita & Noto	2015	x														x			8
Otake	2016	x																	7
Pitzer	2017				x	x													7
Sato & Iwasaki	2016				x								x				x		11
Schofield	2005	x																	22
Schofield	2016	x																	28
Schwindt & Bordes	2014	x	x	x															10
Shigeta, Aoyagi & Haga	2016	x																	14
Simon	2014	x	x					x			x					x			21
Slaton et al	2016		x								x	x		x		x			16
Srail	2017					x								x	x				12
Strumolo, Greenberg & Chen	2011	x																	4
Szczerba, Neiiendam, Lu & Huang	2017	x						x							x				9
Szybalski, Prada Gomez, Urmson, Thrun & Nemec	2018				x											x			3
Taira & Watanabe	2016						x		x	x			x						18
Takahashi & Kuriyama	2018			x	x	x							x			x			19
Takamatsu & Tokura	2007					x	x		x	x			x						23
Takamatsu et al	2005			x	x	x	x		x	x									6
Takamatsu, Hirose, Mizuno, Hashimoto & Otake	2013					x	x		x	x		x							12
Talamonti, Chung & Tijerina	2018				x	x		x	x	x		x	x			x			43
Tan	2016	x													x				7
Tan	2016	x						x						x					8

Tauchi, Tanaka & Kamiya	2017					x	x	x											27
Tippelhofer, Maiwand, Camhi & Fregoso	2014	x						x			x								12
Torii	2017	x																	9
Uno	2016	x																	12
Uno	2015	x	x	x															10
Uno	2015	x																	4
Urano	2018					x	x				x				x		x	x	8
Wagner & Bauer	2014	x		x									x			x			8
Watanabe, Emura, Tsuji, Mori & Nakai	2018				x	x	x	x			x	x	x	x	x	x	x	x	42
Yamada et al	2018	x	x	x	x	x		x			x				x	x			42
Yamamoto	2018	x																	27
Yamaoka	2016					x	x			x									4
Yoshihashi et al	2011	x		x							x					x			3
Zelman & Tsimhoni	2016	x	x	x	x							x							6
Total		**56**	**19**	**28**	**26**	**26**	**19**	**21**	**12**	**15**	**22**	**14**	**15**	**10**	**10**	**28**	**10**	**12**	**1204**
Total in %		**61**	**21**	**30**	**28**	**28**	**21**	**23**	**13**	**16**	**24**	**15**	**16**	**11**	**11**	**30**	**11**	**13**	

Appendix C2: References from patents

Altmannshofer, H., & Takahashi, J. (2018). *Driving assistance apparatus with human machine interface system.* Google Patents. (US Patent App. 15/826,071)

Aoki, K., & Hashimoto, R. (2018). *Vehicle control device.* Google Patents. (US Patent 9,963,149)

Arai, Y., & Nakai, W. (2018). *Driving assistance method, and driving assistance device, information presentation device, and recording medium using same.* Google Patents. (US Patent App. 16/060,044)

Bertollini, G. P., Szczerba, J. F., & Mathieu, R. J. (2017). *Autonomous vehicle control system and method.* Google Patents. (US Patent App. 15/006,750)

Boule, A., Chick, S., Powell, T. R., & Schubert, E. (2018). *Device, method, and graphical user interface for presenting vehicular notifications.* Google Patents. (US Patent App. 15/978,112)

Christian, M., & Mueller, A. (2016). *Method for operating a head-up display, presentation apparatus, vehicle.* Google Patents. (US Patent App. 14/970,195)

Cooprider, T. O., Shen, S., & Ibrahim, F. (2012). *Driver assistance system.* Google Patents. (US Patent App. 13/427,806)

Ebina, A. (2018). *Vehicle information presenting device.* Google Patents. (US Patent App. 16/033,451)

Erick Michael Lavoie, M. B. a. B. G. H. (2016). *System and method for parallel parking a vehicle.* Google Patents. (US Patent App. 14/621,536)

Fairgrieve, A., Hemes, E., Kelly, J., Dennehy, D., & Anker, S. (2017). *Vehicle control system and method.* Google Patents. (US Patent 9,586,595)

Fairgrieve, A., Kelly, J., Gilling, S., & Woolliscroft, D. (2015). *Vehicle speed control system and method.* Google Patents. (US Patent App. 14/421,938)

Feit, S., Miller, R. C., & Champi, J. (2018). *Human-vehicle interaction.* Google Patents. (US Patent App. 15/669,992)

Gordh, M., & Vahtra, R. (2013). *System for driver-vehicle interaction.* Google Patents. (US Patent 13/606,762)

Hahne, U. (2015). *Driver assistance system and method for operating a driver assistance system.* Google Patents. (US Patent 14/460,136)

Hashimoto, R., Torii, H., & Taira, T. (2016). *Vehicle control device.* Google Patents. (US Patent 9,733,642)

Heather Konet, R. G. A. C. N. P. J. C., Adrian Tan. (2016). *Vehicle operation assistance information management.* Google Patents. (US Patent App. 14/749,373)

Heckmann, M., & Wersing, H. (2015). *Method for controlling a driver assistance system.* Google Patents. (US Patent 9,650,056)

Hongsoo, P., Jaeseung, L., & Kim, Y. (2017). *Combiner-positioning apparatus for vehicular head-up display and vehicle including the same.* Google Patents. (US Patent App. 15/498,154)

Hoye, B., Lambert, D., & Sutton, G. (2016). *Automatic engagement of a driver assistance system.* Google Patents. (US Patent 9,238,467)

Huang, P.-s. D. (2018). *Method of operating a vehicle according to a request by a vehicle occupant.* Google Patents. (US Patent App. 15/210,984)

Iguchi, S. (2018). *Vehicle display control device and vehicle display control method.* Google Patents. (US Patent App. 15/899,650)

Imai, N., Kato, M., Kiyokawa, Y., Tomozawa, M., & Yuichi, U. (2018). *Driving assistance apparatus.* Google Patents. (US Patent App. 15/899,650)

Jablonski, R. C. (2018). *Method and apparatus for controlling a vehicle.* Google Patents. (US Patent App. 15/285,741)

Jerusalem, C. R., Huth, J., & Schmidt, G. (2013). *Warning system with warning signaler of a vehicle and a method for warning occupants of a vehicle.* Google Patents. (US Patent App. 13/782,696)

Jones, M. D., Dacko, M. J., & Kirby, B. T. (2019). *Vehicle control system.* Google Patents. (US Patent App. 10/220,857)

Kashiba, Y., & Matsubara, T. (2016). *Autonomous driving device.* Google Patents. (US Patent App. 14/951,751)

Kato, M., & Fujii, Y. (2018). *Vehicle alert apparatus.* Google Patents. (US Patent App. 15/976,377)

Kim, J. S. (2018). *Parking assistance system and parking assistance method.* Google Patents. (US Patent App. 15/802,194)

Kim, J. W. (2015). *Augmented reality display system and method for vehicle.* Google Patents. (US Patent 9,075,563)

Ko, H., Choi, J., & Jeon, D. S. (2019). *Vehicle and control method thereof.* Google Patents. (US Patent App. 10/220,844)

Kornhaas, R. (2015). *Driver assistance system for a motor vehicle.* Google Patents. (US Patent App. 14/490,053)

Korthauer, A., & Placke, L. (2010). *Method and device for voice control of a device or of a system in a motor vehicle.* Google Patents. (US Patent App. 11/883,091)

Kozman, D., & Massoud, Y. (2018). *Autonomous vehicle management.* Google Patents. (US Patent App. 15/344,700)

Kumagai, T. (2016). *Drive support system and drive support method.* Google Patents. (US Patent 14/893,164)

Kurt, A., Redmill, K., Thomas, G., & Ozguner, U. (2018). *Method for autonomously parking a motor vehicle for head-in, tail-in, and parallel parking spots.* Google Patents. (US Patent App. 15/242,173)

Levin, D., Westervall, L., Markkula, G., Kronberg, P., & Victor, T. (2015). *System and method for improving a performance estimation of an operator of a vehicle.* Google Patents. (US Patent 9,101,313)

Liu, R., Sun, J., Yan, Q., & Zhang, Z. (2019). *System, method and apparatus for controlling autonomous driving vehicle.* Google Patents. (US Patent App. 16/025,310)

Lo, R. (2008). *Distance warning device for vehicle.* Google Patents. (US Patent App. 11/644,919)

Makke, O., & Kadry, H. M. (2018). *In-vehicle haptic output.* Google Patents. (US Patent App. 15/762,709)

Matsumoto, K. (2016). *Drive assistance apparatus.* Google Patents. (US Patent 15/012,191)

Matsumura, T. (2015). *Driving assistance apparatus.* Google Patents. (US Patent 14/495,989)

McCarthy, K. C., Uhlmann, E. V., & Lynam, N. R. (2004). *Navigation system for a vehicle.* Google Patents. (US Patent 6,678,614)

McNew, J. M., & Vladimerou, V. (2016). *Management of driver and vehicle modes for semi-autonomous driving systems.* Google Patents. (US Patent App. 14/477,445)

Miller, R., & Tascillo, A. (2004). *Blind spot warning system for an automotive vehicle.* Google Patents. (US Patent 10/065,556)

Mohr, P., Gariepy, R. C., & Kaynama, S. (2016). *Method, system and apparatus for controlling self-driving vehicles.* Google Patents. (US Patent App. 15/166,533)

Munaoka, Y., & Banno, H. (2017). *In-vehicle control apparatus.* Google Patents. (US Patent App. 15/325,749)

Nagy, A., Becker, J., & Dechant, M. A. F. (2018). *Adaptive user interface for an autonomous vehicle.* Google Patents. (US Patent App. 15/540,350)

Nelson, Z. D. (2015). *Haptic steering wheel.* Google Patents. (US Patent App. 14/259,653)

Nogimori, W. (2018). *Drive assist apparatus.* Google Patents. (US Patent App. 15/758,521)

Noh, T. B. (2014). *Parking assistance apparatus and parking assistance method thereof.* Google Patents. (US Patent 13/962,281)

Okuda, Y. (2014). *Driving assistance apparatus and driving assistance method.* Google Patents. (US Patent App. 14/039,738)

Oooka, M., Narita, T., & Noto, N. (2015). *Driving assistance apparatus.* Google Patents. (US Patent App. 14/722,232)

Otake, H. (2016). *Vehicle-use signal information processing device and vehicle-use signal information processing method, as well as driving assistance device and driving assistance method.* Google Patents. (US Patent 9,262,918)

Pitzer, F. (2017). *Motor vehicle steering wheel having a display unit in the steering wheel rim.* Google Patents. (US Patent App. 15/426,315)

Sato, J., & Iwasaki, M. (2016). *Vehicle control apparatus and vehicle control method.* Google Patents. (US Patent 14/815,180)

Schofield, K. (2005). *Automotive lane change aid.* Google Patents. (US Patent 6,882,287)

Schofield, K. (2016). *Driver assistance system for a vehicle.* Google Patents. (US Patent 9,245,448)

Schwindt, O., & Bordes, M. E. G. (2014). *Driver assistance systems using radar and video.* Google Patents. (US Patent 8,718,899)

Shigeta, A., Aoyagi, T., & Haga, T. (2016). *Display control apparatus, display control method of display control apparatus, and eye gaze direction detection system.* Google Patents. (US Patent 15/114,759)

Simon, S. (2014). *Method and display unit for displaying a driving condition of a vehicle and corresponding computer program product.* Google Patents. (US Patent 14/126,20)

Slaton, Z., van der Meijs, F., Jahns, S. K., Doll, J. W. A., Lotz, J., Harbach, A. P., ... Droogendijk, C. (2016). *Predictive cruise control system with advanced operator control and feedback.* Google Patents. (US Patent 9,393,963)

Srail, D. A. (2017). *Automated vehicle human-machine interface system based on glance-direction.* Google Patents. (US Patent 9,841,813)

Strumolo, G. S., Greenberg, J. A., & Chen, Y. (2011). *Steering wheel human/machine interface system and method.* Google Patents. (US Patent App. 12/698,359)

Szczerba, J. F., Neiiendam, T. E., Lu, P., & Huang, X. (2017). *Gesture-based vehicle-user interaction.* Google Patents. (US Patent App. 15/342,451)

Szybalski, A. T., Prada Gomez, L. R., Urmson, C. P., Thrun, S., & Nemec, P. (2018). *User interface for displaying internal state of autonomous driving system.* (US Patent App. 15/344,007)

Tadashi Miyahara, S. I. Y. S. Y. S. Y. K., Mitsuo Shimotani, & Kimura, J. (2018). *Vehicle information display control device, and method for displaying automatic driving information.* Google Patents. (US Patent 15/747,954)

Taira, T., & Watanabe, Y. (2016). *Vehicle traveling control device.* Google Patents. (US Patent 9,884,625)

Takahashi, N., & Kuriyama, T. (2018). *Driving control device.* Google Patents. (US Patent 9,902,398)

Takamatsu, H., Hirose, M., Mizuno, H., Hashimoto, Y., & Otake, H. (2013). *Vehicle integrated control system.* Google Patents. (US Patent 8,442,699)

Takamatsu, H., Miyakoshi, T., Otake, H., Mizuno, H., Kondo, M., & Kawai, K. (2007). *Vehicle integrated control system.* Google Patents. (US Patent 7,243,014)

Talamonti, W. J., Chung, S.-a., & Tijerina, L. (2018). *Vehicle human machine interface control.* Google Patents. (US Patent App. 15/608,266)

Tan, A. (2016a). *Vehicle interface input receiving method.* Google Patents. (US Patent 14/498,747)

Tan, A. (2016b). *Vehicle interface system.* Google Patents. (US Patent 9,248,839)

Tauchi, M., Tanaka, K., & Kamiya, A. (2017). *Vehicular display control device.* Google Patents. (US Patent App. 15/128,570)

Tippelhofer, M., Maiwand, H., Camhi, J., & Fregoso, M. A. L. (2016). *Human machine interface.* Google Patents. (US Patent 13/790,892)

Torii, T. (2017). *Information processing device, vehicle information processing device, information processing method, and vehicle information processing method.* Google Patents. (US Patent App. 15/351,751)

Uno, S. (2015a). *Drive assist system, drive assist method, and drive assist device.* Google Patents. (US Patent 14/763,636)

Uno, S. (2015b). *Driving assistance system, driving assistance method and assistance information providing apparatus.* Google Patents. (US Patent 14/438,444)

Uno, S. (2016). *Drive assist system, drive assist method, and drive assist device.* Google Patents. (US Patent 14/763,636)

Urano, H., & Okumura, B. (2018). *Autonomous driving system.* Google Patents. (US Patent App. 15/877,476)

Watanabe, K., Emura, K., Tsuji, M., Mori, T., & Nakai, W. (2018). *Driving assistance method, and driving assistance device, driving control device, vehicle, driving assistance program, and recording medium using said method.* Google Patents. (US Patent App. 15/565,884)

Yamada, K., Yamaji, O., Gojyo, A., Kajita, S., Mori, T., & Okada, M. (2018). *Driving support device, driving support system and driving support method.* Google Patents. (US Patent App. 15/913,660)

Yamamoto, N. (2018). *Vehicle display control device and vehicle display control method.* Google Patents. (US Patent App. 15/549,462)

Yamaoka, M. (2016). *Vehicle travel control device.* Google Patents. (US Patent 15/068,809)

Yoshihashi, A., Kubota, Y., Endo, T., Kawabata, Y., Nonoyama, T., Ohira, T., ... Ito, T. (2013). *Parking support device.* Google Patents. (US Patent 8,487,783)

Zelman, I., & Tsimhoni, O. (2016). *Situational awareness for a vehicle.* Google Patents. (US Patent App. 15/115,176)

Appendix D1: Theoretical studies

Table 24. This table shows all the theoretical studies sorted on alphabetical order. The columns show the year of publishing, the country of the first author's office, SAE level. type of theoretical paper and number of references. There are 5 types of theoretical studies: summary, design, experiment concept (Exp. con.), literature review (Lit. rev.) and concept presentation (Con. pres.).

Author	Year	Country	SAE level						Type of theoretical studies					Number of references
			0	1	2	3	4	5	Summary	Design	Exp. con.	Lit. rev.	Con. pres.	
Aghaei et al	2016	CA	x						x					59
Altendorf et al	2016	DE	x	x	x	x			x					11
Altendorf et al	2014	DE			x	x			x					39
Amanatidis, Langdon & Clarkson	2017	GB					x	x		x				21
Baltzer, Flemisch, Altendorf & Flemisch	2014	DE				x				x				33
Barat, Fromion, Féron, Guen & Lainé	2017	FR	x						x					1
Bengler	2017	DE	x	x	x	x	x		x					36
Bengler, Zimmermann, Bortot, Kienle& Damböck	2012	DE				x				x				23
Bradley, Langdon & Clarkson	2016	GB	x						x					14
Cabrall et al	2017	NL			x	x	x						x	76
Carsten & Martens	2019	GB			x	x	x			x				60
Choi et al	2018	KR				x							x	17
Costa, Simões, Costa & Arezes	2001	PT				x						x		38
Creaser & Fitch	2015	US			x	x			x					28
Drezet & Colombel	2018	FR					x						x	3
Du, Qin, Zhang, Cao & Dou	2018	CN	x	x	x	x	x	x		x				24
Flemisch et al	2011	DE				x			x					25
Flemisch et al	2003	DE				x			x					54
Flemisch et al	2017	DE	x		x	x				x				67
Flemisch, Winner, Bruder & Bengler	2014	DE				x			x					34
Gaffary & Lécuyer	2018	FR	x									x		63
Geyer, Hakuli, Winner, Franz & Kauer	2011	DE	x							x				14
Gotzig	2014	DE	x						x					13
Gowda, Ju & Kohler	2014	US					x	x			x			12
Hakimi, Kamalrudin, Sidek & Akmal	2018	MY	x	x	x	x	x	x		x				15
Hassoun et al	1994	FR			x								x	12
Hesse et al	2011	DE				x				x				17
Heymann & Degani	2013	IL			x						x			26
Hoc, Young & Blosseville	2009	FR		x	x	x				x				103
Innerwinkler et al	2018	AT				x			x					5
Ive, Ju & Kohler	2014	US					x	x	x					3
Karakaya, Kalb & Bengler	2018	DE				x				x				20
Khastgir, Birrell, Dhadyalla & Jennings	2017	GB	x	x	x	x	x	x	x					26
Krähling, Lages, Griesche, Käthner & Rojas	2014	DE				x							x	5
Kun	2018	US	x	x	x	x	x	x				x		215
Lange, Gutzwiller, Verbancsics & Sin	2014	US						x		x				12
Lee, Lee & Xie	1999	SG		x	x	x	x	x					x	10
Lu & de Winter	2015	NL				x						x		53
Lu, Happee, Cabrall, Kyriakidis & de Winter	2016	NL				x				x		x		122
Meier-Arendt	2018	DE				x			x					2
Meschtscherjakov	2017	AT	x						x					37

Mirnig et al	2017	AT	x	x	x	x	x	x				x		72
Morgan et al	2017	GB					x	x		x				65
Naujoks, Hergeth, Wiedemann & Keinath	2018	DU	x	x	x	x				x				11
Navarro	2017	FR	x							x				93
Nees	2017	US				x			x					10
Norman	2015	US	x	x	x	x	x	x	x					9
Pantazopoulos et al	2016	GR	x										x	5
Pokam, Chauvin, Debernard & Langlois	2015	FR				x					x			10
Qin, Hao & Zhang	2018	CN					x	x		x				26
Saffarian, de Winter & Happee	2012	CA				x				x				60
Serrate, Berger, Tabary & Kolski	2008	FR						x					x	23
Son et al	2018	KR				x					x			26
Terken et al	2017	NL	x										x	13
Umachigi	2017	US		x	x	x			x					17
van den Beukel & van der Voort	2015	NL			x				x					17
van den Beukel & van der Voort	2011	NL		x					x					11
van Waterschoot & van der Voort	2009	NL	x	x	x	x	x		x					27
Walch et al	2017	DE				x						x		82
Wulf, Rimini-Doering, Arnon & Gauterin	2013	DE				x				x				14
Young, Koppel & Charlton	2017	AU	x									x		48
Yun, Lee, Yang & Yang	2018	KR				x					x			15
Zhang, Yu & Shi	2018	CN						x					x	16
Zimmermann & Bengler	2013	DE	x										x	15
Zou, Li, Zhang & Pei	2018	NL				x						x		24
Total			**23**	**14**	**20**	**39**	**15**	**13**	**21**	**17**	**5**	**9**	**10**	

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