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Explorative study over perception and acceptance of innovation and the role of communication and information channels: the case of Autonomous Vehicles

Candidate: Martina Sciaccaluga

Tutors: Nicoletta Buratti, Ilaria Delponte

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1 Preliminary Description

1.1 Research Context

> "Being driven" by intelligent, pilotless vehicles will represent the essential nature of future transportation.[1]

The automation in the transport field is gaining increasing interest from part of research and many important goals have been achieved in different field of application[2] as is possible to see in the timeline referring to intelligent safety systems and their evolution (fig.1). One of the applications that has undergone a significant acceleration is the one of autonomous vehicles. Autonomous Vehicles, (also known as self-driving or driverless vehicles and abbreviated in AVs), are no longer confined to science fiction movies: they are becoming a reality, and, with the wide spreading of the concept of *Mobility as a Service*, self-driving vehicles are an increasingly topical issue.

The global autonomous/driverless car market was valued at USD 24.1 billion in 2019 and is expected to project a CAGR of 18.06%, during the forecast period, 2020-2025.[3]

More and more we talk about automation both in the field of freight and people transport. If the road to fully self-driving private vehicles seems to be still a long way off, automations have begun to open their way through driver support systems and through experimentation on platooning for goods and on the automation of public services at fixed path.

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[1] Intel, Strategy Analytics, "Accelerating the Future: The Economic Impact of the Emerging Passenger Economy", Autonomous Vehicle Service- AVS-, 2017.

[2] NHTSA- National Highway Traffic Safety Administration: https://www.nhtsa.gov/technology-innovation/automated-vehicles

[3] Global Autonomous/Driveless Car Market Projections, 2020-2025: World Market Anticipating a CAGR of ~18%, Research and Markets, 2020

In 2017, autonomous driving has been the focus of the report written by Intel[4] in collaboration with Strategy Analytics[5].

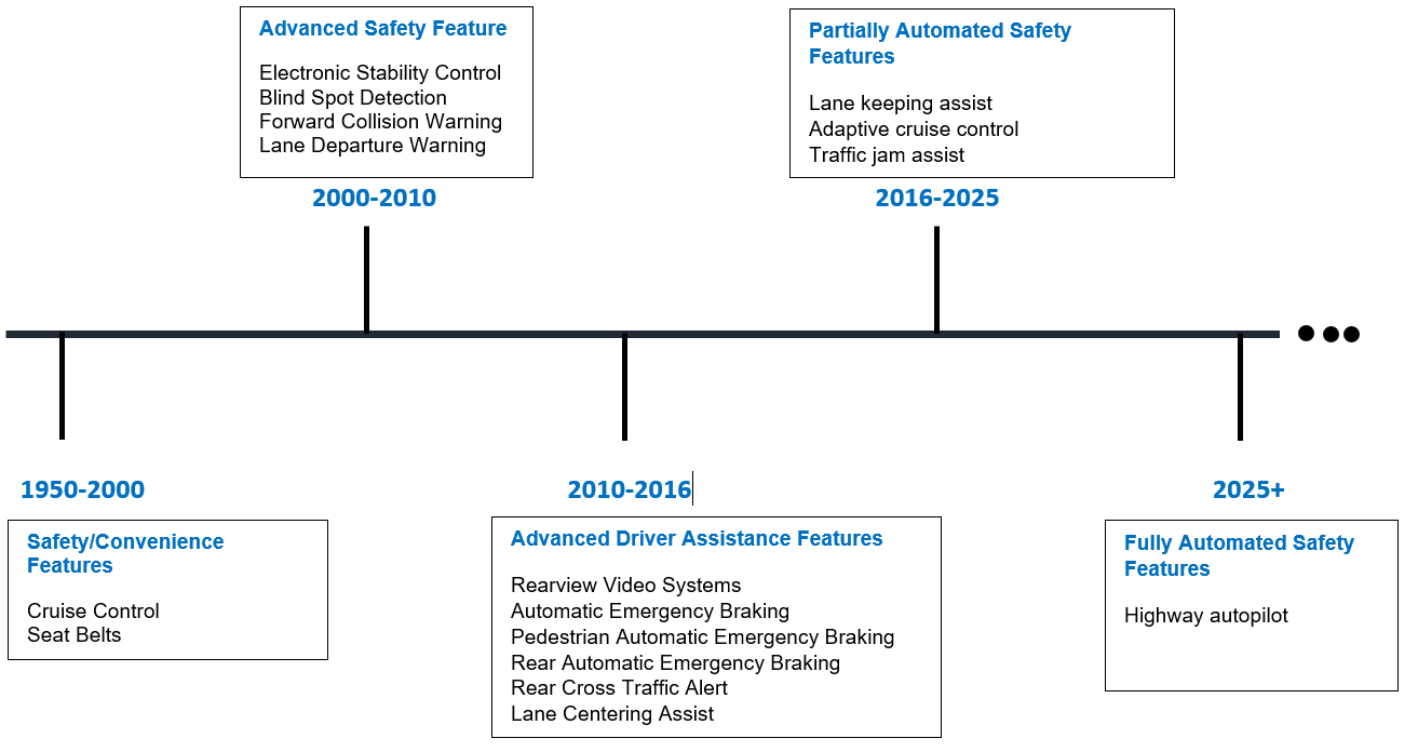

Figure 1 The 5 eras of safety, NHTSA

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[4] Intel Corporation is an American company founded in 1968 and leader in the field of innovation. Its mission is *"to shape the future of technology to help create a better future for the entire world"*. Intel initially dedicated itself to the production of memory devices and with the invention of microprocessors in the early 1970s, the company became the world's largest producer of 'computer brains'. In 1982 the 8086 microprocessor was chosen for IBM personal computers, of which Intel became an official supplier. Currently its activities are fundamental for many different innovation themes. Working in fields of research like AI, analytics and cloud-to edge technology, Intel work is the base of many different innovations of which Self driving cars are just one of the pillars.

[5] Strategy Analytics is a global leader in supporting companies of different nature trough consumer and market research solutions, with a specific focus on innovation expertise. Based on a multi-discipline approach, Strategy Analytics has deep knowledge in the fields of smart devices, connected cars, intelligent home, service providers, IoT, strategic components and media and has worked with Intel with the aim to validate the hypothesis that a "Passenger Economy" based on pilotless vehicles is on the horizon and that it holds massive economic potential.

They coined the term The Passenger Economy, *"The Passenger Economy is the economic and societal value that will be generated by fully autonomous (SAE Level five) pilotless vehicles."* It represents *"the value of products and services derived from the use of fully autonomous pilotless vehicles. This value includes the indirect savings for both consumers and business users regarding time freed from driving and shorter commutes, increased productivity for businesses, and cost savings from the reduced need for emergency services, traffic*"[6]. This definition underlines the social and economic potential of the theme.

The term "Passenger" plays a central role in this concept. Both from a private or a business point of view, the reactions of users, beneficiaries, or workers, is crucial for the successful transition to a new a way of living mobility.

The first step in using something consist in the willingness of using it.

Many people have doubts about this new kind of mobility system and about the changes it will bring along. Some of the reasons for their resistance are rational and recognized by the same user, some are linked to contextual or innovation factors, others are in latent form and sometimes driven by a lack of proper information and linked to the concept of resistance and rational ignorance, here introduced, and deepened in the body of the thesis.

The matter of rational ignorance or the intentional choice to remain uninformed on a topic because the cost of acquiring the information is greater than the estimated potential benefits, nowadays is quite common and well known. The logical but not easy solution is to make the benefits of the object in question particularly evident to the user or to significantly lower the entry barrier to the knowledge, diminishing the effort that the user must make to understand or a synergistic form of both.

In an era where everything changes fast thanks to the quick development of technology potentials, deciding which are the pieces of information effectively useful for our everyday life and which are not, it is quite a complicated subject, and the user needs the information to make aware decisions and the right instruments to overcome the entry barriers of knowledge.

Speaking of mobility and its impacts on different aspects of life, it is necessary to make well-considered choices knowing the pros, cons and above all the how. Moving towards a future of

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[6] Intel, Strategy Analytics, "Accelerating the Future: The Economic Impact of the Emerging Passenger Economy", Autonomous Vehicle Service- AVS-, 2017.

automation, it is increasingly difficult to stay up to date and have an all-encompassing vision of the phenomenon. However, making an informed choice means having the means to make it. Autonomous vehicles cannot remain black boxes in the eyes of potential users, they must begin to be understood and revealed. Their communication must take place in a fluid and permeating way, minimizing the effort required to the user and maximizing the understanding, thus guiding the user to the rationalization of personal choice.

1.2 Research Question and Objectives

There are many studies on the drivers of news technology adoption or rejection. To be appealing to the potential user, technology must be useful and easy to use; but the real question that the stakeholders involved in the process of AVs introduction may ask themselves in order to choose which actions to take is "what factors make technology perceived as useful and easy to use, preparing the population to use it?".

In this vein, this research aims to explore and investigate the reasons behind the public reaction to autonomous vehicles (since, in the opinion of the author, understanding these factors is crucial to ensure a smooth and successful transition toward the future technological era), and more in details, it aims to investigate the role that the lack of information or the disinformation, and the channels of communication may have in the acceptance process.

In the body of the thesis, the literature regarding the resistance and acceptance of technology and innovation by the user will be analyzed, the determinants and factors that guide the choice will be highlighted and the role of the communicative component within the aforementioned choice will be analyzed. Thanks to the contribution of topical information, a framework relating to the state of the art of the phenomenon in question, autonomous vehicles, will be developed. Through the information derived, we will then proceed to the creation and administration of an exploratory questionnaire with the aim of investigating the knowledge and perception of users about the subject and on the channels through which they have come to the information.

Considering the introduction of AVs as a good for society as a whole and for the actors involved (par.3) if adopted and supported by users, the ultimate goal of the research is to devise a road map of useful actions, by the point of view of communication, to be implemented in support of the public acceptance process, completed by a set of recommendations and possible solutions about the channels to be used and the kind of informative action to be promoted.

2 Theory and Literature

2.1 Bibliographic statement

The following thesis is based on studies and research carried out on autonomous vehicles mainly but not only in the sociological and communicative field.

The articles cited are the result of a structured research carried out on searching engines, primarily Scopus and Google Scholar, starting from the use of some fundamental keywords. The object of study was indicated using the terms "autonomous vehicles" or "self-driving cars" depending on whether the inherent theme was related to automation in general or to the specific case of individual or public mobility on rubber. Regarding the topics analyzed, the research revolved around four fundamental pillars: "user acceptance", "user resistance", "public perception" and "innovation communication".

The articles taken into consideration were published starting from 2015 as regards those directly linked to the AV, however older articles were cited as regards sociological models or theories still valid and in use.

Given the innovative and constantly evolving nature of the phenomenon in question, it was the author's responsibility to verify that the information reported was still valid. Considering the role of communication channels and information receive by user also "grey literature" coming from web, videos and online journals has been considered.

2.2 About Innovation and About Auto Industry

"Economic systems are not static"

This sentence sums up one of the greatest contributions of Schumpeter[7].

[7] N.S. Tülüce, A. KoçYurtkurb, "Term of strategic entrepreneurship and Schumpeter's Creative Destruction", Elsevier, 2015.

In contrast to the neoclassical theory, he places the emphasis on the invention that destabilizes the economic cycle, on the "creative destruction" that defines a new balance, on innovation which establishes new routines, and which is itself the essence of development.

In the first place, Schumpeter places a differentiation between innovation and invention:

- Invention is the novelty, the realization of something that did not exist before
- Innovation relates to the invention introduced into the economic system and which becomes expression of the success of the "creative force"

The difference therefore lies in the intentionality of the action: the invention is driven by non-economic motivations, innovation instead refers to the profitable exploitation of an idea that can be inspired by various factors (paradigm shift, innovative solution to a known problem, reconfiguration of resources, etc.) and which may not be strictly innovative.

Also Rogers[8], whose theory will be analyzed in the next paragraph, define invention and innovation but from the point of view of the adopters and explain:

- invention is the process by which a new idea is discovered or created
- the adoption of an innovation is the process of using an existing idea

With an even more firm side approach, technology can be interpreted as the manifestation of physical change of products, with a focus on progressive improvements and economic impact accompanying them. The analysis of technology in relation to economic progress allows creating the theoretical space on which the concept of innovation is grafted, defining the strategic perspectives generating business.

As soon as a discontinuity appears, whether it is an improvement or a replacement for the underlying technology, a period of strong instability begins, known as the “era of ferment”, characterized on the one hand by the conflict between the new and the old technology, on the other by the competition for the affirmation of a standard[9]. The innovations newly introduced are imperfect and are not backed up by that layer of incremental improvements which has undergone previous technology; this will be supplanted only once the new technology will be

[8] E.M Rogers, “Diffusion of Innovations”, free Press, 2003
[9] M. Schilling, F. Izzo, “Gestione dell’innovazione”,McGrawHill Education, 2017

accepted as superior. In this “new versus old” battle, it is the early adopters to play a vital role by providing feedback for the improvement of product / process.

The "era of ferment" ends with the affirmation of a standard model, defined as “a single configuration or a small number of configurations that reach at least 50% of sales of the new product or installations of the new process and maintain 50% of the market share for at least 4 years ".

The advantage of the affirmation of a single dominant design lies in the improvement of the production structure, with consequent cost reduction, easier integration with other systems and simplification relationships with customers and suppliers.

2.3 Innovation Diffusion Theory

Starting from the concept of innovation, studied for over 40 years, many models have been developed to explain the dynamics revolving around it, in particular the decision of the user to adopt it. One of the most famous is the one described by Rogers[10.]

In his model Roger define adoption as a decision of *“full use of an innovation as the best course of action available”* and rejection is the decision *“not to adopt an innovation”.*

Even more important, for the point of view adopted by the author, is his definition of diffusion of innovation: *“the process in which an innovation is communicated thorough certain channels over time among the members of a social system”*.

From this definition four key point of diffusion emerge:

1. innovation
2. communication channels
3. time
4. social system

More in detail **innovation** is described as *“an idea, practice, or project that is perceived as new by an individual or other unit of adoption”.* The part of great interest in this sentence is *perceived as new.* An innovation may have been invented a long time ago, but if individuals

[10] E.M Rogers, “Diffusion of Innovations”, free Press, 2003

perceive it as new, then it may still be an innovation for them.[11] Here comes the importance of information: an innovation is perceived as new if an individual is not informed about it. Another relevant variable, often perceived as an obstacle, is uncertainty about consequences that is *"the changes that occur in an individual or a social system as a result of the adoption or rejection of an innovation".* One again to reduce uncertainty, the only answer is information. Individuals should be informed about its advantages and disadvantages to make them aware of all its consequences. Moreover, Rogers claimed that consequences can be classified as desirable versus undesirable (functional or dysfunctional), direct versus indirect (immediate result or result of the immediate result) and anticipated versus unanticipated (recognized and intended or not).

The second key element is the **Communication Channel**. The definition given by Rogers for communication is *"a process in which participants create and share information with one another in order to reach a mutual understanding".* The communication happens through channels, intended as how a message gets from the source to the receiver, and between sources, intended as individuals or institutions that originates a message.

Rogers states that diffusion is a specific kind of communication and includes these communication elements: an innovation, two individuals or other units of adoption, and a communication channel. Mass media and interpersonal communication are two communication channels. Communication channels also can be categorized as local channels and cosmopolite channels that communicate between an individual of the social system and outside sources. While interpersonal channels can be local or cosmopolite, almost all mass media channels are cosmopolite. Because of these communication channels' characteristics, mass media channels and cosmopolite channels are more significant at the knowledge stage and local channels and interpersonal channels are more important at the persuasion stage of the innovation-decision process. In 2003 Rogers already underlined the importance of interdisciplinarity claiming that *"the diffusion of innovations requires at least some degree of heterophily, which is the degree to which two or more individuals who interact are different in certain attributes*." One of the most distinctive problems in the diffusion of innovations is that the participants are usually quite homogeneous.

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[11] I,Sahin, "Detailed review of Rogers' diffusion theory and educational technology-related studies based on Rogers'theory", TOJET- The Turkish online journal of educational technology, Ioawa state University, 2006.

The third key element is represented by the **Time** intended as a context and a dimension where the other variables act.

Finally, the **Social System,** "*a set of interrelated units engaged in joint problem solving to accomplish a common goal*". Diffusion, for Rogers, is influenced by the social structure of the system. The nature and the type of social system can affect the *"innovativeness of users*".

Given these premises, Rogers elaborate an Innovation-Decision Process[12] based on information. The process is composed of two different aspects: "*an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation*".

The process is composed of five stages that succeed in a temporal manner, (fig.2) and will end, when *"the innovation loses its distinctive quality as the separate identity of the new idea disappears"*.
The stages are the following:

- knowledge
- persuasion
- decision
- implementation
- confirmation

For what concerns the scope of the thesis, the knowledge stage, the persuasion stage, and the decision stage are the most important.

The **Knowledge** stage is the one where potential user learns about the innovation and start looking for information about it. The main questions that the individual asks himself are "what the innovation is and how and why it works". The search for answers to these questions creates three different kinds of knowledge:

- awareness-knowledge
- how-to-knowledge
- principles-knowledge.

[12] E.M Rogers, "Diffusion of Innovations", free Press, 2003

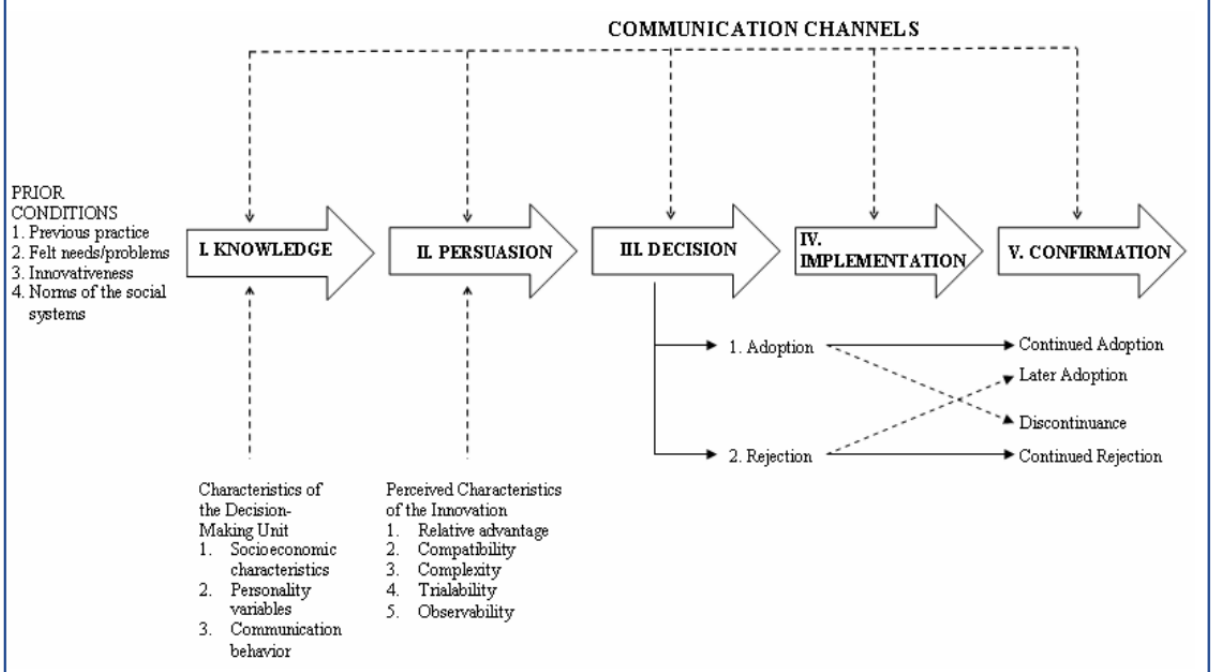

Figure 2 Innovation Decision Process, Rogers

Awareness knowledge is the first step knowledge, it represents the discover of innovation's existence. This can motivate some potential users to seek more information.

The second type of knowledge, the how-to-know knowledge, is related to the seeking of how to use an innovation correctly. To increase the adoption chance of an innovation, an individual should have a sufficient level of how-to-knowledge prior to the trial of this innovation. Thus, this knowledge becomes more critical for relatively complex innovations.

The last type of knowledge, the principles knowledge regards the functioning principles describing how and why an innovation works. It is important to notice that innovation can be adopted without this kind of knowledge, but the consequences of misuse of innovation can cause its discontinuance. The study of Sprangue[13], about the introduction of innovation in teaching, give a relevant example: the biggest barrier to faculty use of technology in teaching was that faculty lack a vision of **why** or **how** to integrate technology in the classroom.

[13] D.Sprague, K.Kopfman, S.Dorsey, "Faculty development in the integration of technology in teacher education courses", Journal of Computing in Teacher Education, 1999.

The second stage**,** the **Persuasion** one, is the stage of attitude. At this point, the potential user has his own negative or positive attitude toward the innovation, but this attitude is not directly related to the adoption or rejection of the innovation. The attitude is developed after he knows about the innovation: while the knowledge stage is characterized by a cognitive attitude, the persuasion one is linked to an affective or feeling attitude, that means that the potential user is involved more sensitively with the innovation at this stage.

The degree of uncertainty about the innovation's functioning and the social reinforcement from others (colleagues, peers, etc.) affect the individual's opinions and beliefs about the innovation.

The following stage, the **Decision** Stage, is when the potential user chooses to adopt or reject the innovation. If an innovation has a partial trial basis, it is usually adopted more quickly, since most individuals first want to try the innovation in their own situation and then come to an adoption decision. The possibility of trial can speed up the innovation decision process. However, rejection is possible in every stage of the innovation-decision process. Rogers expressed two types of rejection: active rejection and passive rejection. In an active rejection situation, an individual tries an innovation and thinks about adopting it, but later he or she decides not to adopt it. A discontinuance decision, which is to reject an innovation after adopting it earlier, may be considered as an active type of rejection. In a passive rejection (or non-adoption) position, the individual does not think about adopting the innovation at all. The dynamics of this stages can change also according to the type of culture, for example, in the easter population, as already mentioned by Anania, the group can influence the adoption of an innovation and can transform the personal innovation decision into a collective innovation decision.

In the **Implementation** stage, the innovation is put into practice. In this stage the uncertainty of the outcomes is still present, even if less than before. For this reason, the user needs some technical assistance from change agents.

The last stage, the **Confirmation**, happens when the decision has been made but the user is still looking for support for his decision. The possible danger consists of the withdrawal of the decision made. This could happen if the user is "exposed to conflicting messages about the innovation".

During this stage, the innovation Discontinuance, can happen in two ways:

- replacement discontinuance, the user rejects the innovation to adopt a better one, replacing it
- disenchantment discontinuance, the user rejects the innovation because he or she is not satisfied with its performance or the innovation does not meet the needs of the individual: it does not provide a perceived relative advantage, which is the first attribute of innovations and affects the rate of adoption

Focusing on the innovation itself, Rogers develops further the idea and analyze the attributes of innovation that could help in decreasing the uncertainty connected to the adoption.

He identifies the innovation attributes as:

- *relative advantage* (the degree to which an innovation is perceived as being better than the idea it supersedes, may be in the form of economic gain or in the form of cost savings, the costs that are saved could be financial, such as investment costs, or social)
- *compatibility* (the degree to which an innovation is perceived as consistent with the existing personal, cultural and traditional values, past experiences, and needs of potential adopters)
- *complexity* (the degree to which an innovation is perceived as relatively difficult to understand and use: complexity of the idea (is it easy to understand?), and complexity of execution (is it easy to implement?). Complexity has to be reduced on both these dimensions for the consumer)
- *trialability* (the degree to which an innovation may be experimented with on a limited basis)
- *observability* (the degree to which the results of an innovation are visible to others)

He states that the user perception of this features can predict and affect the adoption rate, defined as *"the relative speed with which an innovation is adopted by members of a social system"*. Rogers argued that innovations offering more relative advantage, compatibility, simplicity, trialability, and observability will be adopted faster than other innovations. But *"getting a new idea adopted, even when is has obvious advantages, is difficult"* so the availability of all of these variables of innovations speeds up the innovation-diffusion process. Many other variables seem to influence the adoption such as the kind of adoption-decision, if

optional, collective or authoritative; the communication channels, the social systems and the change agents or catalysts. For instance, the personal and optional innovations usually are adopted easier and faster than the organizational or collective ones.

However, Rogers identifies the relative advantage as the stronger variable to consider.

2.4 Innovation Resistance Theory

"The typical human tendency is to strive for consistency and status quo rather than to continuously search for, and embrace new behaviors"[14] Sheth, 1981

This radical claim about the humankind introduces another important theoretical framework when speaking about innovation and its adoption: innovation resistance.

Automobile manufacturers certainly realize the benefits of automated features on vehicles, but individuals do not see this new technology from that perspective. Consumers are typically resistant to innovations, especially revolutionary ones, as innovations can change their established routines and day-to-day existence[15].

It is worth highlighting three aspects of consumer resistance:

- Resistance can impact the timing of innovation adoption. The marketing literature categorizes consumers into five categories: innovators, early adopters, early majority, late majority, and laggards. Each group has a certain level of resistance, and the variations in resistance level influence adoption timing,
- There exists a continuum of resistance: from passive resistance (inertia) to active resistance (par. 2.4.1)
- Various classes of innovations (evolutionary and revolutionary innovations) cause different levels of resistance as they conflict with the consumers 'routines differently.

[14] J.N. Sheth, "Innovation resistance: the less developed concept (LDC) in diffusion research", Research, 1981.
[15] A. Talebian, M. Sabyasachee, "Predicting the adoption of connected autonomous vehicles: A new approach based on the theory of diffusion of innovation", Transportation Research Part C, Elsevier, 2018

As reported by S. Ram[16] in its research, the theme of resistance is usually undervalued because of the researchers "pro-innovation bias", based on the premises that every innovation is good for the customer. Innovation of any kind involves changes for the users and therefore, resistance to a change is a normal consumer response. It is necessary to underline that innovation resistance is not to be considered the opposite of innovation adoption or diffusion, on the contrary it is a complementary phase. After all Adoption starts for real only after the initial resistance of users is overcome.

Analyzing innovation from the point of view of resistance can give a further insight on what happens to the innovation since the time it is conceived, in its first phase of existence, when diffusion and adoption are still far away: if the resistance is too high, the innovation dies and there will be no adoption at all.

Obviously, adoption and resistance can coexist in the life of an innovation, and it is exactly for this reason that the study and deep knowledge of resistance is essential.

Resistance can be defined as *"any conduct that serves to maintain status quo in the face of pressure to alter the status quo"*[17]and is associated with the degree to which individuals feel themselves threatened by change. The innovation, from the perspective of the individual, could impose changes on his behavior and therefore alter the equilibrium of his life, therefore he often considers safer to resist rather than adopt it, with all the consequent efforts.

Innovation Resistance can be viewed as influence by and dependent on three sets of factors:

- Perceived Innovation Characteristics
- Consumer Characteristics
- Characteristics of Propagation Mechanisms

The perceived innovation characteristics are to be intended as the five explained by Rogers with the addition of Perceived Risk and Communicability defined respectively as

- the risk associated with adopting the innovation, physical risk, functional risk, psychological risk, and social risk. It depends on the type of innovation. "Minor" or

[16] S.Ram, "A model of innovation resistance", NA-Advanced consumer research, Association for consumer research, 1987
[17] G.Zaltman, M.Wallendorf . "Consumer Behavior: Basic Findings and Management Implications", New York: John Wiley & Sons, 1983

"Continuous" innovations (Robertson, 1971) have lower levels of perceived risk for the consumer, while "Major" or "Discontinuous" innovations threaten disruption of routine behavior and have higher levels of perceived risk associated with them.

- the ease and effectiveness with which the results of an innovation can be disseminated to others: the ease with which the benefits of the product can be conveyed to the consumer. It can be divided into two components: tangibility of the benefits from adopting the innovation, and ability of the marketer to communicate the benefits

The Consumer Characteristics are fundamental because the resistance to innovation is dependent on the psychological characteristics of the consumer. Some of those characteristics are:

- Personality
- Attitudes
- Value Orientation
- Previous Innovative Experience
- Perception.
- Motivation
- Beliefs

These consumer characteristics can affect the resistance to innovation and reflect the willingness to innovate. But even if a consumer shows a high willingness to innovate, he can lack the ability to innovate, he can be restrained by other obstacles such as education, income, mobility and age. That's a relevant factor to consider when thinking of adoption, because even consumers with a high willingness to adopt the innovation may not do so because it is well beyond their means or too sophisticated for them to comprehend[18], and when thinking about communication that need to be educational and clear for different target audience.

The characteristics of propagation mechanism are probably the most important feature for the scope of this thesis. As already said, communicability of innovation can be divided into

[18] S.Ram, "A model of innovation resistance", NA-Advanced consumer research, Association for consumer research, 1987.

two components: tangibility of the benefits from adopting the innovation, and ability of the marketer to communicate the benefits and can be categorized according to two variables: the type of contact with the consumer and the extent of marketers control (fig.3).

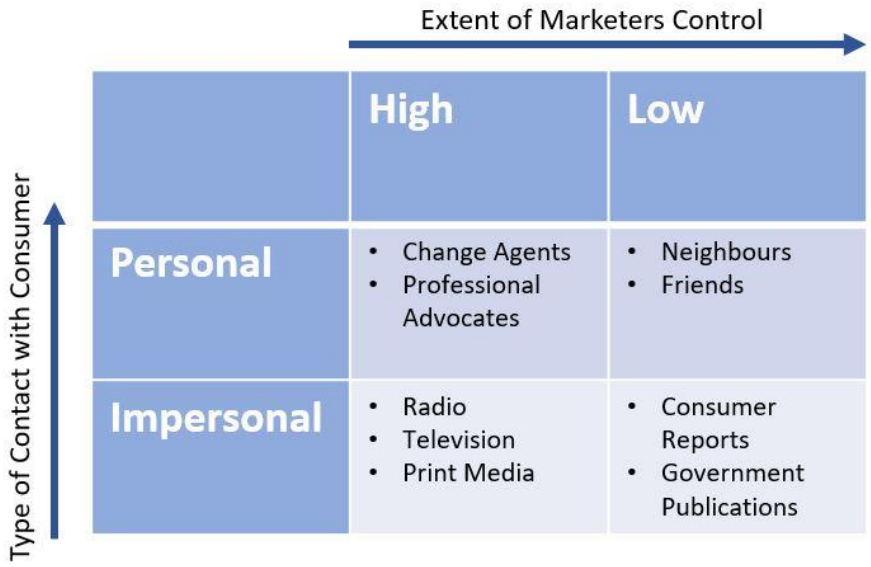

Figure 3 Classification of Propagation Mechanism

As demonstrated by previous studies[19], when the innovation is introduced to the market, marketer-controlled propagation mechanisms such as advertising and testimonials play an important role in reducing consumer resistance. When people start getting used to the new product or technology, propagation mechanism, outside marketers' control, such as word of mouth or consumer reports, take over, and help in reducing people resistance.

This evidence had led the author of the research to make the following assumptions:

- The earlier the innovation is in its life cycle. the greater the effectiveness of marketer-controlled propagation mechanisms (such as mass media) in reducing innovation resistance
- The later the innovation is in its life cycle. the greater the effectiveness of propagation mechanisms not controlled by the marketer in reducing innovation resistance

[19] Robertson, S. Thomas, "Innovative Behavior and Communication", New York: Holt, Rinehart & Winston, 1971.

- The less clear is the communication, the less motivated the consumer will be to seek further information, leading to higher resistance
- The less convincing the propagation mechanism is, the less likely the consumer will be to develop favorable predispositions to the innovation and higher the innovation resistance
- The less credible the propagation mechanism, or the lower the perceived expertise of the propagation mechanism, the less likely it is that the consumer will accept favorable messages about the innovation. and higher the resistance
- The less informative the propagation mechanism is about the innovation, the worse off the consumer is with respect to making a decision about the innovation
- The higher the perceived similarity of the source (typically in propagation mechanisms involving direct contact with the consumer). the higher the attractiveness of the source, and the higher the receptivity to the information - hence, lower the innovation resistance

2.4.1 Active and Passive Resistance

Another reflection deserves to be externalized and analyzed and concerns the two different types of resistance, the passive and the active one. Innovation resistance is universally assumed to result from negative product evaluation formed in the persuasion stage or beyond, but this vision is limited to a specific type of resistance.

Often the active resistance is the only one taken into consideration. In the theory of the diffusion of technology, for example, and in many of the different models currently in use in the field of innovation, it is taken for granted that consumers smoothly proceed from the knowledge stage to the persuasion stage and to decision stage, using their individual perceptions of the innovation to evaluate and decide whether to adopt or reject it, in fact, neglecting all the resistance and rejection happening a-priori, before having information on the innovation and thinking about it. When consumers reject an innovation prior to the persuasion stage, they never even consider its potential[20].

In this sense active and passive resistance are to be intended as follow[21]:

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[20] R.P. Bagozzi, K.H. Lee, "Consumer resistance to, and acceptance of, innovations" Advances in Consumer Research, 1999

[21] K. Talke, S. Heidenreich, "How to overcome pro-change bias: incorporating passive and active innovation resistance in innovation decision model", Product Development & Management Association, 2013

- *passive innovation resistance* as a negative outcome of the knowledge stage, resulting from a generic predisposition of consumers to resist innovations prior to new product evaluation;
- *active innovation resistance* as a negative outcome of the persuasion stage: an attitudinal outcome that follows an unfavorable new product evaluation.

2.4.2 Passive Innovation Resistance

More in detail, *passive innovation resistance* is defined as resistance to the changes required by an innovation. It depends on adopter-specific factors that form individuals' personality-related inclination to resist changes and situation-specific factors that determine their status quo satisfaction (fig. 4). These factors push individuals to resist innovations without evaluating them. As soon as passive innovation resistance exceeds an adopter-specific threshold, individuals engage in behaviors to maintain the status quo in face of an innovation's pressure for alteration. Accordingly, passive innovation resistance depends primarily on individuals' inclination to resist changes or their status quo satisfaction, or both in combination, respectively a individual inclination factor and a situation specific factor.[22]

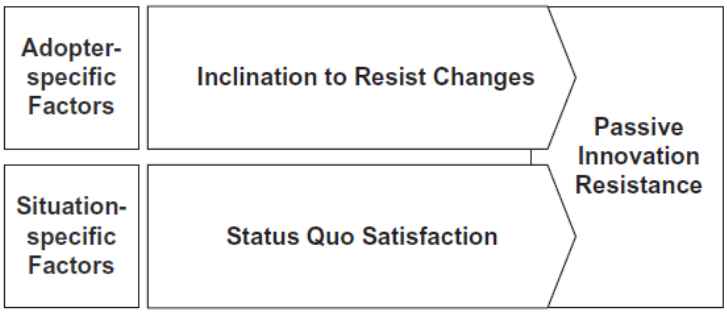


Figure 4 Passive Resistance Factors

According to these two variables, situation-specific status quo satisfaction and adopter-specific inclination to resist changes, and their relative value, it possible to divide the passive resistance in four specific subsets: low passive resistance, cognitive passive resistance, situational passive resistance, and dual passive resistance (fig.5).

[22] R.P. Bagozzi, K.H. Lee, "Consumer resistance to, and acceptance of, innovations" Advances in Consumer Research, 1999

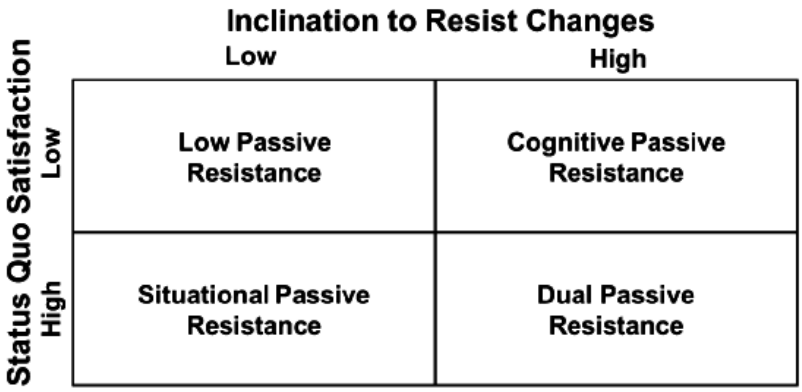


Figure 5 Types of Passive Resistance

The **individual's inclination to resist change** is the most powerful construct in predicting change-related behaviors[23] and can be conceptualized as the ensemble of six related but distinct elements:

- reluctance to lose control
- cognitive rigidity
- lack of psychological resilience
- intolerance to the adjustment
- preference for low levels of stimulation
- reluctance to give up old habits

The **status quo satisfaction** is another decisive discriminant in the innovation decision process. It derives from a situation specific factor that is the ownership of products. It shapes the perception that the individual forms about his or her status quo. Users tend to get emotionally attached to the products they possess and, when exposed to innovations they end up preferring tried, known and experimented products because, changing the situation by switching to a new or different product could generate potential losses that likely appear to outweigh potential gains. Given the often-irrational nature of the feeling, even products that are objectively of superior quality do not get considered.

[23] S. Oreg, "Resistance to change: developing an individual differences measure", Journal of Applied Psychology, 2003

2.4.3 Active Innovation Resistance

Active innovation resistance, it has been said that it happens after that the user has evaluated the innovation, giving a negative valuation of it. It can be therefore classified as a kind of resistance that evolves from innovation specific factors. As reported in the study of Rogers, users shape their attitude toward an innovation based on their evaluation of its attributes. If some attributes are perceived as disappointing or not satisfying the expectations, barriers arise and active resistance begins, therefore it can be said that active innovation resistance results primarily from innovation-specific barriers[24].

These barriers related to the innovation can be divided in to functional and psychological barriers (fig.6)

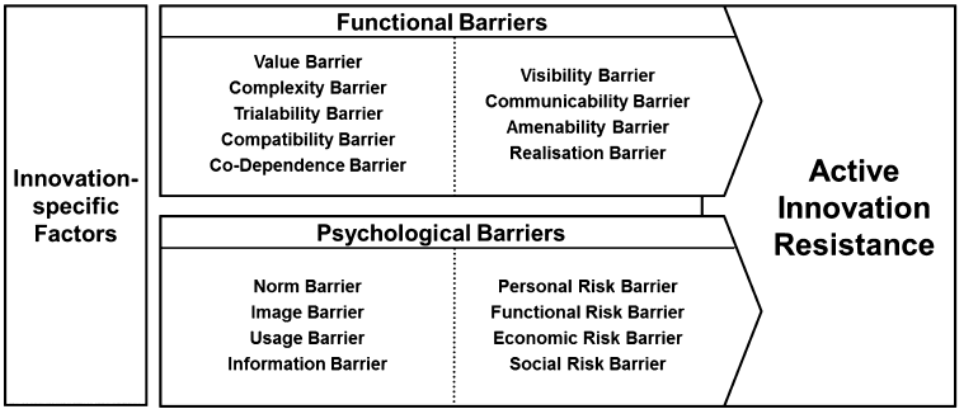


Figure 6 Active Innovation Factors

When an individual judge or evaluate one or more product attributes as dysfunctional or inadequate for his or her needs and expectations, **functional barriers** arise, whereas **psychological barriers** arise as soon as the innovation conflicts with a consumer's social norms, values, or individual usage patterns, or if its usage is perceived as being too risky[25]. The functional and psychological barriers are the one described in the following table. (tab.1)

[24] K. Talke, S. Heidenreich, "How to overcome pro-change bias: incorporating passive and active innovation resistance in innovation decision model", Product Development & Management Association, 2013
[25] R.P Bagozzi, K.H. Lee, "Consumer resistance to, and acceptance of, innovations". Advances in Consumer Research, 1999

Table 1 Functional and Psychological Barriers

Functional Barriers	
Value barriers	perceived lack of relative advantage or superior performance by the innovation over existing alternatives
Complexity barriers	an innovation is perceived as relatively difficult to understand (complexity of the idea) or use (complexity of execution)
Trialability barriers	perceived difficulties in testing the innovation prior to adoption
Compatibility barriers	an innovation is perceived as incompatible with existent and past products
Co-dependence barriers	A product is perceived as depending too heavily on additional products for full functionality
Communicability barriers	reflect a perceived ineffectiveness when describing the benefits or shortcomings of an innovation to others
Visibility barriers	consumers perceive difficulties in observing others using the innovation
Amenability barriers	an innovation seemingly has limited potential to be modified, updated, or tailored to specific consumer needs
Realization barriers	the time span before the benefits of the innovation become manifest is perceived as too long
Psychological Barriers	
Norm barriers	an innovation is perceived as violating group norms, or societal and family values

Image barriers	unfavorable associations attributed to an innovation, such as its brand, manufacturer, or country of origin
Usage barriers	the innovation's inconsistencies with past experiences that threaten to disrupt established usage patterns
Information barriers	perceived information asymmetries that make consumers uncertain of unwanted consequences
Personal risk barriers	innovation perceived as hazardous, such as when they fear that an innovation entails *physical risks* and could cause harm to them or their property
Functional risk barriers	That it performs improperly and functions unreliably,
Economic risk barriers	it represents a bad value for money,
Social risk barrirs	it will prompt disapproval from relevant social groups

2.5 Technology acceptance model

Nothing more than the urban transportation service needs to be a user-oriented system in order to achieve a positive and synergic effect on the mobility system and on the lives of citizens. The advent of autonomous vehicles can change ones and for all the transport system as we know it.

The definition given by Schumpeter in his economics of innovation theory[26], asses that innovation is a destructive process that challenges current best practices by superseding existing products or processes with new ones; a process famously termed "creative destruction". It well describes the idea of disruptive technology associated with AVs. Understanding what people need, want and fear about this new technology may impact on the result of its introduction.

[26] N.S. Tülüce, A. KoçYurtkurb, "Term of strategic entrepreneurship and Schumpeter's Creative Destruction", Elsevier, 2015.

Both automotive industries and policy maker need to have a clear vision of the user, developing a framework with the aim of building a user centered schedule.[27]

To overcome the user barriers in the acceptance process it is important to have a clear vision about it.[28]

Many different studies focus on the concept of user acceptation and user behavior toward innovation and two main ideas, already mentioned, come to the surface when speaking of technology introduction:

- neophobia: extreme or irrational fear or dislike of anything new or unfamiliar
- rational ignorance: deliberate choice of a person not to acquire a certain kind of information because of its cost in terms of time and effort that yields little or no perceived benefit.

When speaking about AVs introduction, many different factors influence the judgement of the potential user. They can be simplified and classified as below:

- ‘‘People-oriented” factors: resistance is created by user-internal factors such as gender, age or cultural background
- ‘‘System-oriented” factors: technological features such as user interface, reliability or design are the origin of resistance
- ‘‘Interaction” factors: resistance is developed by the interaction between users and the technology, and its magnitude is varying according to settings and typology of user[29]

To estimate the reaction of the users towards the AVs, many methods have been reinterpreted and revised to comply to the contemporary issue. One of the most quoted is the technology acceptance model (TAM)[30]. The Technology Acceptance model has been implemented in 1986

[27] M. Sciaccaluga, I. Delponte, “Investigation on human factors and key aspects involved in autonomous vehicles - Avs - acceptance: new instruments and perspectives”,Elsevier, 2019.
[28] M. König, L.Neumayr , “Users' resistance towards radical innovations: The case of the self-driving car”,Elsevier, 2017
[29] M. König, L.Neumayr , “Users' resistance towards radical innovations: The case of the self-driving car”, Elsevier, 2017
[30] V. Venkatesh, M.G. Morris, G.B. Davis, F.D. Davis, “User Acceptance of information technology: Toward a Unified View”, MIS Quarterly, 2003

by Fred Davis as adaptation of Theory of Reasonable Action and is specifically customized for modelling user's acceptance of technologies or information systems. It aims at explaining the general determinants involved in the process of acceptance and leading to the understanding of user behaviours (fig.7) (regardless the population of origin of the user and the kind of technology involved)[31]

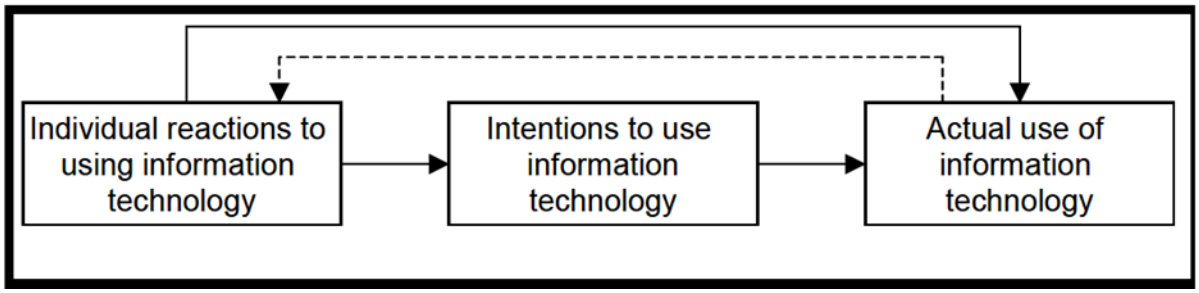


Figure 7 Basic concept underlying user acceptance models

Key elements of this model are *Perceived Usefulness (PU)* and *Perceived Ease of Use (PEOU)* defined respectively as a person's degree of belief that using a specific technology system will increase his job performance or improve their actions and a person's degree of belief that using a technology system requires no additional effort or the degree of expectation for the target system to be effortless.

According to the model PU and PEOU are the features responsible of influencing the *Attitude Toward Using* and, consequently the *Actual System Use.*

PU and *PEOU* themselves are in turn influenced by *external variables* or *antecedents*, and therefore the effects of these elements on the actual use is mediated by PU and PEOU.

PU is used both as dependent and independent variable since it is forecasted by the PEOU and that in return it forecasts the attitude toward use and the intention of use.

In the last evolution of the Original TAM structure, has been determined that both PU and PEOU have a direct effect on the behavioural intention and therefor there is no need to have the intermediate construct (attitude toward use) (fig.8).

[31] P.C. Lai, "The literature review of technology adoption models and theories for the novelty technology", JISTEM Journal of information system and technology management, 2017.

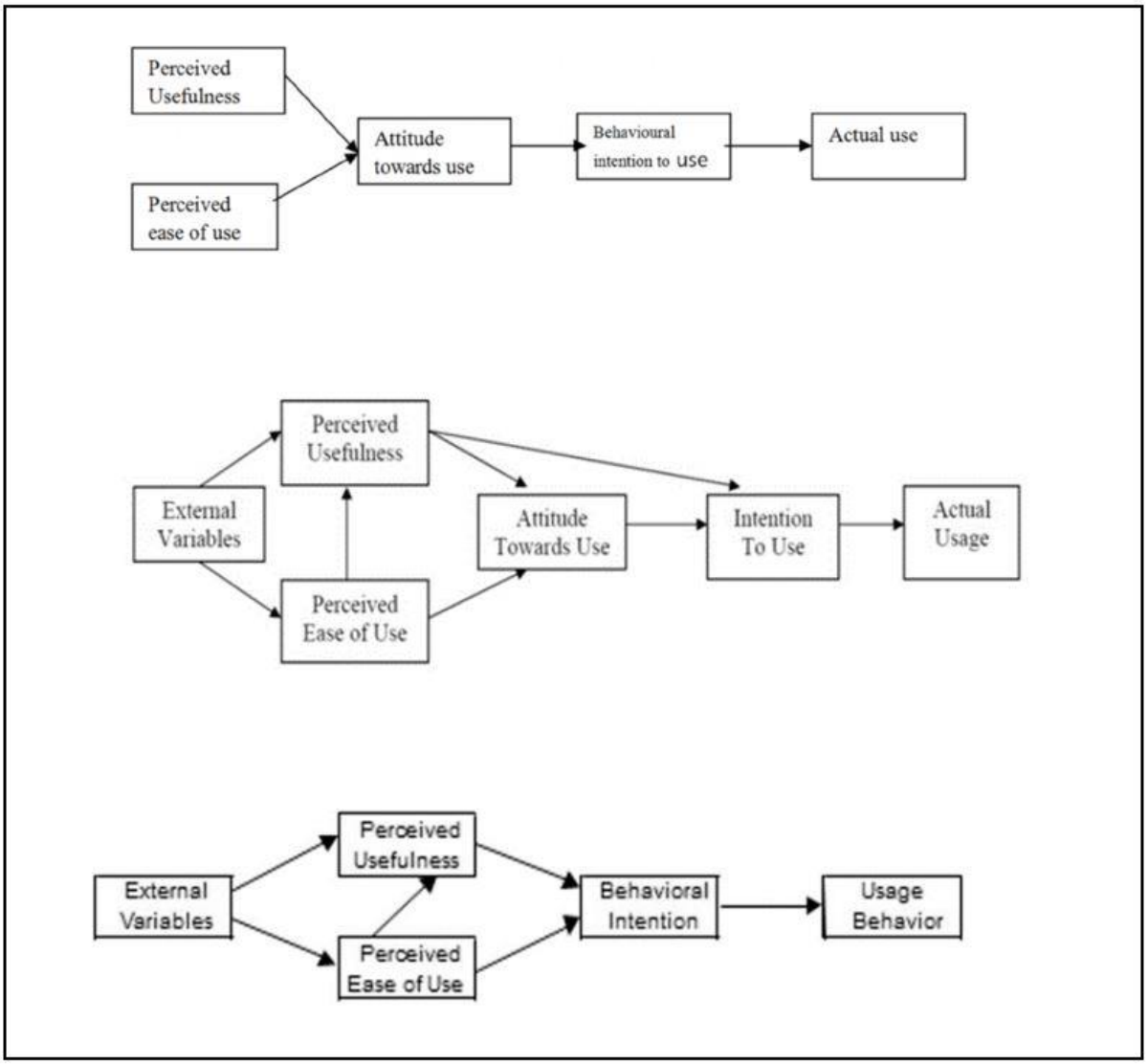


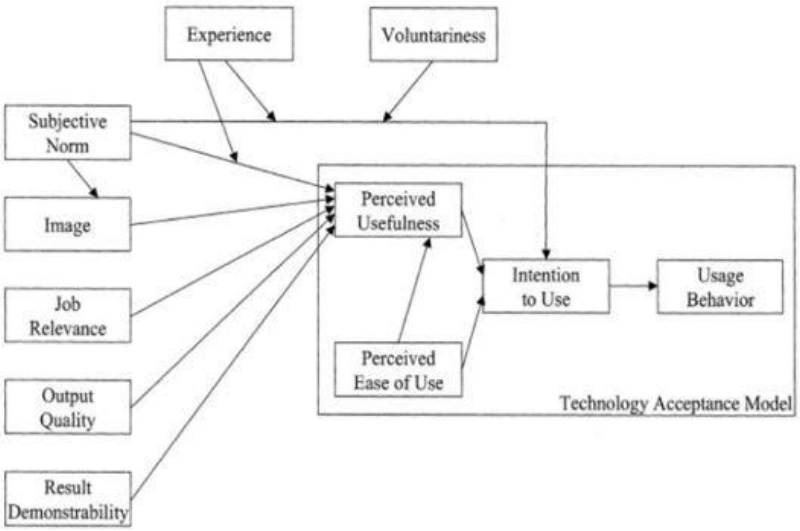
Figure 8 The original TAM and its evolutions

Working on the final version of the first technology acceptance model, it has been evolved into TAM 2 (fig.9), in which more information is specified about the external variables or determinants of PU[32]. The determined antecedents can be group into two different families: the sphere of social influence (Subjective norm, Image) and the one of system characteristics (Job relevance, Output Quality, Result Demonstrability), which are defined on the concept according to which the user creates a perception of the usefulness of a system using as a base line the evaluation of the matching between its working goals and the results of the tasks done

[32] V. Venkatesh, H. Bala, Technology Acceptance Model 3 and a Research Agenda on Interventions, 2008, Decision Science Vol. 39.

using the system in question. Experience and Voluntariness works as moderators of the effects of subjective norms.

As already widely expressed, there are many internal and external factors that influence the user and his perception and consequently his behavior. The latest evolution of the TAM model, the TAM3 model, provides an in-depth picture. This model, as explained by Venkatesh[33] aims at explaining the general determinants involved in the process of acceptance and at leading to the understanding of user behaviors, PU and PEOU. Surpassing the previous versions of the



Determinants	Definitions
Perceived ease of use	The degree to which a person believes that using an IT will be free of effort
Subjective Norm	The degree to which an individual perceives that most people are important to him or she think he or she should or should not use the system
Image	The degree to which an individual perceives that use of an innovation will enhance his or her status in his or her social system
Job relevance	The degree to which an individual believes that the target system is applicable to his or her job or activity
Output Quality	The degree to which an individual believes that the system performs its job task well
Result Demonstrability	The degree to which an individual believes that the result of using a system are tangible, observable and communicable

Figure 9 Technology Acceptance Model 2 and PU determinants

[33] V. Venkatesh, H. Bala, "Technology Acceptance Model 3 and a Research Agenda on Interventions", Decision Science, 2008

TAM, it provides a fundamental insight also into the determinants PEOU (tab.2), paving the way for structured hypotheses regarding user behavior.

In general terms PU and PEOU are influenced by four macro areas of interest as shown in (fig.10) that are Individual differences, System characteristics, Social influence and Facilitating Conditions.

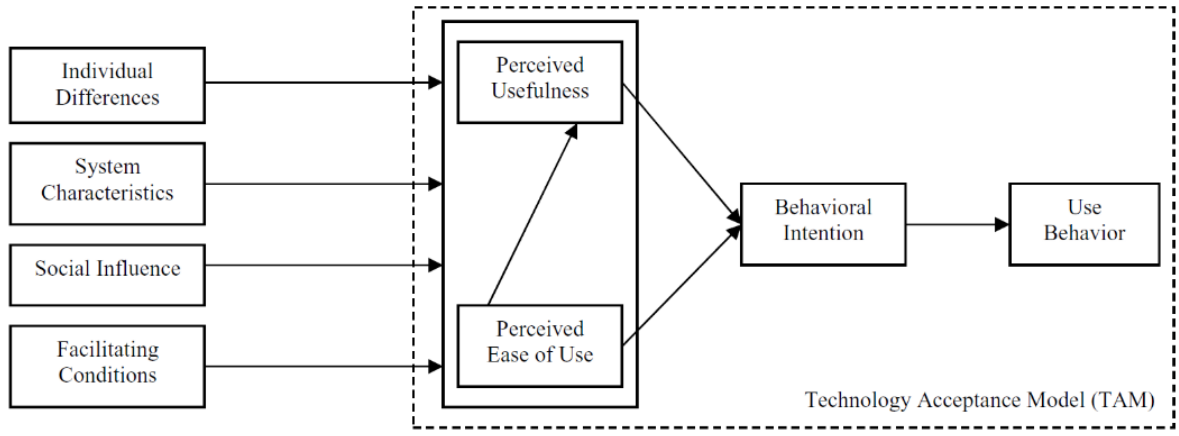


Figure 10 Macro areas influencing PU and PEOU

We have already seen that the antecedents of PU can be group into two different families: the sphere of social influence (Subjective norm, Image) and the one of system characteristics (Job relevance, Output Quality, Result Demonstrability).

The determinants of PEOU can be classified into two categories, *anchors* (Computer self-efficacy, Perceptions of external control, Computer anxiety and Computer playfulness) and *adjustments* (Perceived enjoyment and objective usability).

The anchors are determinants that act a priori and are user's baseline. Come from their general beliefs about technology and usage. It creates the fundamental attitude towards the technology in question.

The adjustments are factors that come from direct experience with the technology and are used to adjust the user's attitude towards the technology deriving from a priory impression.

TAM 3 (fig.11) involves the four categories: individual differences, social influence, system characteristics and facilitating conditions.

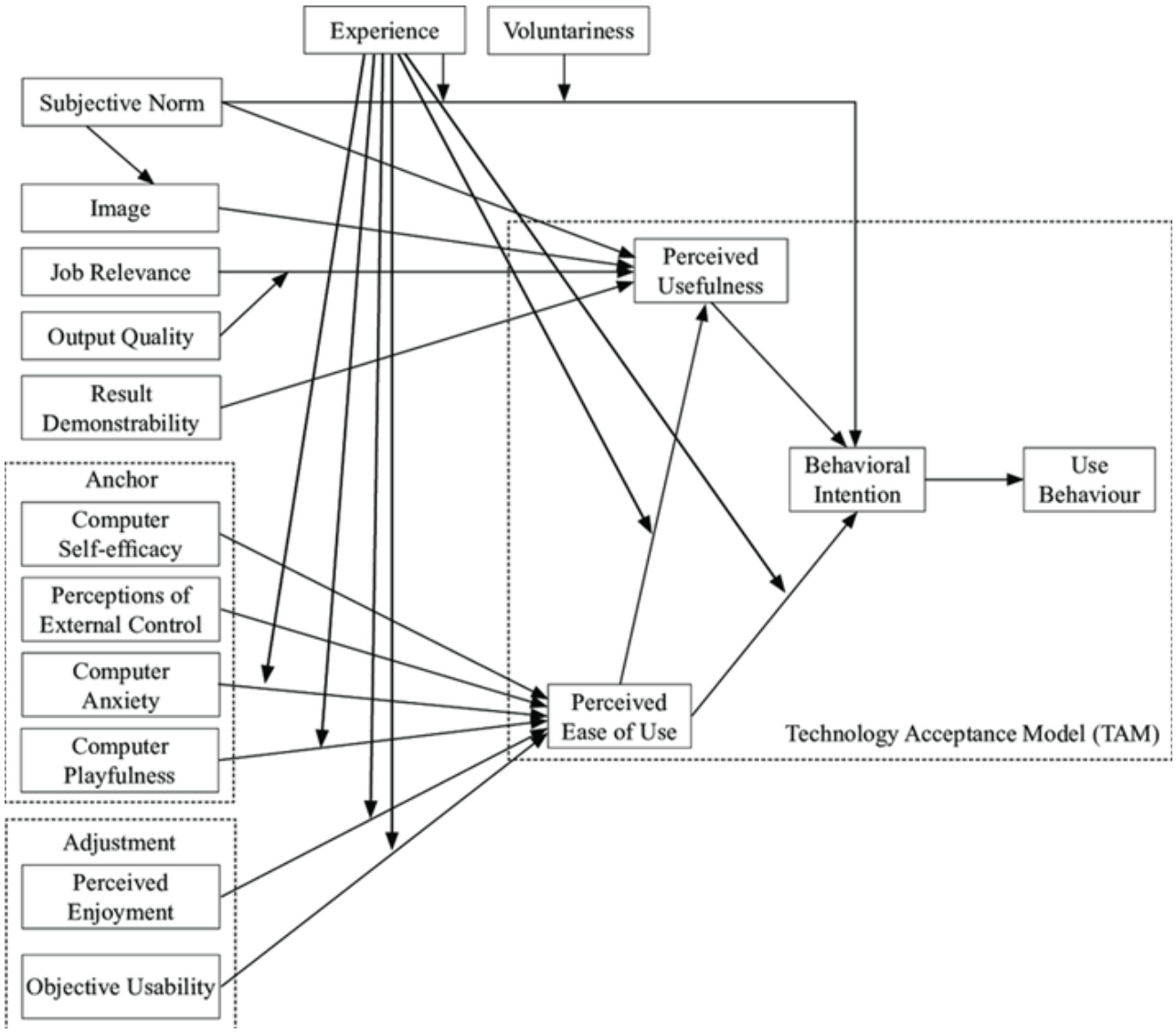


Figure 11 Technology Acceptance Model 3

Table 2 Determinants of PEOU

Determinants	Definition
Computer Self-Efficacy	The degree to which an individual believes that he or she has the ability to perform a specific task/job using the computer
Perception of External Control	The degree to which an individual believes that organizational and technical resources exist to support the use of the system
Computer Anxiety	The degree of an individual's apprehension, or even fear, when she/he is faced with the possibility of using computers
Computer Playfulness	the degree of cognitive spontaneity in microcomputer interactions
Perceived Enjoyment	The extent to which the activity of using a specific system is perceived to be enjoyable, aside from any performance consequences resulting from system use
Objective Usability	A comparison of systems based on the actual level (rather than perceptions) of effort required to completing specific tasks

2.6 Human Factors

According to the studies of Carlson[34], trust can increase when the user acknowledges information related to past performances of the technology, results of reliability tests and

[34] M.S. Carlson, J. Drury, M. Dasai, H.Kwak, H. Yanco, "Identifying Factors that influence Trust in Automated cars and Medical Diagnosis Systems", AAAI Spring Symposia, 2014

reputation of the manufacturer. The research of Kyriakidis[35] also pointed out that those who are used to the cruise control feature are more incline to use AVs, having less trust issues regarding automated systems (and confirming the importance of the relevance principle).

That can explain why, according to the research of Heiko Hahnenwald[36] those who already have experience with ADAS are more likely to adopt autonomous vehicles. (fig.12)

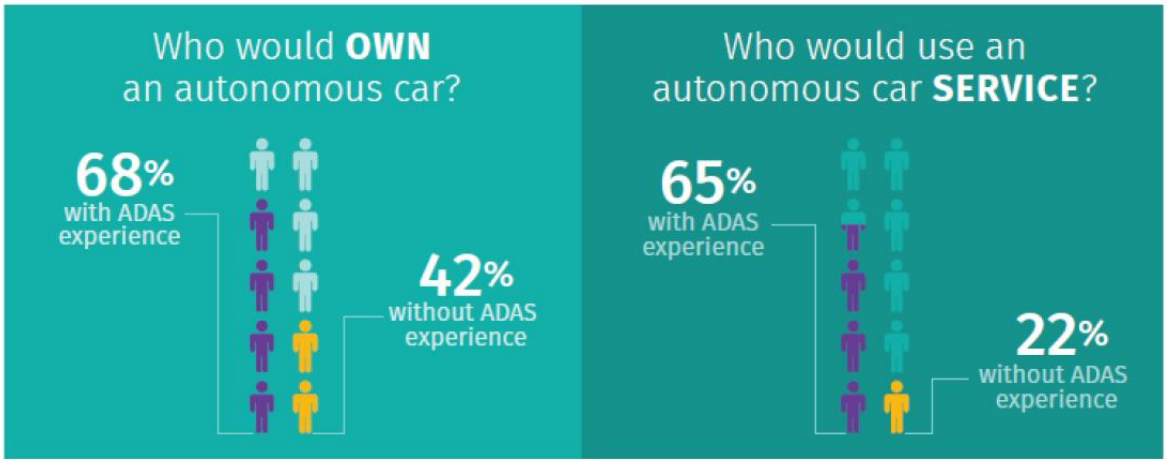


Figure 12 Percentages of AVs Adoption with and without experience of ADAS

These considerations underline that the user behavior, in particular perceived usefulness, and perceived ease of use, can be influenced by the amount of knowledge, experience and information the user has acquired relatively to the AVs issue. Considering something as relevant, in order process it, means to find its own place in the mental network of knowledge everyone possesses, to connect it with other pieces of knowledge, the proper ones, previously inserted in the personal framework. If the proper location doesn't exist or if it's too difficult to find, the new piece of information is discharged as irrelevant and dismissed. The dismissal avoids the possibility to start the learning and acquaintance process necessary to enhance the level of trust of the user and to increase the willingness to adopt AVs.

[35] M. Kyriakidis, R. Happee, J.C. de Winter "Public opinion on automated driving: results of an international questionnaire among 5000 respondents". Transp. Res. Part F: Traffic Psychol. Behav., 2015.
[36] H. Hahnenwald, "SWOT Analysis of the connected and automated driving ecosystem in Europe", SCOUT, 2018

The development of a proper user formation process and of a complementary informative marketing campaign seems crucial to create a first, competent layer of knowledge, ready to welcome innovation to come.

For this reason, recently, a wide range of studies has been conducted on the automations potential users and their attitudes in order to predispose the AVs incumbent advent, below some of the research results are reviewed.

The first main discriminative people-oriented factor analyzed as concern the intention to use automated vehicles, is sex and its relation with age. The existence of a wide gap between men and women AVs perception has been proved.

The key factor of this difference lays on affective reactions, both positive and negative, towards the AVs. The research underlines woman are more worried than men about autonomous vehicles and therefore less prone to use them, the same goes for aged people[37].

Emotions are important psychological markers, especially when processing new information.

Women are more likely to anticipate anxiety and not pleasure, on the contrary men feel more pleasure and less anxiety towards the AVs, they are more worried about liability issues rather than possible failures of automated systems[38] and this impact their willingness to use them.

The effect of biological sex on the willingness to use AVs is stronger for young people because the increase of age is linked to the decrease of magnitude in the difference of anxiety perceptions between sexes. The decrease may be due to the statistically higher percentage of men involved in car accidents, this kind of life experience can contribute to create and increase the negative effect of anxiety, smoothing out the gap between man and women. Age therefore works as moderator agent of sex differences, enhancing the non-willingness to use AVs[39].

Other factors may be considered as moderators in the tendency to use autonomous vehicles; according to the studies of Christoph Hohenberger one of them is the self-enhancement.

The intention of using a new technology depends on its own perceived characteristics. User cognitive evaluation determines the proneness to use the technology and any kind of affective

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[37] C. Hohenberger, M. Spörrle, I. M. Welpe, "How and Why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups", Elsevier, 2016

[38] M. Kyriakidis, R. Happee, J.C. de Winter "Public opinion on automated driving: results of an international questionnaire among 5000 respondents". Transp. Res. Part F: Traffic Psychol. Behav., 2015.

responses, both positive and negative, can influence the cognitive process and therefore the willingness to use the technology. The “Anxiety” factor may decrease the willingness to adopt the new technology and attenuate the effect of positive cognitive evaluation.

Any characteristic of the technology is perceived as affect and, according to the theory of the affect as information, the affect itself provides a source of information about objects and serves as feedback to understand how to evaluate and how to react to the object in question.

Self-enhancement may be able to mitigate the negative effects of anxiety (fig. 13). The term self-enhancement indicates a person-related factor: the individual desires to demonstrate competence in the social environment and to dominate others. The status perception too can contribute in using AVs as a public act and, due to their higher cost, it can reinforce the personal idea of self-status and power. A set of evaluations influences in a direct way the willingness to use innovative technology, this is related to economic, time and safety benefits.

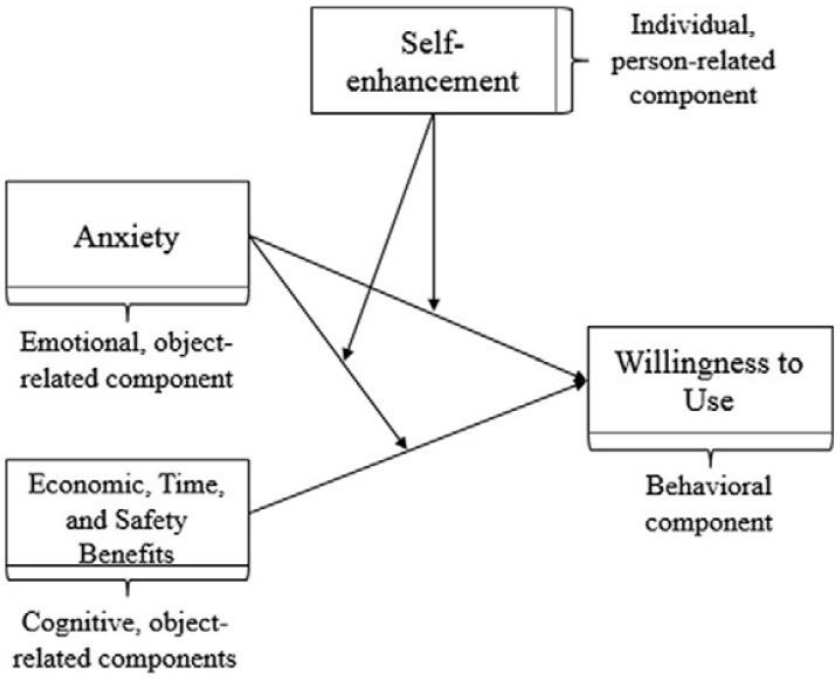

Figure 13 Effects of Anxiety, Self-enhancement, and benefits on Willingness to use

The higher are the benefits in terms of economic, safety and time, the higher is the level of willingness to use the technology. In contrast, negative affect such as anxiety influence

negatively the tendency to use AVs but this effect can be moderated by self- enhancement motivation[40].

A powerful discriminative factor is represented by the nationality. According to the research of Emily Anania et al., the nationality may impact on the willingness to use AVs by influencing the perception of collective good. A collectivist culture like the Indian one, that focuses on group needs, seems to be more prone to adopt autonomous vehicles than an individualistic one such as the American, mainly focused on personal gain[41].

One of the user fears that mostly appears in the surveys is the future possibility that the AVs won't be able to behave like humans while driving, affecting the psychological and social sphere of users and damaging the social equilibrium. The social component and the decision making of drivers have a relevant role in the mobility system.

As stated in the studies of Barry Brown and Eric Laurier[42], the road is a social and socially organized environment. Drivers as social actors are sensitive to the actions of the other drivers who are interpreted by them. Driving is not just a functional action but a communicative one, driving movements can indicate not only drivers' intent but also their mood, character, and tendencies.

On the road it is possible to establish relationships of cooperativity or competitiveness, the established equilibriums are influenced by the actions of individuals and can easily be damaged. This leads to the problem of transparency, according to the research, especially in anticipation of mixed transactional road environments, AVs should express their intentions not only through external indicators or visualizations of their state but through evident behavioral elements, easily interpretable by other social actors.

An example of the importance of social behavior on the road is given by the study of Zimmermanna[43], about social cooperation in lane changes through a game-theoretic model. According to the research, drivers mainly respond in a cooperative way to those vehicles

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[40] C. Hohenberger, M. Spörrle, I. M. Welpe, "Not fearless, but self-enhanced: The effects of anxiety on the willingness to use autonomous cars depend on individual levels of self-enhancement", Elsevier,2017

[41] E. C. Anania, S. Rice, N. W. Walters, M. Pierce, S. R. Winter, M. N. Milner, "The effects of positive and negative information on consumers' willingness to ride in a driverless vehicle", Elsevier, 2018

[42] B.Brown, E.Laurier, "The trouble with autopilots: Assisted and autonomous driving on the social road", CHI, 2017

[43] M. Zimmermanna , D. Schopfa , N. Lüttekena , Z. Liua , K. Storosta , M. Baumannb , R.Happeec , K. J. Benglera, "Carrot and stick: A game-theoretic approach to motivate cooperative driving through social interaction" , Elsevier, 2018

identified as cooperative: social information and judgements facilitate direct reciprocity in cooperation.

During the experiment participants discovered the tendency to a cooperative or to a selfish attitude of other drivers, this led to the establishment of a system of penalties and rewards: non-cooperative drivers received less cooperation than drivers with an average or high cooperativeness. This emphasizes the social nature of driving interaction[44].

The central and determinant role of the user is clear and the development of specific training, formation processes and awareness campaign is crucial.

According to Hohenberger, it's necessary to study specific campaigns tailored on the needs of population to implement a successful introduction schedule.

Promoting AVs for men means elicited status motives, underlining the hedonistic and self-enhancement factors, whereas for women it's important to reinforce the safety feeling, emphasizing the comfort in terms of protection and safety conditions. Given the pronounced difference of perception in young men and women, a practical and specific training to mitigate the relevant gap between sexes should be conduct in a proper and specific way. Elderly people seem to be less prone to pay for automated technology, it's important to underline the enhancement of their mobility conditions, creating a specific program oriented to smooth the first approach between elderlies and AVs.

As previously said, nationality matters when considering innovation introduction. The type of view and community style embraced by the nation have repercussions on the expectations and on the fears towards AVs. It's crucial to find the right social drivers to develop a collective sensitivity about the issue of innovative mobility systems.

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[44] M. Zimmermanna , D. Schopfa , N. Lüttekena , Z. Liua , K. Storosta , M. Baumannb , R.Happeec , K. J. Benglera, “Carrot and stick: A game-theoretic approach to motivate cooperative driving through social interaction” , Elsevier, 2018

2.7 New instruments and perspectives

In such a new field, new tools can make the difference: Emotion, Experience and Gamification can give a mayor contribution in reinforcing the traditional data collection and communication system.

The term "Gamification" refers to a practice that consists of using mechanics of game design in contexts beyond the game ones, or, in other words:

"A process of enhancing services with motivational affordances in order to invoke playful experiences and further behavioral outcomes"[45]. (fig.14)

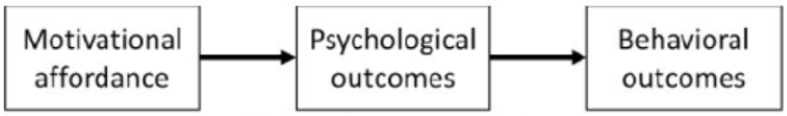

Figure 14 The principle at the base of gamification

With deeper motivations than just "having to", it's easier to obtain psychological response, which, in turn, will naturally lead to the desired behavioral response actuation.

From the economic point of view, gamification can be interpreted as a mean to support user's overall value creation."[46]

Gamification works by satisfying some of the deepest human desires: awards and rewards, status, achievement, competition and collaboration, free expression, and altruism.

Through gamification and using emotions as cognitive markers, the user can learn what he needs to understand to approach and use and correctly understand the upcoming automations. With the purpose of fulfilling playful objectives, the user will have a smoothed perception of the learning effort, overcoming the barriers of rational ignorance and predisposing the knowledge triggers able to make new information relevant. Tools based on gamification and

[45] K.Huotari, J. Hamari, "Defining gamification: a service marketing perspective", In Proceedings of the 16th International Academic MindTrek Conference, 2012.
[46] Ivi

active learning can be applied to different stages of the virtuous circle of innovation introduction.

As Carlo Ratti[47] said, there are two main moments of this constructive circle: one of sensing, during which information is gathered, and one of actuating, where specific actions are implemented as answer to the previous collected data. Any living being acts in this way, explores the situation, and then reacts to it.

As can be deduced from the overview presented, if some of the determinants are directly linked to the experience of technology, others, a priori, are entirely attributable to the social sphere and to the communication and information sphere.

Starting from these bases, this research has deepened the aspects related to the communication channels of innovation and their effects, investigating possible ways of information dissemination.

2.8 Adoption Network

The genesis of most innovations is the search for a solution to a problem.

In the case of the automotive sector, the inefficiencies we face, of which autonomous cars represent an attempt to overcome (p46), relate to the use of cars themselves and are mainly contained in three broad categories: direct costs (costs of maintaining cars, and road construction costs), indirect costs (resulting from congestion of transport routes, pollution produced, etc.) and social problems related to road safety.

According to a study by the University of California at Berkeley[48], the producers of cars take an incremental approach, while companies operating in the technology sector take a radical approach.

Incumbent companies, by virtue of their resources, pursue incremental innovation objectives, adding features on new models and implementing step-by-step experimentation.

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[47] Carlo Ratti, Smart City and Smart Citizens, Egea
[48] T. Jiang, S. Petrovic,U. Ayyer, A.Tolani, S. Husain, “Self-Driving Cars: Disruptive or Incremental?”, Applied Innovation Review, 2015.

The new entrants, precisely because they have not developed previous skills and resources in the sector of automotive, exploit their technological knowledge to develop such radical innovation.

From the point of view of the SAE[49] levels (the international standard J3016 published by SAE International, a regulatory body in the automotive industry, has defined six different levels for automatic driving, based on how much the driver has to intervene, rather than on the capabilities of the vehicle, it would be further analyzed at p.45), 1 and 2, represent an incremental innovation, as they add functionality to a product that basically remains the same, while the levels from 3 to 5 represent the real radical innovation, from a technological point of view.

Also, as high-tech markets become more and more interconnected, it becomes more difficult to overcome the resistance of customers to adopt a new product which leads the value of an innovation not to depend exclusively by its intrinsic characteristics, but also by the existence of an infrastructure that supports it adequately[50].

This "adoption network" includes companies that provide complementary products or services to innovation and companies involved in distribution innovation or information about it. The decisions of the players of this network of adoption and the support they provide to innovation is therefore able to influence its commercial success.

The elements that distinguish this adoption network are network externalities, complementary goods, learning process, cost of access. We can also define them conditions that favor or hinder the spread of an innovation. In the following lines a brief resume of the conditions is presented.

Network externalities[51] refer to situations where the value of a product increases based on number of users who adopt it. This means that, for an innovation to spread, it is essential to reach a certain number of adopters, called critical mass, which they will give more and more

[49] SAE International, previously known as the Society of Automotive Engineers, is a U.S.-based, globally active professional association and standards developing organization for engineering professionals in various industries. Principal emphasis is placed on global transport industries such as aerospace, automotive, and commercial vehicles. Accordingly, the name SAE International was established to reflect the broader emphasis on mobility.
[50] B. Chakravorti,"The role of adoption networks in the success of innovations a strategic perspective" Technology in society, Vol.6, 2004.
[51] J. Fagerberg,B. Verspagen, "Innovation, growth and economic development: have the conditions for cath-up changed?", InderScience, 2007

value to the product. Consumers and businesses, therefore, receive benefits from the fact that other consumers and / or businesses have chosen their own technology. These benefits are of two types: direct and indirect. The direct benefits networks exist when the value a user gets from the product is directly related to the number of other users adopting it: a phone acquires more value for a individual as the total number of users who use one increases, the more people connected, the more benefits get each user. The value of these technologies therefore derives from communications and connectivity between users.

Indirect network externalities, on the other hand, occur when the value of an asset for an individual increases with the increase of complementary products or services. If multiple users adopt a certain product, it is more likely that the developers of related products create complementary products, which in turn creates even greater value for each customer, thereby increasing the installed base and so on in this virtuous cycle[52].

Complementary goods: The presence of complementary goods therefore makes the success of the diffusion of a radical innovation. Users will not purchase the emerging technology platform if there are no complementary products to use on it.

The third condition that can hinder even the most brilliant innovations is the cost of access. In

some cases, it may happen that a dominant design has taken root so deeply in the habits of users, that a new and better performing product that may change their routine and that, in the beginning, is a bit more expensive, remain unwanted, leaving the users faithful to the less performing product.

Finally, one of the most relevant criteria and main interest of the author: the Learning Process

The learning process represents the most important and challenging obstacle to overcome.

When introducing a radical innovation to the market, it is necessary to pay close attention to

how the usefulness and functioning of the product is communicated. If it turns out to be too complex to be used or the benefits of using it are not understood, the long-awaited and indispensable economic returns for the survival of the project and the beneficial for society remain unreached.

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[52] S. Slater, J. Mohr, S. Sengupta, “Market Orientation- Marketing Strategy”, Wiley Online Library, 2010

As seen, the process of introduction and affirmation of innovation is complex and depends on several variables. In the case of autonomous vehicles and in this thesis, we will focus on the learning and information process and its factors and on the need for complementary goods.

Let's now enter the heart of the topic with a brief overview on Autonomous vehicles before delving into each of its parts.

3 Autonomous Driving Overview

When it comes to autonomous vehicles and their introduction, the subject can be approached on different levels and from different points of view. There are the individual repercussions and on the life of the citizen, there are the various actors involved, there are technological, legal, and infrastructural issue and then there is society as a whole, which evolving and looking for new equilibriums is changing with the support of technology and the knowledge connected to it.

Half of the world's population lives in cities, and according to the United Nations, the share will rise to about two thirds of the world's population by 2050. By 2030, there will be 40 megacities in the world, in each of which over ten million inhabitants will live. Consequently, how declared by the director of the Population Division within the Department of Economic and Social Affairs of the United Nations[53], *"managing urban areas will become the main challenge to the development of twenty-first century"*. Cities will have to be more "intelligent" to ensure economic growth, environmental sustainability, social resilience, security.

A city, for being "smart" will have to be connected. We can therefore speak of "urban digitalism": the single networks that innervate the city (energy, telecommunications, transport, health, water, etc.) will acquire information (IoT-internet of things) in order to process them (big data) and provide services (e-services). These networks will also be increasingly interconnected with each other, thus configuring itself as a sort of "network of networks", whose correct management and resilience to events, natural and malicious, are vital.

In the case of vehicles, the effects of digitalization will be linked to the availability of self-driving, connected and cooperative vehicles, capable of creating a transport system intelligent and cooperative (C-ITS, Cooperative Intelligent Transportation System).

"Connected" means that there are two-way information exchanges between vehicles (V2V, vehicle to vehicle), between vehicles and transport infrastructure (V2I, vehicle to infrastructure), between vehicles and control centers and provision of services via the internet, etc. Generally, we speak of V2X communications (vehicle-to-everything), i.e. communications between the vehicle and any other ground or on-board apparatus.

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[53] United Nations, Population Division, https://www.un.org/development/desa/pd/

"Cooperatives" implies that, thanks to the exchange of information, vehicles with a high level of automation can regulate motion according to expected contextual conditions, such as presence of vehicles arriving at an intersection, existence of critical weather situations, forming queues, emergency braking, etc. To build a C-ITS system, where vehicles are able to face the most complex situations, technologies for autonomous driving, connectivity and cooperation will have to be integrated with each other. A C-ITS system will be able to generate services and various functionality: providing information about traffic conditions, status of the road, weather conditions; generate alarms for example to prevent situations of accidents; activate assistance services in case of need; support the reduction of consumption by optimizing the flows on the arteries, etc. All observers do not doubt the spread of C-ITS systems, even if the dynamics with which these systems will spread are obviously subject to discussion and estimates. However, the most challenging issue appears to be the creation of fully autonomous driving vehicles. Tim Cook, Apple's CEO, said autonomous driving "*is probably one of the projects of Artificial Intelligence more difficult to achieve*"[54]. Despite this, the main world producers have stated that they will be technologically ready to market self-driving vehicles between 2020 and 2025, although, in addition to the development of technologies, there's still need to define various regulatory and insurance aspects on international scale. Let's imagine we are in 2050 in a European city. Viability and roads would appear a lot different from what we are used to. We probably wouldn't see any vertical or horizontal signs, traffic lights, car parks, petrol stations around us. Driverless vehicles would advance closely, side by side and at a very short distance from each other. The pace would be extremely regular, without congestion phenomena, with reduced noise emissions and zero polluting emissions. The scenario described, although futuristic, is widely believed credible.

How much a vehicle can take on the tasks of the driver in case of need and how man and machine can interact on the road today and in the future, are questions that result from different stages of development. Experts call this process "five levels of vehicle automation".

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[54] Techcrunch https://techcrunch.com/2017/06/13/tim-cook-says-apples-car-project-is-the-mother-of-all-ai-projects/

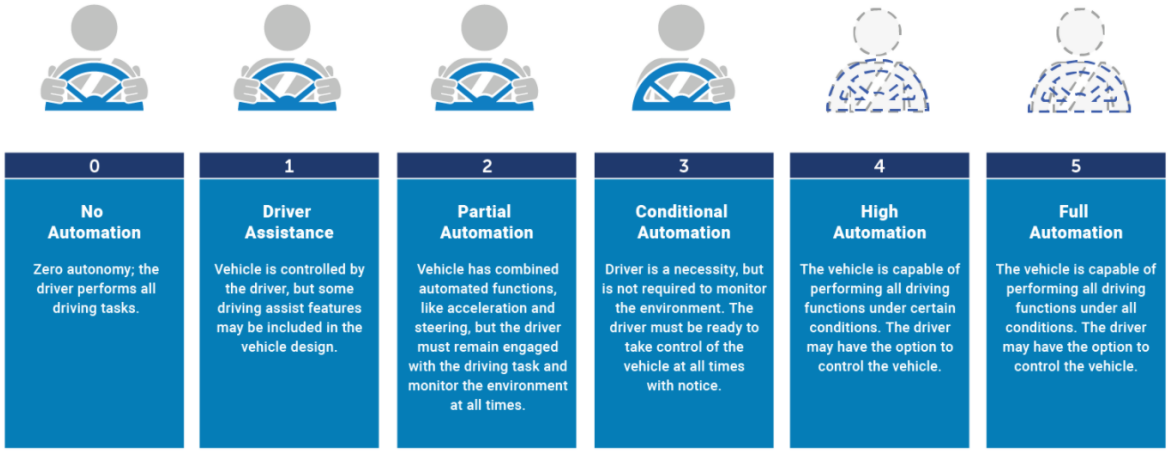

Figure 15 Society of Automotive Engineers (SAE) Automation Levels

When in the collective imagination we think of autonomous vehicles, we tend to visualize a vehicle without a driver, ready to perform all the functions a human driver, in reality this is not the case, or rather, more and more likely one day it will be but not yet. As clearly defined by the Society of Automotive Engineers (SAE), it is possible to divide the automation continuum into 5 relevant steps according to the importance of the contribution requested from the human driver. (fig.15)

Currently, level 1 and 2 private vehicles circulate on our roads and competition towards level 3 is open. It is interesting to note that most of the sites of the most important companies in the automotive landscape have sections dedicated to automation in which they explain in detail the automations of the models on sale and illustrate the commercial road map of the next few years towards level 3 vehicles, with even more enthusiasm.

3.1 Autonomous Vehicles Introduction's Effects

More in details, as explained in the scheme of Ripple Effect (fig.16) of AVs developed by Dimitris Milakis[55], imagining for a moment to leave aside all the social and implementation

[55] D. Milakis, B. Van Arem, B. Van Wee , "Policy and society related implications of automated driving: A review of literature and directions for future research", Journal of Intelligent Transportation Systems, 2017.

doubts involved, if the technology of autonomous vehicles could become part of daily life at full capacity, the effects would be disruptive and would affect not only the mobility sector but, according to a cascade effect, most of the essential macro-areas of civil life. Ripple model here has been used to show and conceptualize the sequentially spreading effects that AVs can bring in many aspects of mobility and society. Unlike the same model used in physics, in this reinterpreted vision, feedback is provided from the various sections and have the power to modify the effects on other areas by creating implementation and synergistic interactions. It also allows to envision what could be the downside effect and the area that may need interventions in the future

AVs are placed in the center as source of changes happening in the first, second and third ripples (fig.16).

- The first ripple concerns the implications of automated driving on traffic, travel cost, and travel choices.
- The second ripple includes implications of automated driving with respect to vehicle ownership and sharing, location choices and land use, and transport infrastructure.
- The third ripple contains the wider societal implications (i.e. energy consumption, air pollution, safety, social equity, economy, and public health) of the introduction of automated vehicles

1) First Ripple: Travel Costs Implications

According to the study the fixed costs and generalized transport costs, intended as the sum of effort, travel time and financial costs, of AVs are due to reduce over time.

In a first moment, fixed cost will be higher due to the advanced technology required for AVs. This could influence the penetration rate and therefore the magnitude of the positive effects of AVs adoption. But the generalized costs could sensibly decrease presenting lower effort, time, and money consumption for travelling.

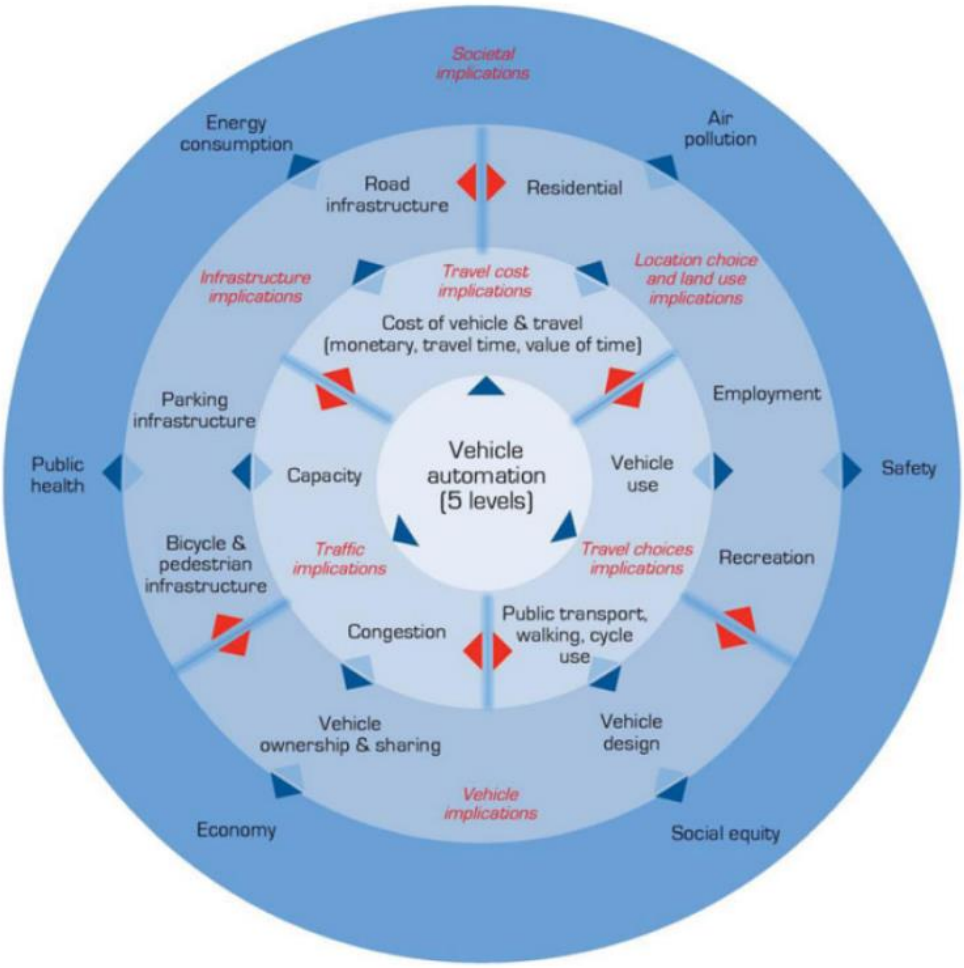

Figure 16 Ripple diagram of Avs introduction effects

Travel costs thanks to AVs can be optimized and reduced, starting with time saving due to:

- higher travel time reliability
- the possibility to perform activities other than driving
- less congestion delays because of increased road capacity and
- reduced search time for parking owing to self-parking capability, but also increased use of shared vehicles,

The potential increase of mobility demand could limit the benefits leading to a reduction of fuel and time savings.

1) First Ripple: Road Capacity

The road capacity could be increased, and the congestion reduced due to free flow capacity, traffic flow stability. These benefits are highly dependent on the level of automation, the connectivity between vehicles and their respective penetration rates, the deployment path as well as human factors. And could be limited by a fast increase in vehicle travel demand

2) First Ripple: Travel Choices

Travel choices will also undergo changes, according to literature, travel demand will undergo a significant increase (between 3% and 27%) due to factors such as the desire to make longer journeys, the choice of use of the car (also understood such as "Mobility as a Service") on other types of transport and an increase in mobility in general terms. Those who live in rural areas will have easier access to the city center (an element that will push some to seek rural life as they will not have to give up comfort, contributing to the management of the overpopulation of urban centers). Increasing the number of vehicles on road could still inhibit the use of more active means such as bicycles

3) Second Ripple: Vehicle ownership and sharing

AVS could make easier the development of ridesharing and vehicle sharing service by reducing operational costs (such as drivers), presenting higher flexibility and lower prices. This could lead to a decrease in the ownership of individual cars especially for urban residents, avoiding fixed cost and time use. But an intense use of shared vehicles could lead to a fast wear out of the vehicles themselves and consequent frequent replacement.

4) Second Ripple: Location Choices and Land Use

The effect of AVS could have influence both on macro and micro spatial scale. On macro scale AVs could promote an ex-urbanization wave to rural areas. New centers could rise and evolve in peripheral growth poles.

On micro scale, AVs could support changes in streetscapes, building and modifying landscape design and land uses: reducing on-street and off-street parking could leave space to new public space, promoting a more people-friendly land use. AVs could reduce the space required for parking by up to 90% and the required parking spaces could move to peripheral areas, improving the management and exploitation of the urban territory.

5) Second Ripple: Transport Infrastructure

Obviously, the infrastructure needs to adapt to the new connected vehicles. The increase or decrease of roads will depend on first effects of AVS: a decrease in need if the AVS will guarantee a stable and optimized road capacity, an increase in need if, because of the induce travel demand, there will be a proliferation of vehicles. Fewer Parking infrastructure will allow pedestrians to benefit from more dedicated space and finally AVs could enhance a change in ownership and organizational structure.

6) Third Ripple: Energy Consumption and Air pollution

AVs introduction may lead to an energy and emission improvement because of reduces congestion, homogeneous traffic flows, less air resistance. However, there is the possibility that to allow the passenger to do other activities, the vehicles will be bigger in size, limiting fuel efficacy. The reduced need of parking infrastructure can bring environmental benefits, but it is not possible to exclude the case where an AV is programmed to drive itself in the peripherical area, where parking is cheaper, producing therefore more emissions and congestion.

7) Third Ripple: Safety

The majority of accidents is due to human error: Typical reasons include, in descending order, errors of recognition (e.g., inattention), decision (e.g., driving aggressively), performance (e.g., improper directional control), and non-performance (e.g., sleep). The AVs could significantly reduce accidents caused by human drivers. Thanks to advanced technologies applied to automated vehicles with respect to perception of the environment and motion planning, identification, and avoidance of moving obstacles, longitudinal, lateral and intersection control, and automatic parking systems, for example. On the other hand, cyberattacks, software vulnerability and inability of users to handle the Av could compromise safety levels.

8) Third Ripple: Social Equity

AVs could have both positive and negative implications for social equity. Fragile groups such as young, elderly, and impaired people could gain access to a wider mobility chance. But the first the first automated vehicles in the market are likely to be quite expensive, thus limiting these benefits to only a specific group of society, resulting in social exclusion for others. In the transition period, owners of automated vehicles will probably enjoy higher levels of travel safety compared to drivers of conventional vehicles. Still stand the fact that potential conversion of redundant road space to bicycle and pedestrian infrastructures could offer

accessibility benefits to vulnerable population groups. Finally, the decrease of the requirements for construction of off-street parking spaces could increase housing affordability.

9) Third Ripple: Economy

As already discussed, the increase in safety and the prevention of accidents could lead to a conspicuous saving in human capital losses, medical expenses, lost productivity and quality of life, property damage, insurances, and crash prevention costs. A reduction in delays of different nature can have a positive effect on travel costs for user and direct production costs for business. The possibility of performing other activities rather driving while on the road ca result in an increase in productivity and the sharing of vehicles may result in a decrease of personal costs of ownership. The lack of need of on road parking can promote the building of more productive activities, however, a possible massive reduction in car ownership levels might have a critical negative impact on the automotive industry. New business models are likely to emerge while strictly car-related industries might experience losses. AVs could lead to direct job losses for various professionals but, at the same time, could guarantee the generation of new jobs in hardware and software technology. It is likely that job related changes will vary according to country.

10) Third Ripple: Public Health

Public health benefits might result from reduced congestion, lower traffic noise, increased traffic safety, and lower emissions from automated vehicles.

3.2 Benefits

As reported on the NHTSA website[56], in general the positive effects are many and concern the following areas:

[56] NHTSA- National Highway Traffic Safety Administration: https://www.nhtsa.gov/technology-innovation/automated-vehicles

1) Safety

AVs could drastically reduce injuries, being the solution to the fact that the 95% of serious crashes are due to human errors. Most of these errors are impossible for a machine to make. Over 40% of the fatal crashes is linked to alcohol, distraction, drug involvement or fatigue, or a combination of the previous reason. AVs could bring at least a 40% fatal crash-rate reduction, without considering crashes due to speeding, aggressive driving, over/compensation, inexperience, slow reaction times, inattention, and various other driver shortcomings. Even when the critical reason behind a crash is attributed to the vehicle, roadway or environment, additional human factors are regularly found to have contributed to the crash occurrence and/or injury severity. Every year when people are backing out of driveways or parking spaces, in the U.S, up to 200 people are killed, and it is frequently older people or children, and it comes down to the fact that we don't have eyes in the back of our head, and even the backup cameras still have blind spots. But if you have a vehicle that has LiDAR and radar and 29 cameras, you're just not going to hit them.[57]

Assuming different rates of AVs penetration, AVs may be assumed to reduce crash and injury rates by 50%, versus non-AVs at the early, 10% market penetration rate (reflecting savings due to eliminating the aforementioned factors, as well as reductions due to fewer legal violations like running red lights), and 90% safer at the 90% market penetration rate (reflecting the near elimination of human error as a primary crash cause, thanks to improving vehicle automation technology).

2) Economic and societal

In 2010 the amount of costs related to vehicle crashes mounted to 242 billion dollars and the ones linked to loss of life or decreased quality of life due to injuries were 594 billion dollars. Emissions have been estimated to fall when travel is smooth, rather than forced, estimating that

a 20% reduction in accelerations and decelerations should lead to 5% reductions in fuel consumption and associated emissions. Thus, while AVs may increase VMT, emissions per mile could be reduced. Additional fuel savings may accrue through AVs' smart parking decisions helping avoid ''cruising for parking''.

[57] D. Muller, Waymo, "Why you should want driveless cars on roads now", Youtube, 2021

3) Efficiency and Convenience

AVs have the potential to smooth traffic flow and reduce traffic congestion, reducing the waste of additional fuel costs and vehicle emissions and improving the quantity of time that drivers can spend with family or at work. AVs can sense and possibly anticipate lead vehicles' braking and acceleration decisions. Such technology allows for smoother braking and fine speed adjustments of following vehicles, leading to fuel savings, less brake wear, and reductions in traffic-destabilizing shockwave propagation. AVs are also expected to use existing lanes and intersections more efficiently through shorter gaps between vehicles, coordinated platoons, and more efficient route choices. Many of these features, such as adaptive cruise control (ACC), are already being integrated into automobiles and some of the benefits will be realized before AVs are fully operational.

4) Mobility and Travel-behavior impact

AVs can provide new mobility options for old or impaired people and for children or younger people, enabling people to overcome the problem of driving and empowering them (unlocking, as consequence, new employment opportunities for all).
Parking habits could change, maximizing land organization and streets management and mobility as a service could spread thanks to ride sharing programs and mobility optimization.

5) Freight transportation

The same technologies that apply to autonomous cars can also apply to the trucking industry, increasing fuel economy and lowering the need for truck drivers. While workers would likely still need to load and unload cargo, long-distance journeys may be made without drivers, with warehousing employees handling container contents at either end. Additional benefits can emerge through higher fuel economies when using tightly coupled road-train platoons, thanks to reduced air resistance of shared slipstreams, not to mention lowered travel times from higher capacity networks.

Of course, many such benefits may not be realized until an high AV adoption rate is reached: all the positive estimated impacts, suggesting economic benefits reaching $196 billion ($442 billion, comprehensive) will be possible only with a 90% AV market penetration rate. Meaningful congestion benefits are estimated to accrue to all travellers early on, while the magnitude of crash benefits grows over time (and accrues largely to AV owners/users). For example, congestion savings represent 66% of benefits, and crash savings represent 21% of benefits – at the 10% market penetration level, versus 31% and 54% of benefits, respectively, at the 90% penetration rate. When comprehensive crash costs are included, overall crash savings jump by more than a factor of three[58]. (tab.3)

Table 3 AVs economic effects in different markets shares scenarios

	Assumed market shares		
	10%	50%	90%
Crash cost savings from AVs			
Lives saved (per year)	1100	9600	21,700
Fewer crashes	211,000	1,880,000	4,220,000
Economic cost savings	$5.5 B	$48.8 B	$109.7 B
Comprehensive cost savings	$17.7 B	$158.1 B	$355.4 B
Economic cost savings per AV	$430	$770	$960
Comprehensive cost savings per AV	$1390	$2480	$3100
Congestion benefits			
Travel time savings (M hours)	756	1680	2772
Fuel savings (M gallons)	102	224	724
Total savings	$16.8	$37.4	$63.0
Savings per AV	$1320	$590	$550
Other AV impacts			
Parking savings	$3.2	$15.9	$28.7
Savings per AV	$250	$250	$250
VMT increase	2.0%	7.5%	9.0%
Change in total # vehicles	−4.7%	−23.7%	−42.6%
Annual savings: Economic costs only	$25.5 B	$102.2 B	$201.4 B
Annual savings: Comprehensive costs	$37.7 B	$211.5 B	$447.1 B
Annual savings per AV: Economic costs only	$2000	$1610	$1760
Annual savings per AV: Comprehensive costs	$2960	$3320	$3900
Net present value of AV benefits minus added purchase price: Economic costs only	$5210	$7250	$10,390
Net present value of AV benefits minus added purchase price: Comprehensive costs	$12,510	$20,250	$26,660
Assumptions			
Number of AVs operating in U.S.	12.0 M	45.1 M	65.1 M
Crash reduction fraction per AV	0.5	0.75	0.9
Freeway congestion benefit (delay reduction)	15%	35%	60%
Arterial congestion benefit	5%	10%	15%
Fuel savings	13%	18%	25%
Non-AV following-vehicle fuel efficiency benefit (freeway)	8%	13%	13%
VMT increase per AV	20%	15%	10%
% of AVs shared across users	10%	10%	10%
Added purchase price for AV capabilities	$10,000	$5000	$3000
Discount rate	10%	10%	10%
Vehicle lifetime (years)	15	15	15

[58] D.J. Fagnant, K. Kockelman, "Preparing a nation for autonomous vehicles: opportunities, barriers and policy reccomendations", Transportation Research Part A, Elsevier, 2015.

3.3 Limits and Barriers

As we have seen, the benefits brought by the introduction are many and of different nature but with them also come many limits and barriers of major importance:

- Reduced security and privacy: AVs are likely to store a large amount of personal data (such as trip patterns and users' preferences) and may be vulnerable to leakage of such information.
- Social inequity: Initial cost of AVs is likely to be much higher when compared to their counterpart driver operated vehicles. The technology needed for an AV includes the addition of new sensors, communication and guidance technology, and software for each automobile: only wealthy consumers might be able to afford AVs as personal vehicles.59
- Obscurity in accountability: refers to the lack of clarity in identifying who is accountable for the accidents and/or damages related to AVs- the owner, the manufacturer, or someone else?60
- Lack of customer acceptance: If potential customers do not accept the AV as an alternative to manned vehicles and do not show confidence in it, the adoption of AVs cannot be expedited, regardless of how safe AVs eventually become, there is likely to be an initial perception that they are potentially unsafe because the lack of a human driver. Perception issues have often been known to drive policy and could delay implementation.61
- Potential loss of employment: AVs will replace human drivers and can have a significant impact on employment. This can be a barrier to the popularity and subsequent growth of AVs.
- Inadequate infrastructures: huge infrastructure investments are required to make AVs viable on the road. AVs might need a dedicated lane, which requires additional

[59] D.J.Fagnant, K.Kockelman, "Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations", Transport. Res. Part A, 2015.
[60] S.Li, P.C.Sui, J.Xiao, R.Chahine, "Policy formulation for highly automated vehicles: emerging importance, research frontiers and insights", Transport. Res. Part A, 2018.
[61] L. Buckley, S.A. Kaye, A.K. Pradhan, "A qualitative examination of drivers' responses to partially automated vehicles. Transport", Res. Part F: Traffic Psychol. Behav., 2018.

investment. Deployment of smart technologies is essential to enable vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications.62

- Lack of standards: AVs are likely to be operated on a network, wherein they can talk and respond to each other to avoid crashes and escape traffic jams. For this purpose, AVs manufactured by different companies must follow standards so that they can fully leverage the advantages of automation through efficient communication. However, making this happen, particularly in emerging markets, has its challenges.
- Absence of regulations and certification: here is a lack of consistent certification framework and standardized set of safety norms for the acceptance across different levels. Under these circumstances, AV manufacturers and suppliers may encounter regulatory uncertainty, leading to slower technological innovations.
- Manufacturing costs: The high manufacturing cost of AVs is one of the key barriers to their adoption on a mass scale
- Induced travel: AVs could increase the vehicle miles traveled and urban sprawl. AVs is likely to reduce travel times and emissions, such savings can be offset by an increase in the demand for travel. Vehicle miles traveled can also be induced due to shift from public transit to low occupancy AVs

3.3.1 The ethic implication of AVs and The Moral Machine

A brief insight should be devoted to the fears linked to the ethical choices of autonomous vehicles in the event of an accident and related legal responsibilities. Perhaps the best-known public domain theme related to autonomous vehicles and even one of the most spread fears.

This theme has been faced and presented in different ways and from different perspectives, from the technical to the philosophical one and from the medical to the computer scientist one: a definitive answer does not currently exist, but innumerable interpretations have been provided on the basis of the reference discipline.

One of the methodologies that has certainly reached the public most is that of the *Moral Machine*.

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[62] E.Fraedrich, D.Heinrichs, F.J.Bahamonde-Birke, R.Cyganski, "Autonomous driving, the built environment and policy implications", Transport. Res. Part A, 2018

With this name we refer to an online platform, developed by Iyad Rahwan's Scalable Cooperation group at the Massachusetts Institute of Technology, that generates moral dilemmas and collects information on the decisions that people make between two destructive outcomes.

This is the presentation of the Moral Machine, usable by everyone online[63]

"From self-driving cars on public roads to self-piloting reusable rockets landing on self-sailing ships, machine intelligence is supporting or entirely taking over ever more complex human activities at an ever-increasing pace. The greater autonomy given to machine intelligence in these roles can result in situations where they must make autonomous choices involving human life and limb. This calls for not just a clearer understanding of how humans make such choices, but also a clearer understanding of how humans perceive machine intelligence making such choices.

Recent scientific studies on machine ethics have raised awareness about the topic in the media and public discourse. This website aims to take the discussion further, by providing a platform for 1) building a crowd-sourced picture of human opinion on how machines should make decisions when faced with moral dilemmas, and 2) crowd-sourcing assembly and discussion of potential scenarios of moral consequence"

The platform is the idea of Iyad Rahwan and social psychologists Azim Shariff and Jean-François Bonnefon and is based on *The trolley problem*, introduced for the first time by Philippa Foot in 1978.

The trolley problem is a series of experiments in the field of ethics and psychology that are based on stylized ethical dilemmas in which the choice lies in sacrificing one person to save many or not. Trolley problems have been used in the development of moral theory and in the psychological study of moral judgments and behavior.

The chain of experiments starts from a basic scenario in which a crazy trolley travels at high speed on a track and is about to hit 5 people on the tracks, a third person can intervene and hijack the vehicle on another track where it would only kill one person. From here a long series of variants are developed based on the modification of the variables

[63] The Moral Machine: https://www.moralmachine.net/

present in the scenario but the heart of the experiment remains centered on the choice to either do nothing and let several people die or intervene and sacrifice one initially "safe" person to save them.[64]

There are many interpretations:

Giving an interpretation according to the utilitarian point of view, the third component of the scene is morally obliged to divert the trolley onto the alternative track, killing a person instead of 5. According to this type of ethical reference, the choice would be morally the most correct. Looking at the situation from a responsibility point of view, as evil is taking place, acting and participating in such malicious events would result in guilt. The one who maneuvers the exchange would therefore become responsible for the evil done, regardless of the purpose, while otherwise, the responsibility could not be attributed to him or to anyone else present. Obviously, this vision is opposed by all those who consider human life as an invaluable asset and who reply that being present and able to act morally obliges a third person to intervene to try to minimize the damage. Not acting, in this case, is an immoral choice.

This type of considerations, in addition to not having absolute value, are also influenced by the culture of origin as demonstrated by B.D. Pulford and A.M. Colman[65] as well as by the mental state in which the person who has to make the choice finds himself (as underlined by the study of Lucifera et al.[66] it is very different to make a rational choice by observing from the external rather than being "hot" involved in the scenario).

The trolley problem was the center of many investigations and simulations and in most cases the respondents chose to kill the single person to save five. changing the variables in the field, however, the result changes: in fact, if the single person turns out to be a relative, a young person or a partner, respondents are less inclined to sacrifice the individual person for the salvation of the five.[67]

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[64] Lucifora C., Grasso G.M., Perconti P., Plebe A., “Moral Dilemmas in self-driving cars”, Rivist ainternazionale di filosofia e psicologia, 2020

[65] B.D. Pulford and A.M. Colman, “Cultural differences in responses to real-life and hypothetical trolley problems”, Research Gate, 2014.

[66] Ivi

[67] A. Bleske-Rechek; L.A. Nelson; J. P. Baker; M. W. Remiker; S. J. Brandt . "Evolution and the trolley problem: people save five over one unless the one is young, genetically related or a romantic partner", Journal of Social, Evolutionary, and Cultural Psychology. 2010

By subjecting professional philosophers to the same test, in 2013 it was shown that 69.9% of participants would have sacrificed the single life to save the five, 8% would not have acted by letting the trolley invest the five people and 24% had a totally different vision and did not respond to the test.[68]

This dilemma was therefore taken as a reference to develop different scenarios and place them in the reality of autonomous vehicles. In the new versions of the dilemma, an equally extreme situation is represented in which the difficult choice must be made by the software that drives the vehicle. The choice is represented by into whom or what to crash, affecting the variables of the deadly outcome.

Choices always include changing lanes or not, hitting different types and numbers of pedestrians, and sometimes hitting pedestrians or letting the vehicle crash and kill the driver.

In this last case a relevant topic emerges: should the software value the safety of the car's occupants more, or less, than that of potential victims outside the car?

It is easy to understand that such an issue is extremely important and controversial especially from the point of view of a product that is bought by a user and who may choose not to protect it.

Starting from what has just been illustrated, the Moral Machine of the MIT Media Lab was born with the aim of collecting the thoughts and opinions of users regarding the possible choices in front of which a vehicle could be found, based on the paradigm of the trolley problem. The data of the moral machine endorse the results of several studies showing the gap between choices made by different nationalities.

However, other studies[69] contest the usefulness of the research, while acknowledging the value of collecting data on the subject for public debate, they consider the research itself to be inconsistent and not very useful for solving the problem. They argue that the proposed reasoning methodology could be counterproductive and that the opinions gathered cannot be considered representative of the collective opinion. Another argument raised is the technical

[68] Bourget D., Chalmers D. J., “What do philosophers believe?”, Philosophical studies, 2013
[69] De Freitas J., Anthony S.E., Censi A., Alvarez A.G., “Doubting driveless dilemmas”, APS- Association for psychological science, 2020

impossibility of any type of software to be able to consider such a number of random variables to cross with false positives and road legislation.

Another issue of greater importance consists in understanding who should be responsible for dictating the ethical standards to be implemented in autonomous vehicles. one option is that the legislative system and governmental authorities are responsible for it.

Regarding this topic, in 2016 in Germany, the government appointed a special commission to study the ethical implications of the phenomenon. From their meeting, a report was born containing 20 rules that must be taken into consideration for the management of the ethical issue of autonomous vehicles.

Below are 3 particularly significant examples linked to the dilemma and the relationship between knowledge of the AV and users:

8) Genuine dilemmatic decisions, such as a decision between one human life and another, depend on the actual specific situation, incorporating "unpredictable" behavior by parties affected. They can thus not be clearly standardized, nor can they be programmed such that they are ethically unquestionable. Technological systems must be designed to avoid accidents. However, they cannot be standardized to a complex or intuitive assessment of the impacts of an accident in such a way that they can replace or anticipate the decision of a responsible driver with the moral capacity to make correct judgements. It is true that a human driver would be acting unlawfully if he killed a person in an emergency to save the lives of one or more other persons, but he would not necessarily be acting culpably. Such legal judgements, made in retrospect and taking special circumstances into account, cannot readily be transformed into abstract/general ex ante appraisals and thus also not into corresponding programming activities. For this reason, perhaps more than any other, it would be desirable for an independent public sector agency (for instance a Federal Bureau for the Investigation of Accidents Involving Automated Transport Systems or a Federal Office for Safety in Automated and Connected Transport) to systematically process the lessons learned. [70]

[70] Federal Ministry of Transport and Digital Infrastructure, "Ethics Commission- Automated and Connected Driving", BMVI, 2017.
https://web.archive.org/web/20170914192519/http://www.bmvi.de/SharedDocs/EN/publications/report-ethics-commission.pdf?__blob=publicationFile

Two other points cited by the commission are worthy of attention, and relevant to the central argument of this thesis:

12) The public is entitled to be informed about new technologies and their deployment in a sufficiently differentiated manner. For the practical implementation of the principles developed here, guidance for the deployment and programming of automated vehicles should be derived in a form that is as transparent as possible, communicated in public and reviewed by a professionally suitable independent body.

20) The proper use of automated systems should form part of people's general digital education. The proper handling of automated driving systems should be taught in an appropriate manner during driving tuition and tested.

For the author it is interesting to note that also the Committee delegated to the ethical study of the phenomenon has underlined how the complete and transparent information, the sharing of technical topics with the public and the education of the same are fundamental steps for the good management of the phenomenon from an overall point of view.

Another notable topic is the perception of the moral machine.

If the topic on which this experiment is based is already known by most because it is very delicate, close to every road user and, in part, treated in a sensational way by the media, the moral machine has amplified the debate on this issue by placing itself as a mediating tool. Its characteristics, namely being digital and available online without the need for any type of account, having a user-friendly and easy to use interface and captivating graphics, have brought it closer to a gamified experience. Born as a data collection ploy on the subject, it has evolved to become a hub of opinion. An example of this is the addition on the site of the editor mode where each user can create their own scenario and make it publicly available.

All these elements, combined with the possibility of comparing the results of one's choices with those of other users, highlight the gamification aspect underlying this experiment, and this is probably what made it so popular and "talked about".

Another point of view on the moral machine is the one given by Derek Muller: the reality is that 99% of accidents aren't like those presented in the scenes of the "Moral" machine. Every year, around 1.3 million people are killed on the roads, almost all of them due to human error. If autonomous cars can reduce these fatalities, then the real moral dilemma is not getting them on the road sooner for fear we haven't worked out exactly how they'll react to extremely

unlikely hypothetical scenarios. Humans are becoming worse drivers because they're just prone to distraction. These vehicles have way more experience than any human driver because they've now accumulated data over 20 million miles of driving on public roads. An average human driver would have to drive for a thousand years to accumulate that sort of experience. The real moral dilemma is therefore why we are not adopting autonomous vehicle now.[71]

3.4 Critical reflection on antecedents and above

The dynamics revolving around autonomous vehicles resistance, acceptance and adoption are not new to society.

During an interview, Chris Urmson, the head, the head of Google's self-driving-car project, said: *"Another related technology, in a lot of ways, is the elevator…. It's another technology that had a fairly profound impact on cities.",* and Elon Musk, the CEO of Tesla, has the same opinion as claimed himself.

Even if thinking about it now may seems a bit strange, elevators changed completely how humans physically move through building and cities, adding the vertical dimension: elevators made higher floors more desirable, they also enabled architects to build up, creating the vertical aesthetic of the modern city, skyscraper-dotted horizons.

Urmson enriched the parallel adding that *"There's another really interesting parallel in the way they were introduced. The technology was this magic thing that would whisk you up floors. You couldn't possibly imagine relinquishing your life to this thing. So, it was people's job to sit in the elevator and press the button for you—because it was so complicated. People grew accustomed to it, and they realized they didn't really need the person there to press the button."*

Still in the mid-1900s, the elevator operators where responsible of "driving the vehicle" but there were driverless elevators as far back as the early 1900s, but nobody trusted them. It wasn't until the middle of the twentieth century that the tipping point came along for the driverless elevator as the result of a strike by the elevator operators' union in New York City in 1945. The strike was devastating, costing the city an estimated one hundred million dollars. Suddenly, there was an economic incentive to go back to the automatic elevator. Over the next

[71] D. Muller, in collaboration with Waymo, "Why you should want driverless cars on roads now", Youtube, 2021

decade there was a massive effort to build trust in automatic elevators, which resulted in the elimination of tens of thousands of elevator operator jobs.

"Trained operators armed with cranks and levers have been replaced with buttons; motion sensors have made holding the door less of a heroic act.[72]*"*

Now we take the elevators for granted, we don't think about how safe it is or how does it work, even if, after all, twenty-seven people die yearly as the result of faulty automatic elevators. However, according to the Center for Disease Control's National Center for Health Statistics, one thousand six hundred people die from falling downstairs: that means you're sixty times as likely to have a fatal accident taking the stairs. Unfortunately, numbers alone rarely change perception.[73]

When the autonomous vehicles will be the main transport mean, people are likely to see human-driven cars differently. "*People may outlaw driving cars because it's too dangerous*," Musk said at a developer's conference in California earlier this year. *"You can't have a person driving a two-ton death machine."*[74]

Obviously, elevators and vehicles are completely different scenarios, at least from the technical point of view, but the fundamental issue with the adoption of "driverless," in both cases, isn't so much the technology, which can be much safer without a human driver, it's about trusting a machine to do something as well as we believe a human can do it: it's all about *perception*.

As the potential of AV emerged, public opinion and industry experts faced discussions on the matter highlighting both the benefits and the risks. Since the process of transitioning to AV has begun, however, research continues to advance and many of the risks associated with AV are being addressed and curbed with increasing success. But if research can evolve and develop on the basis of previous successes and failures, public knowledge is not updating at the same rate, and many of the collective fears remain tied to limits and barriers being resolved. The question the researcher asks is therefore, how much do potential users know about AV and the progress made in the field today? By what means do they inform themselves?

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[72] Boston Globe, 2014 https://www.bostonglobe.com/ideas/2014/03/02/how-elevator-transformed america/b8u17Vx897wUQ8zWMTSvYO/story.html#:~:text=The%20arrival%20of%20the%20elevator,climb%20six%20flights%20of%20stairs.

[73] Inc. bringing Innovation to market, 2018 https://www.inc.com/thomas-koulopoulos/100-years-ago-we-feared-a-different-kind-of-driverless-vehicle.html

[74] The Atlantic, 2015. https://www.theatlantic.com/technology/archive/2015/12/magic-boxes-with-buttons/419841/

If well understood in their deep dynamics, these means could be part of a joint strategy aimed at public information and at creating a network of knowledge preparatory to critical thinking and the formation of conscious thinking.

Leaving the analysis of these questions to the following sections, with paragraph 3.3 we intend to deepen the experimentation in progress starting from the pioneer states up to the situation in Italy with some representative examples.

The progress of experiments, increasingly people oriented, is bringing technology closer to the future of the population. The key to make them an integral part of everyday life is making citizens aware of these advances. Example of good practice is the American case and the push towards divulgating graphic info, open to all citizens.

3.5 Experimentations

The experimentation on the most advanced autonomous driving proceeds quickly all over the world; the best-known examples to the public come from overseas and consist of Tesla, Google, Apple and Uber, but they are not the only ones.

A theme that combines the aspects of active safety and comfort is represented by the electronic driver assistance systems (ADAS). Many new generation cars, but already regularly on the market, are equipped with Level 2 systems, often standard even on medium and low-range vehicles. With this technology, the driver can leave the vehicle to control the accelerator and steering in specific situations such as for example the active maintenance of speed on the motorway or traffic jam in urban traffic. Level 2 is the highest permitted to circulate by traffic regulations in many countries and requires the driver to always remain ready to intervene. The objective of the research, however, is clearly to reach Level five in the future.[75][76]

"Volkswagen has announced that it will test its automated driving service in China after it has just been issued the first license plate to affix to the car for road tests. According to Volkswagen Group China, testing will begin next month in the Haiheng community in Hefei, the capital of Anhui province in eastern China, with the aim of optimizing the user experience. The testing area extends over 16 km2 with a total road length of 80 km, a route where vehicles will pass

[75] Jeniot: https://www.jeniot.it/blog/stato-sperimentazione-guida-autonoma-in-italia
[76] Economyup: https://www.economyup.it/mobilita/guida-autonoma-dove-e-come-si-sta-sperimentando-in-italia/

near schools, shops, parks, hospitals, and residential communities. By the beginning of 2021, Volkswagen intends to test the first batch of ten self-driving electric vehicles with passengers on board and approximately 400,000 residents of the area, through a mobile application, will be able to use a self-driving car."[77]

So cites the article by Maurilio Rigo published in Repubblica on 28 August 2020

3.5.1 Pioneers

As reported by the CNN, at the end of 2020 a start-up (AutoX) supported by Alibaba announced the launch of the first fleet of 25 driverless taxis (Fiat Chrysler) on the road in Shenzhen. As the first company to achieve this, AutoX has set a milestone for the automotive industries. This is the first project where there is no safety driver in the vehicle or other type of remote controller. The government has not imposed any restrictions on the areas that can be traveled by taxis, but the company has stated that for the moment they are concentrated in the downtown areas, which are easier to manage.

"It's a dream," AutoX CEO Jianxiong Xiao said in an interview. "After working so hard for so many years, we've finally reached the point that the technology is mature enough, that we feel confident by ourselves, to really remove the safety driver."[78]

The CEO reveals that he has prevailed over related legislation by constantly investing and improving vehicle software and AI. The company has about a hundred machines equipped with sensors that move around the country with the aim of collecting data and training the AI to obtain the best possible result.

The project is still in the trial phase and not accessible to the public, but the company hopes to make the service fully operational within 2 or 3 years and, according to Xiao, the coronavirus pandemic demonstrated the need for contactless services, which encouraged the government to move faster with autonomous technology.

Always in 2020 the city of Beijing opened 111 roads with about 322.46 km in the Beijing Economic-Technological Development Area in the southeast suburb for the tests, covering

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[77]Repubblica: https://www.repubblica.it/motori/sezioni/attualita/2020/08/28/news/dalla_cina_agli_stati_uniti_prove_di_guida_autonoma-265682616/

[78] CNN: https://edition.cnn.com/2020/12/03/tech/autox-robotaxi-china-intl-hnk/index.html

almost the whole area except for sections where schools, hospitals and office buildings are located.

The city issued a license for carrying passengers in self-driving car tests to 40 vehicles from Chinese internet giant Baidu. The regulations gave the green light to road tests for self-driving vehicles carrying passengers.

So far, Beijing has opened 151 roads with about 503.68 km, ranking first in the country. As of December, the city has issued road test licenses to 77 vehicles from 13 companies, which traveled over 1 million km.

According to a government plan, test spaces for intelligent connected vehicles in the capital are expected to reach 500 square km by 2022, and a total of 2,000 km of roads are expected to be open for testing

3.5.2 America

"On the other side of the ocean, Ford, Bedrock and Bosch are exploring advanced autonomous driving technology in Detroit to simplify parking. The three companies have started an experimental project using Ford Escape-based prototypes that can drive and park autonomously inside the Bedrock Assembly Garage in Detroit, using Bosch's intelligent infrastructure. It should be noted that this is the first solution for autonomous parking in the United States, thanks to which the vehicle parks itself within the specially set up area. The trial will involve the Corktown district, where Ford's new mobility innovation district is located, set up specifically for the development, testing and launch of new solutions capable of solving the challenges of urban transport, thus preparing for a mobility increasingly connected and autonomous."

As reported by Scientific American[79], experimentation of great importance both for the names involved and for the entity is the one carried out in Miami. The Miami project, focused on delivery services and in operation since 2018, involves two major players on the American scene: Walmart and Ford. A fleet of several dozen vehicles was deployed in the project as part of a larger design idea according to which Ford intends to launch a functioning AV fleet by 2023 (currently delayed due to Covid19).

[79] Scientifica American: https://www.scientificamerican.com/custom-media/pictet/self-driving-cars-to-test-city-limits/

Sherif Marakby, president and CEO of Ford Autonomous Vehicles (FAV), states that the vehicle itself is not the determining factor in the success of their introduction. The aspects that will play the decisive role will be the way in which cities and citizens prepare to welcome them. AVs have great potential for improving urban management but only if they can exploit them in the correct way.

"It takes a lot of work with a city and its people to build a successful autonomous-vehicle operation," says Marakby. *"We worked with officials in Miami for months before we even started our experiments there. […] Infrastructure (digital and physical ones) has to start with the city. But it can't do it on its own. It won't happen without partnerships."*

As for the gradual introduction of technology, Marakby has his vision. He envisions, in a first phase, a city with AV-only lanes in multi-lane roadways, expanding them over time to complete AV-only roadways. Eventually, entire regions of the city, such as the traffic-choked downtown section, might be restricted to AVs. An additional key step would be setting up AV-only curb drop-off zones, so the vehicles don't block roadways waiting for spots to open.

Another relevant example is the case of Waymo Google project, in October 2015, this google car, known as the Firefly, went on a public road, ridden by Steve Mann, who has a disability, he is legally blind. Surveys show 74% of people believe they are above average drivers. In the 20th century, 60 million people were killed on the road. This car could detect a stop sign or a pedestrian 500 meters away. And one of the interesting things is that the vehicle is able not only to see where things are and where they're going, but also to make predictions about where they're likely to go. So, the Firefly doesn't just have one potential future. It's constantly imagining, possibilities and possible reactions

In 2019, Waymo released a study of its data, over 6.1 million miles of automated driving in the Phoenix, Arizona metropolitan area. Of the 18 total accidents that occurred during the study, none were serious enough to expect significant injury or death. In Waymo's Safety Report, they found some types of accidents have been eliminated by this autonomous driving system, like the car doesn't go off the road and it doesn't hit stationary objects.[80]

Looking at the eight significant accidents that happened with Waymo vehicles over the six million miles of driving, all eight of them involved a human driver of another vehicle doing

[80] D. Muller in collaboration with Waymo, "Why you should want driveless cars on roads now", Youtube, 2021

something dangerous or illegal, like driving on the wrong side of the road or running a red light or going through a stop sign or failing to yield or going 20 miles per hour over the speed limit. There were three incidents involving Waymo vehicles and pedestrians, but in all three, the Waymo vehicle was stationary, and the pedestrian or cyclist/skateboarder ran into the vehicle. Waymo also takes some of that real-world data so that researchers can put it into simulations changing some variables for the sake of training the software. So, they try adding like a bicyclist going fast or going slow, or they make the car turn faster or slower. Changing all these parameters and variables, they test the software and its reactions.

Looking beyond the ocean, it is possible to see how not only the experiments are proceeding at full capacity but also the communication and management "meta-apparatus" is maturing.

In June 2019, on the "Uber Elevate Summit"[81] event, held in Washington DC, Elaine Chao as Department of Transportation Secretary, declared that on the roads of 36 American states, in that period there were tests on more than 1400 self-driving cars, trucks and other vehicles operated by 80 different companies.

In particular, the state of California, one of the pioneers to have implemented AV testing on public roads, has 62 companies registered in its territory to carry out this tests.

The American Department of Transportation (DOT) has introduced and continues to support guidelines and rules to facilitate and clear industrial and commercial access to autonomous vehicles and related trials.

Thanks to the US Government initiative held by NHTSA “AV TEST”, the population can have a clear vision (also thanks to the use of illustrative graphic info fig.17) of the ongoing trials, their extent, and related statistics.

Through this initiative, states and companies can voluntarily provide information about AV trials. The agency has developed an interactive tool, frequently updated, with which the population can view data and information.

[81]Techcrunch: https://techcrunch.com/tag/uber-elevate-summit-2019/

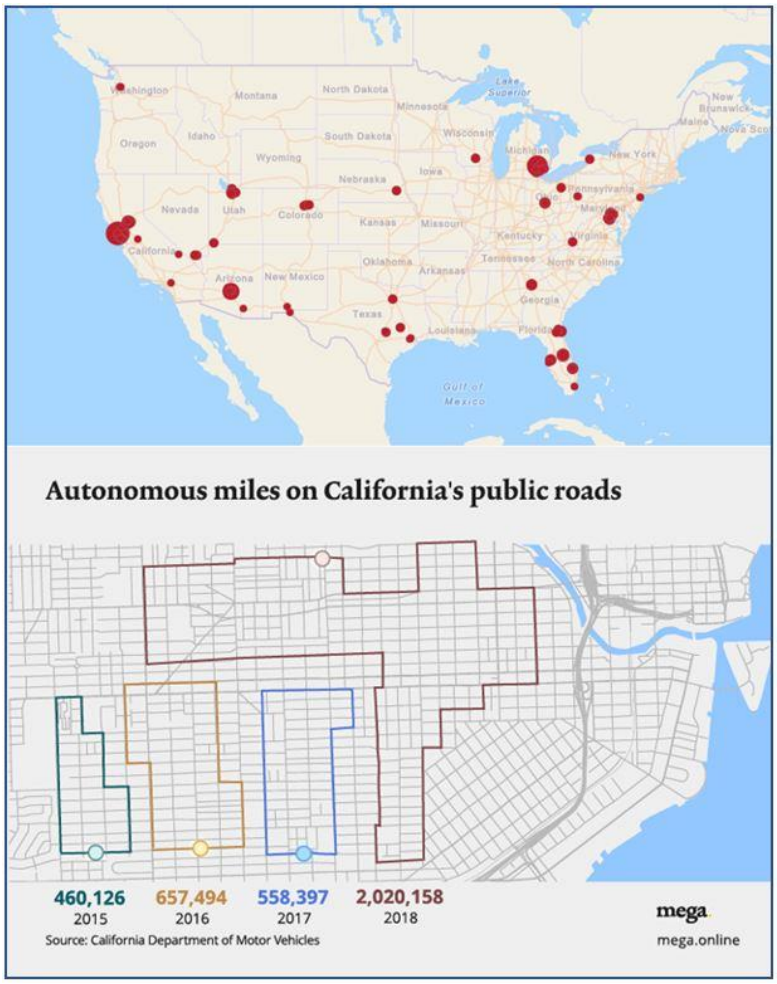

Figure 17 American Graphic Info about AVs experimentations

Using specific filters, it is also possible to see the experimentations divided according to the type of vehicle or the kind of road involved in the experimentation (fig.18).

A growing number of AV founders and engineers understand that public education and acceptance will be necessary if they ever hope to commercially deploy their technology.

Ten companies and nine states have already signed on as participants in the voluntary web pilot […] *"The more information the public has about the on-road testing of automated driving systems, the more they will understand the development of this promising technology,"* NHTSA Deputy Administrator James Owens said in a statement. *"Automated driving systems are not yet available for sale to the public, and the AV TEST Initiative will help improve public understanding of the technology's potential and limitations as it continues to develop."*[82]

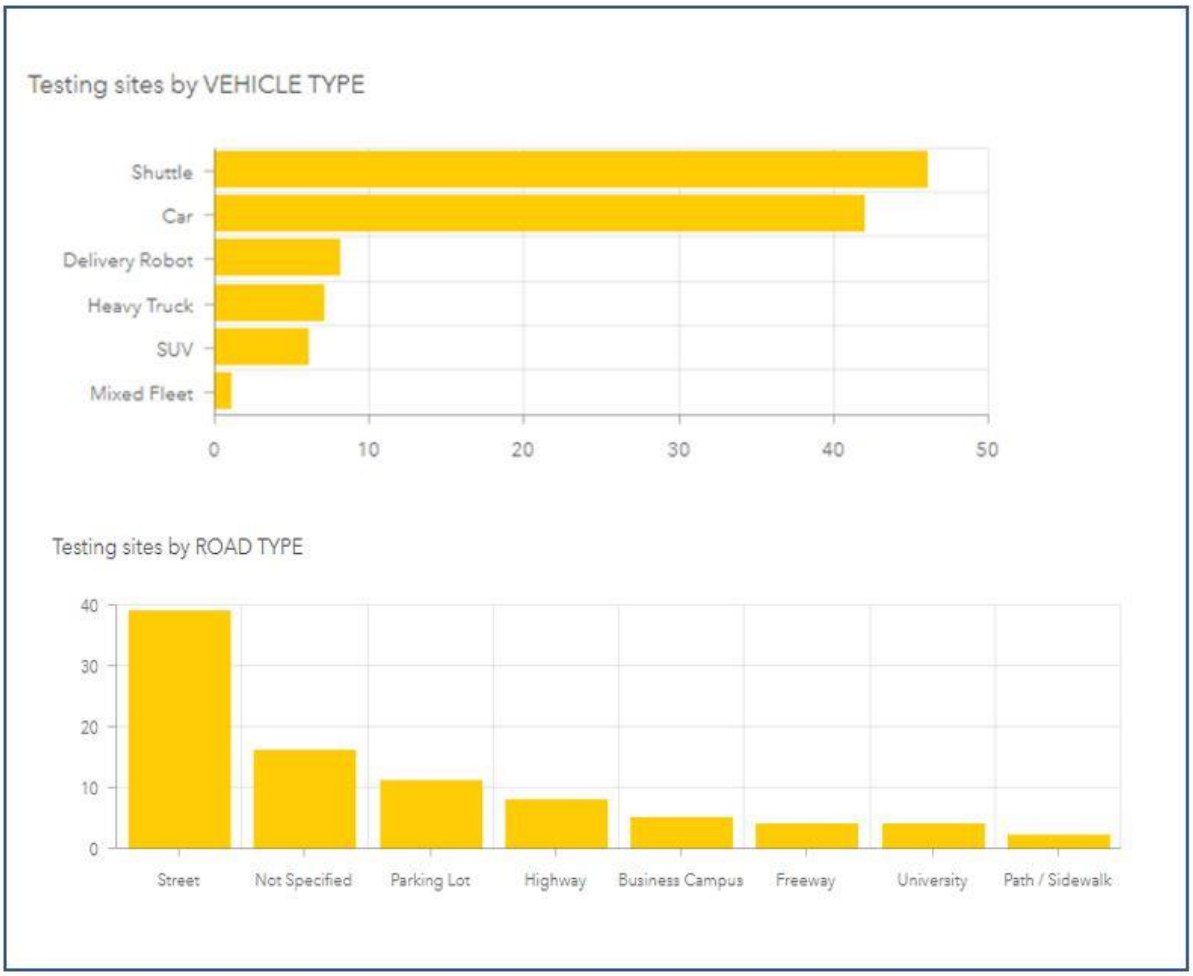

Figure 18 Experimentations divided for Kind of vehicle and road involved

The SAE itself, responsible, as we have already seen, of the definition of the 5 levels, recognizes the leading importance of communication and people engagement: *"SAE International announces a new visual chart for use with its J3016™ "Levels of Driving*

[82] Techcrunch: https://techcrunch.com/2020/09/02/track-autonomous-vehicle-testing-in-your-state-with-this-new-tool-from-the-u-s-government/

Automation" standard that defines the six levels of driving automation, from no automation to full automation. The new chart offers more "consumer-friendly" terms and definitions for the levels, which are frequently cited and referred to by industry and media. The infographic will help to eliminate confusion by providing clarity and using terms more commonly used by consumers"(fig.19).[83]

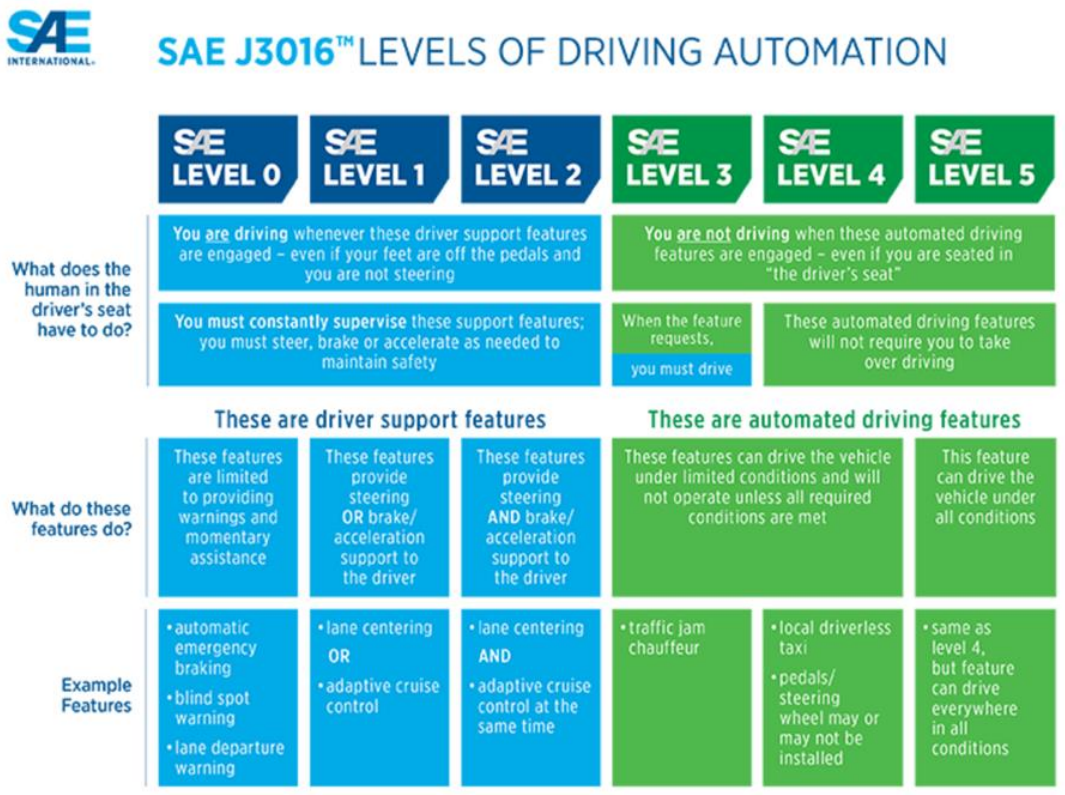

Figure 19 SAE Visual Chart

This specific interest in education and the dissemination of information to the public takes shape in the decision to transmit news on existing trials in the clearest and most explanatory way possible, as mentioned above, the info graphics assume an important role in the American campaign.

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[83] SAE: https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles

3.5.3 Italy

The experimentation of autonomous vehicles in Italy is currently regulated by the decree of the Ministry of Infrastructure and Transport (MIT) n ° 70 of 28 February 2018 or the "Smart Road" decree (Implementation methods and operational tools of the road experimentation of Smart Road solutions and connected and automatic driving). This decree deals with all the fundamental principles and rules for carrying out tests with autonomous vehicles (it should be remembered that currently the highway code does not allow the homologation of self-driving cars).

In September 2020, the Decree was updated: the strong propensity for technological innovation that characterizes the Observatory (The Technical Support Observatory for Smart Roads and for the connected and self-driving vehicle, set up at MIT, as required by art. 20 of Ministerial Decree 70/2018, became operational on 19 June 2018) led him to review and update the content of decree 70/2018, in the completion phase of its process, introducing, among other things, the possibility of experimenting on the public road also vehicles of innovative kind, today neither homologated nor type-approved, according to the current national and international standards of the sector. It now provides for the experimentation of "innovative means of transport" which, for example, "do not have a steering wheel or a pedal". In other words, a scenario of totally autonomous vehicles opens, they can travel our streets, naturally under the supervision of the experts.[84]

An important sign of innovation and openness towards new horizons was thus given, also following up the different needs expressed by multiple stakeholders.

Even in the case of tests, those who request the test permission (manufacturers, universities, research bodies ...) must be able to guarantee that they meet certain criteria including:

- the vehicle must be able to comply with the rules of the highway code,
- the vehicle must be able to interact correctly with other road users,
- the vehicle must ensure the possibility at any time to switch from automatic to manual mode immediately
- the responsible must always be on board and he is effectively and legally responsible of the vehicle (even when in autonomous mode)

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[84] MIT: https://mit.gov.it/comunicazione/news/smart-road/smart-road-importante-segnale-di-innovazione-e-apertura-verso-nuovi

If we talk about actual road tests, the first Italian city to host them was Merano where in 2019, for a week, the first experimentation of autonomous buses open to the public took place. An electric minibus of the Navya company has continuously traveled a circular urban section reserved for it and closed to the public on the edge of the historic center, for a duration of ten minutes each way and with a maximum speed of 25 km / h. The vehicle, that can contain up to 15 people, is currently distributed in 25 countries, in some for-test purposes, in others, such as Sweden, it is already integrated into the urban transport system.

The Autopilot project took place in Livorno and in other five European cities. The experiment, which ended in 2019, focused on a Renegade model jeep which, constantly connected with MoniCa, the digital port platform, traveled the Florence-Pisa-Livorno super road updated in real time on any disruption.

In Turin, a 35 km route of roads (both in the center and suburbs) was created to test autonomous vehicles in different scenarios. The vehicle in question, supported by integrated technology and 5G bridges, interacts with the road and signs. From January 2020 the electric and autonomous van Olli 2 moves on the streets with its 25 km / h and a maximum capacity of 12 passengers. The vehicle, made by the American company Local Motors, is at level 4 of automation and the drivers, at least for the moment, will not be eliminated. The hope for the near future is that these vans will replace part of the city's car fleet.

In Milan, the Milanese public transport company (ATM) is promoting a Smart Mobility plan that aims to test a public transport system based on level 5 autonomous vehicles (with a capacity of 15 people and accessible to disabled people). Meanwhile, thanks to an active collaboration with the Politecnico, a prototype autonomous driving study is being tested on some selected lines (as they are linked to suitable routes) and plans for a future autonomous mobility are being designed.

Finally, the city of Monza, impossible not to mention in terms of media coverage and simulators. The Simulator Room project was presented in Monza during the Formula 1 Grand Prix and, as the name suggests, consists of an AVs simulator developed by the Polytechnic researcher that opens the way for further research and experimentation in the AVs field.

3.5.4 Platooning and Infrastructure

Platooning is a new freight delivery system based on automated vans, one of the many possibilities offered by autonomous vehicles. With this term we mean a group of AVs that can travel in columns at close range and at high speed in a safe and risk-free way. Each vehicle in the formation communicates with the others, the first vehicle drives and controls speed and direction while the others follow with perfect speed and braking matching. The Platooning can be 'pure', meaning that all the vehicles will be autonomous, or, much more likely, 'hybrid', meaning that the first vehicle in the line will have a human driver, and only the following ones will be truly autonomous (fig.20).

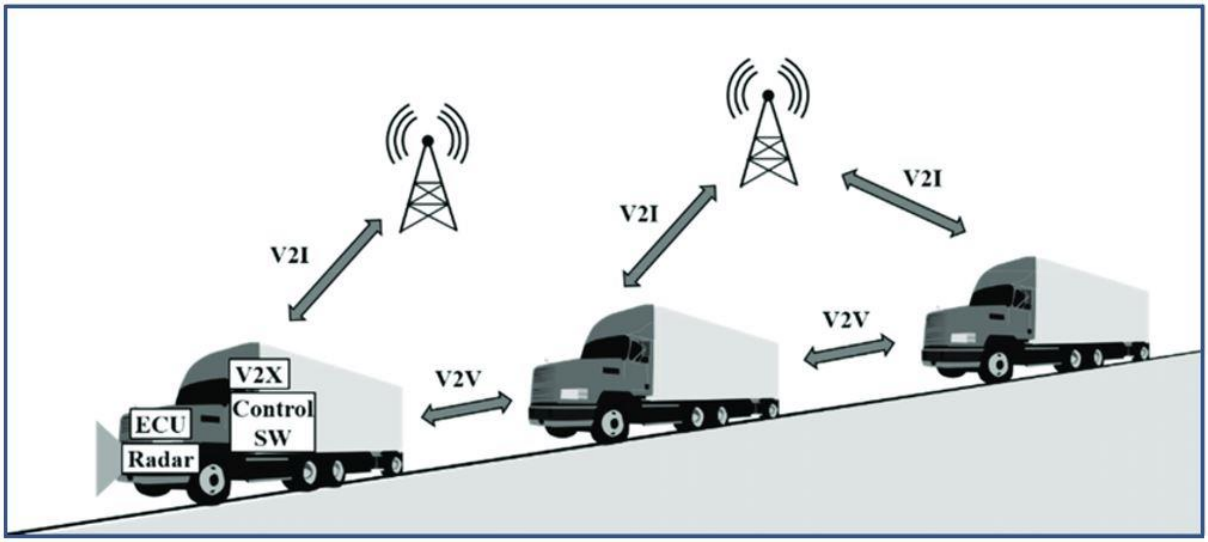

Figure 20 The functioning of Platooning

The benefits of platooning are numerous and range from more technical and physical reasons to considerations connected with human nature. This type of organization increases the aerodynamics of the group, allows better management of road capacity and traffic flow; fuel consumption is optimized and restarts (for example at traffic lights) are more efficient and can reduce the percentage of road accidents.

The phenomenon of platooning could revolutionize and optimize the world of goods distribution as explained by Lupi [85]. They visualize a scenario in which each platoon goes from a large distribution center to smaller sorting ones located near the city center where the various

[85] M. Lupi, A.Pratelli, A. Farina, "Modlling and simulation of a new urban freight distribution system based on automatic van platooning and fixed split up locations", IET Intellignt Transport System, 2019.

vehicles separate and each, autonomously, completes the delivery along the final stretch of the journey. The driver of the leading vehicle, after leaving the station, reaches another center where his performance is required, thus optimizing the logistics chain. When the deliveries have been completed, the different vehicles return to the point where they split and recompose the original platooning formation to return to the major sorting center (first leg of the outward journey). All made possible by the application of refined simulation and management algorithms.

In a 2017 study[86] concerning the experimentation of vehicular platooning, the various possible management strategies (decentralized and distributed) are investigated such as predecessor following, symmetric bidirectional control or cooperative adaptive cruise control, opening the doors to many future possibilities.

Speaking about people mobility and platooning, in the following particular application tested in Padua, there is already a coexistence between autonomous vehicles and vehicles with drivers and this gives life to innumerable customizations of the service. If we think about this technology applied to people's mobility the possibilities are many. A not well-known example of this is represented by the Next Future Transportation project in Padua. Supported by the Municipality, the project focuses on electric and modular minibuses from a local company (fig.24). The modularity allows, in addition to an easy composition of the vehicle according to the needs, to customize the routes based on real-time analysis of the passengers' destinations. The project foresees two successive phases, the first test will be carried out in a dedicated area closed to traffic, subsequently and with the green light of MIT, they will move on to experimentation on roads open to traffic.

Another strongly underestimated sector is the one concerning AVs propaedeutic infrastructures. As already underlined, the advancement and experimentation of vehicles alone is not enough: it must be supported by the development of both the social and infrastructural (physical and digital) context to be a successful experience.

With the aim of making the most of the potential of the new vehicles, various experiments have begun on complementary infrastructures or "smart roads". Anas has recently instanced funds for approximately 140 million euros to adapt 2500 highway km to V2X connections.

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[86] M. Làd, I. Herman, Z. Huràk, “Vehicular platooning experiments using autonomous slot cars”, Elsevier,2017

In Veneto, 74 km of road have been transformed into e-roads, creating a technological interconnection between infrastructures and all vehicles (including heavy vehicles). A similar experience began in 2020 and carried out in Brenner in collaboration with MIT. The C-roads Italy project puts vehicles in communication with special radio centers capable of reporting different types of disruptions (accidents, queues, works, weather...)

The MASA (Modena Automotive Smart Area), on the other hand, located in Modena, is an urban area equipped with a basic infrastructure for V2X systems and ready for the experimentation of level 3 and 4 autonomous vehicles. The area could soon include a fast-flowing extra-urban route. Also in the Modena area, near the racetrack, is the Smart Dynamic Area, a safe and reserved area where, in a multidisciplinary context, research is carried out on the application of technological innovations to mobility (AI, computer vision, UX, ethics …).

3.5.5 Experimentations effects

As can be seen from these examples, experimentation spread throughout the Italian territory and make it clear the concreteness and the advancement of this technology, as well as the will to implement it in the best possible way as soon as possible. The communication of these events, conducted in a structured and above all continuous way, providing for public follow-up communications of the results and their dissemination, can lead the possible user in the different states of knowledge that precede acceptance. Each of these experiments uses specific technologies and dynamics that contribute to an overall knowledge on the subject. Combining the possibility of seeing the vehicle firsthand and supporting the meeting with adequate communication actions is a key element to overcome user barriers and resistance.

The use of graphic info and centralized information on past, in progress and in program experiments, with clear and easily understandable visualizations and ergonomically correct user interfaces, can be useful for understanding the operational dynamics, not always expressed in the newspaper articles.

Also, the evolution of infrastructures has begun and is aimed not only at welcoming the new type of vehicles but also at gradually progressing along the innovative path, supporting step by step the small but fundamental innovations that are already underway.

By correctly conveying infrastructural experiments, lead step by step, people would have the opportunity to formulate an informed opinion on the possible implications of the transition

without being misled by imaginary scenarios that are impossible to implement. Likewise, if the phenomenon of platooning, presented in its pure and hybrid forms and in its version applied to public passenger transport, is used as an example of transition, this could dispel doubts about the methods of introduction of AVs.
In particular, in the case of hybrid platooning, it is possible to appreciate the advantages given by autonomous technology with all the safety provided by traditional mobility with driver. The driver can react correctly to all the disruptions typical of a standard road environment, not yet equipped with features for autonomous systems, while the autonomous component of platooning can demonstrate the on-road benefits of this technology as well as the benefits of independent autonomous technology once arrived in areas suitable for it.

The new era of the infrastructure could give evidence of the way in which e gradual enhancement can guarantee the safety of normal vehicles as well as supporting the development of the new mobility.

4 Society, Stakeholders and AVs Introduction

4.1 Who are the Stakeholders and How to classify them

Stakeholder is any individual, group of people or organization (regardless, in the latter case, of its profit or non-profit nature) who has interest in a project or in the business objectives that a company or an entity pursues and the way it does it.

Depending on the context, the term can take different meanings. The stakeholders of a project are, for example, all the people or groups who support that project in different ways and care about its success, including the developers, but also project managers, investors, consultants and even testers of the project. When we talk about corporate stakeholders, we refer, however, to all those individuals and groups, for using Freeman's words, "without whose support the organization would cease to exist."

But if in the eighties there was a tendency to emphasize the concept of corporate stakeholders, to the point of making it the main topic of corporate governance, today things have changed, and the term stakeholders means a wider set of agents connected to the project in question by a series of more or less strong and influencing interests.

Starting from the traditional view of business, the center of interest was represented by the shareholders or stockholders that are the owners of a company or project. The primary objective was therefore the satisfaction of their needs. With the advent of the stakeholder theory[87], it is highlighted that there are also other actors involved: employees, customers, suppliers, and many others.

Over time, the idea and the very concept of stakeholder has expanded to go beyond the purely corporate sphere and involve various aspects of working life. The nature and exact definition of what a stakeholder is has always been fought and contested[88] and adapts to the evolution of the epochs and of the business idea as summarized in the tab. 4 by Mitchel et al[89]

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[87] R.E. Freeman, J.S. Harrison, A.C. Wicks, B.L. Parmar, S. De Colle, "*Stakeholder Theory: The State of the Art",* Cambridge University Press, 2010.
[88] S. Miles, "Stakeholders: essentially contested or just confused?". Journal of Business Ethics. 2012
[89] R.K. Mitchell,B.R. Agle, D.J. Wood, "Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts", The academy of Management review, 1997

Table 4 Evolution of the Idea of Stakeholder in history, Mitchel et al.

Stanford memo, 1963	"those groups without whose support the organization would cease to exist" (cited in Freeman & Reed, 1983, and Freeman, 1984)
Rhenman, 1964	"are depending on the firm in order to achieve their personal goals and on whom the firm is depending for its existence" (cited in Näsi, 1995)
Ahlstedt & Jahnukainen, 1971	"driven by their own interests and goals are participants in a firm, and thus depending on it and whom for its sake the firm is depending" (cited in Näsi, 1995)
Freeman & Reed, 1983: 91	Wide: "can affect the achievement of an organization's objectives or who is affected by the achievement of an organization's objectives" Narrow: "on which the organization is dependent for its continued survival"
Freeman, 1984: 46	"can affect or is affected by the achievement of the organization's objectives"
Freeman & Gilbert, 1987: 397	"can affect or is affected by a business"
Cornell & Shapiro, 1987: 5	"claimants" who have "contracts"
Evan & Freeman, 1988: 75–76	"have a stake in or claim on the firm"
Evan & Freeman, 1988: 79	"benefit from or are harmed by, and whose rights are violated or respected by, corporate actions"
Bowie, 1988: 112, n. 2	"without whose support the organization would cease to exist"
Alkhafaji, 1989: 36	"groups to whom the corporation is responsible"
Carroll, 1989: 57	"asserts to have one or more of these kinds of stakes"—"ranging from an interest to a right (legal or moral) to ownership or legal title to the company's assets or property"
Freeman & Evan, 1990	contract holders
Thompson et al., 1991: 209	in "relationship with an organization"
Savage et al., 1991: 61	"have an interest in the actions of an organization and . . . the ability to influence it"
Hill & Jones, 1992: 133	"constituents who have a legitimate claim on the firm . . . established through the existence of an exchange relationship" who supply "the firm with critical resources (contributions) and in exchange each expects its interests to be satisfied (by inducements)"
Brenner, 1993: 205	"having some legitimate, non-trivial relationship with an organization [such as] exchange transactions, action impacts, and moral responsibilities"
Carroll, 1993: 60	"asserts to have one or more of the kinds of stakes in business"—may be affected or affect . . .
Freeman, 1994: 415	participants in "the human process of joint value creation"
Wicks et al., 1994: 483	"interact with and give meaning and definition to the corporation"
Langtry, 1994: 433	the firm is significantly responsible for their well-being, or they hold a moral or legal claim on the firm
Starik, 1994: 90	"can and are making their actual stakes known"—"are or might be influenced by, or are or potentially are influencers of, some organization"
Clarkson, 1994: 5	"bear some form of risk as a result of having invested some form of capital, human or financial, something of value, in a firm" or "are placed at risk as a result of a firm's activities"
Clarkson, 1995: 106	"have, or claim, ownership, rights, or interests in a corporation and its activities"
Näsi, 1995: 19	"interact with the firm and thus make its operation possible"
Brenner, 1995: 76, n. 1	"are or which could impact or be impacted by the firm/organization"
Donaldson & Preston, 1995: 85	"persons or groups with legitimate interests in procedural and/or substantive aspects of corporate activity"

Regardless of its definition in the strict sense, each project must therefore relate to a multiplicity of subjects who place in it a series of interests different in nature, as summarized by Serretta. (tab. 5)[90].

Table 5 different Stakeholders and their interests

Stakeholder Group	Issues of Concern
Customers	Product safety and content, Advertising practices, Trade-off between product/service price and environmental and social issues
Community	Charitable contributions, Local employment, impact on environment, political activity and regulatory compliance
Employees	Wages and benefits, Health and safety, Training and advancement, Gender Issues
Environment	Regulatory compliance, Emissions and hazardous materials, Waste reduction and recycling programs, environmentally friendly packaging
Institutional Investors	Financial returns, good corporate governance,

From the point of view of the nature of the stakeholders, it is also possible to divide them into macro categories such as

[90] Serretta H. et al., "Core corporate governance dilemmas facing boards. A South African perspective", in SAJEMS, 2009.

- public institutions: local territorial bodies (municipalities, provinces, regions, mountain communities, etc.), functional agencies (consortia, chambers of commerce, health companies, environmental agencies, universities, etc.), subsidiaries and investee companies
- organized groups: pressure groups (trade unions, trade associations, political parties and movements, mass media), local associations (cultural, environmental, consumer, social, sports or recreational groups, etc.)
- unorganized groups: citizens and communities (all citizens making up the local community)

From the point of view of their location with respect to the company or project in question they can be internal stakeholder and external stakeholder.

- The internal stakeholders of a company are all those subjects who interact directly and from within the organization precisely with business processes such as owners, members of the Board of Directors, managers, employees and so on.
- The external stakeholders are instead all those subjects such as institutions, governments, sector authorities, consumers, protection associations, etc. who, while operating outside the company, have an interest in the business of the same.

As we can see it can be a very widespread phenomenon that can involve large portions of society, it is therefore not surprising that stakeholder analysis and stakeholder mapping are fundamental tasks in modern management. For the well-being and success of the project itself it is good to know how to correctly map the stakeholders into categories based on the weight that their interests and therefore their support to the project. This type of analysis, especially for large processes involving many variables and actors, can be very complex and for this reason the use of clear, simple and visual analysis tools can be of great help in trying to schematize and rationalize the situation.[91]

Two of the most common method are the power-interest stakeholder matrix and the salience model.

[91] D.H.T. Walker, L.M. Bourne, A. Shelley, "Influence, stakeholder mapping and visualization", Construction Management and Economics, 2008.

The power-influence stakeholder matrix is based on two different variables, like indicated in the name, power and interest, disposed on cartesian diagram. (fig.21). For example, in the first quadrant (strong power, strong interest) there are the key stakeholders for the company, those to whom it will have to turn with high-impact activities. The second method, that is the salience model, is based on the graphic representation given by the Venn diagram and relates factors such as legitimacy (A), power (B) and urgency (C) and therefore allows to identify the saliency, described by Mitchell as The degree to which managers give priority to the competing stakeholder claims, of each stakeholder.

By crossing the 3 sets, 7 types of stakeholders are defined, characterized by a different degree of saliency (fig.22):

1. *Discretionary stakeholders*: These stakeholders have little urgency or power and are unlikely to exert much pressure. They have legitimate claims
2. *Dormant stakeholders*: These stakeholders have much power but no legitimacy or urgency and therefore are not likely to become heavily involved
3. *Demanding stakeholders*: These stakeholders have little power or legitimacy but can make much "noise" because they want things to be addressed immediately
4. *Dominant stakeholders*: These stakeholders have both formal power and legitimacy, but little urgency. They tend to have certain expectations that must be met
5. *Dangerous stakeholders*: These stakeholders have power and urgency but are not pertinent to the project
6. *Dependent stakeholders*: These stakeholders have urgent and legitimate stakes in the project but little power. These stakeholders may lean on another stakeholder group to have their voices heard
7. *Definitive stakeholders*: These stakeholders have power, legitimacy and urgency and therefore have the highest salience
8. *Non-stakeholders*: These stakeholders have no power, legitimacy, or urgency (outside the regions defined by the circles A, B, and C).

This type of analysis helps not only to know the different types of stakeholders potentially involved or engageable but also helps to make a SWOT-type assessment to evaluate any threats and allies, mechanisms to positively influence other stakeholders, key people to be informed about the project during the execution phase, negative stakeholders as well as their adverse

effects on the project and to understand the needs of which category of stakeholders to prioritize for the success of the project.

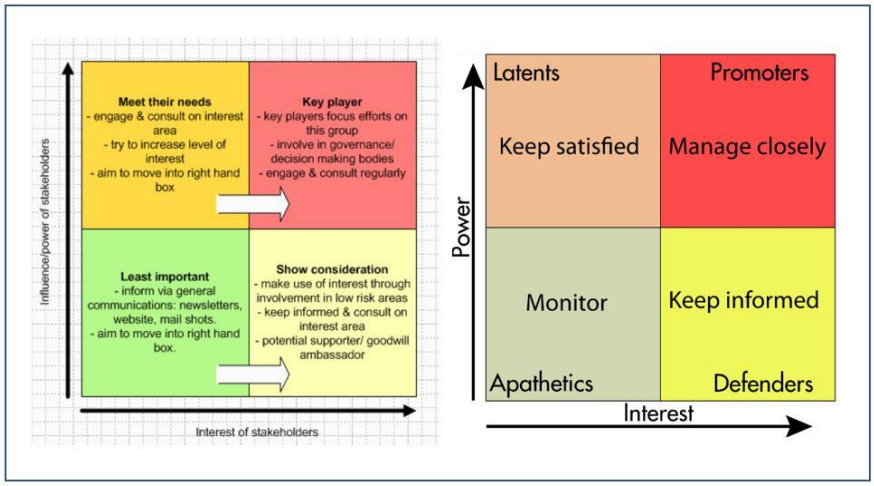

Figure 21 Power-Interest Stakeholder Matrix

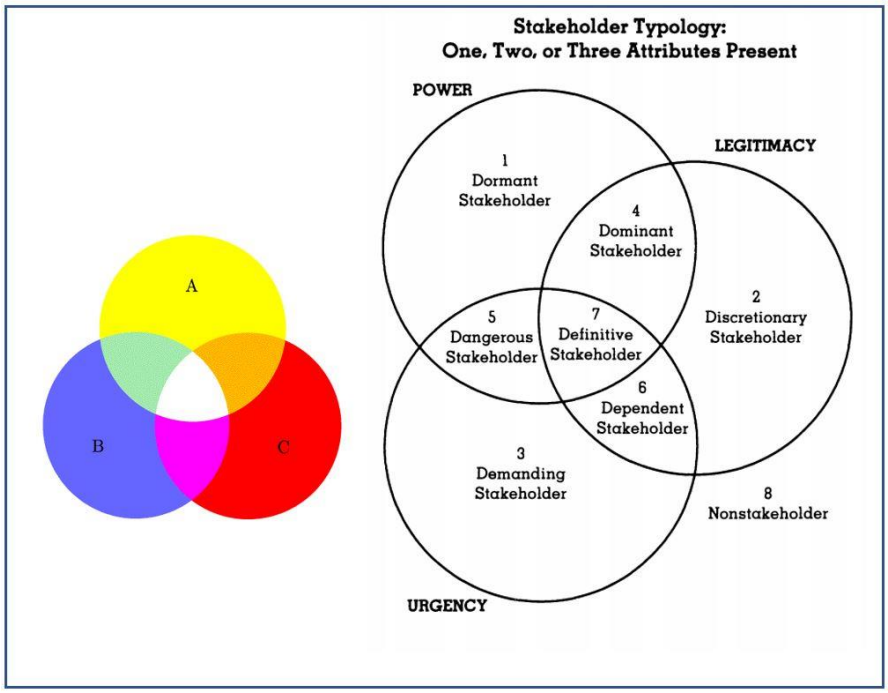

Figure 17 Salience Model

4.2 AVs' Stakeholders

Returning to the sector of competence of this thesis it is possible to identify a set of stakeholders of autonomous vehicles. The categories involved are many and different: some of them are involved in a more widespread way, others are only superficially affected by the phenomenon and while the action of some specific stakeholder is already fundamental starting from the phases preceding the introduction, for others the involvement will take place more in the long term, once the vehicles autonomous will be a reality. Kelly et al.[92]group stakeholders into three broad categories: government/authorities (ministry of transport, other national ministry, national parliament, politicians, local authorities, provinces, municipality), businesses/operators (transport operator, transport provider, private financier, national business associations, retailer, major employers) and communities/local neighborhoods (environment associations, transport users' associations, media, transport users, citizens).

Below a selection of the most relevant stakeholder is presented:

Political institutions at local, national, European, and international level and their emanations: regulations and planning at the federal levels depend a great deal on the changes in political landscapes. The openness of governments and the cooperation they receive in legislating such laws play another big part in the execution of breakthrough technologies. The advantages for legislators and regulators are numerous such as reduction in road accidents, better regulation of traffic laws, substantial decrease in personal car ownerships, moderation in congestion and traffic jams and many more. But the potential risks that this technology presents are equally exceptional. The increase in automation opens this technology to malicious attackers taking control of the vehicle which can provoke intentional accidents. Additionally, pinpointing the location of a person by knowing constantly the vehicle's location can violate personal freedom of individuals. A large portion of the investment must be invested in researching cyber security of users. In addition, regulators must balance the liability risks to automotive industries through favorable legislations to encourage innovation in this field while ensuring the efficacy of standards in screening technologies.

[92]J. Kelly, P.Jones, F.Barta, R.Hossinger, A.Witte, A. Christian, "Successful transport decision-making: A project management and stakeholder engagement handbook", Guide maps consortium, 2004.

Users: We have already said a lot about this type of stakeholder, and much more will be examined. Three aspects have been highlighted for autonomous systems to be successful; users should accept the technology, have trust in the system's safety and should perceive additional value. As already mentioned, the consequences in the lives of potential end users are many and with a high degree of impact. The end users are those whose acceptance or not of the AVS can modify the fate of the product and the process of its insertion, hindering or supporting it and acting as a catalyst.

Public transport operators: Transport operators link the (potential) users of the system, with the developers of the system. The transport operator furthermore both have an interest in developing autonomous shuttle systems and must power to implement the system. The primary role of the transport operators is providing public transport services. They feel a strong need to be competitive in the future. They perceive autonomous vehicles as a "key topic for the future" of society and their companies and as a decisive element of competitiveness in markets where completely new players could emerge. A first group of operators has the sole task to develop autonomous shuttle systems. A discussion here is whether they will continue with the role of operating the autonomous vehicle systems, or whether this role will be transferred to public transportation operators. The second group develops this system in conjunction with the operation of traditional public transport systems. In this group of companies, the development of autonomous shuttle systems needs to be balanced with the company's other responsibilities. Within larger transport operation companies, the attitude towards autonomous vehicle operation varies from enthusiasm, pride, and positive curiosity on one side to jealousy and reactance on the other. Currently, autonomous vehicles are developed as an addition to the traditional transport system, though there is no fear of losing jobs for drivers (yet), on the contrary, drivers see it as an opportunity to engage in additional tasks[93].

Insurance companies – as demand for insurance goes down as risks of crashes drop, insurance companies will lose revenue from this segment of their business. Traditionally, car insurers have always insured consumers in the event of accidents that are caused because of human error. With AVs, the auto insurers would have to shift their core business model to focus more

[93] G. Fournier, D. Korbee, G. Naderer, T. Viere, "Avenue Autonomous Vehicles to Evolve to a New Urban Experience", Hochschule Pforzheim, 2018

on insuring car manufacturers from liabilities due to technical failure of their systems, as opposed to protecting customers[94].

Road infrastructure and Safety managers: even if the insurers and legislators come up with solution to manage AVs, the infrastructure development to deploy this technology is another major factor. The transition will take place in several planned and well executed stages if AVs are to become a widely adopted technology. The planned and coordinated execution of this shift can lead to a smooth integration of AVs and a substantial change in the mobility and transportation channels of the future.

Car manufacturers: Although there's time for car companies to adapt to the new reality of self-driving devices, many serious and disruptive changes are likely to happen, or example fewer consumers will own cars, as car-sharing utilization increases. Interest of the car manufacturers is therefore to balance the handling of their traditional product and the new AVs, managing the insertion of incremental innovation to conquer the buyers trust and, at the same time keep up with the innovation race related to AVs and competitors.

Suppliers of automotive components and technology: much of the technology and services required of these subjects will change and modify over time, the R&D departments will have to adapt their activities in an even more dynamic way and with an eye to market feedback

Auto repair companies and aftermarket – fewer accidents will mean fewer trips to the repair shop, there will not only be fewer accidents but less need for replacement parts and aftermarket upgrades.

More in the long run….

Professional drivers: As demand for drivers gets reduced, there will still be a need for more highly skilled drivers and fleet managers. The set of skill required will change and a new kind of professional formation will take place.

Hotels and motels: Drivers will be able to sleep in comfortable long-distance cars as they zip along the highways.

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[94] M.Baertoncello, D. Wee, "Ten ways autonomous driving could redefine the automotive world", Mc Kinsey & Company, 2015

Domestic and short-haul airlines: Many people will choose to take a comfortable car ride instead of going through the many hassles of air travel.

Ride-hailing companies: Services like Uber and others will need to survive the transition to owning their cars and managing the ownership aspect of fleet management or change the business organization

Rental cars: Why rent a car when you can just as easily call for a self-driving vehicle? The concept of mobility as a service and the change in the driver paradigm will press the rental market to innovate their internal process to keep up to date with the market demands.

Parking garages, lots, and street spaces: Long-term parking will decrease as car fleets are continuously on the move. Reshaping street spaces remains to be imagined.

Energy and Petroleum companies: Although the mix of energy used to fuel self-driving cars may shift to electricity, researchers are predicting that the driverless car era will consume more energy.

Environmental protection: The environmental associations will have to cope with the decrease in emission (also thanks to the reductions of start and stops) but also with the higher energy consumption

Real estate: Fewer gas stations and garages may be needed. Since commuting will be faster and easier, residential property value will shift from urban to suburban areas and even the job market will change its dynamics according to the easier way to reach the workplace for commuters.

Media & entertainment: on the long period, concept self-driving cars will have screens for people to watch movies, read and see the news, and provide a more relevant time spent commuting pushing the entertainment sector to adjust their content to be experienced under different modalities and channels.

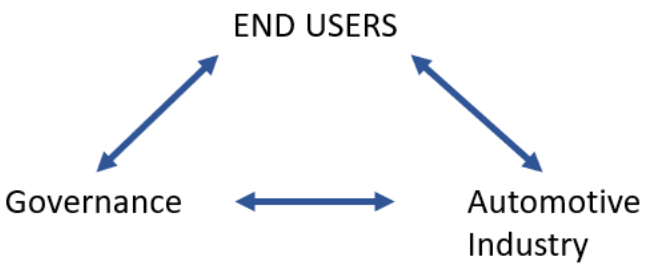
4.3 AVs' Stakeholder focus of the research

As expressed, it is the author's intention to focus on the category of "user" stakeholders to understand the reasons behind the decision to adopt the technology and its methods. To do this,

we start from the reasons underpinning the choice of adoption and from the sources of information from which users access the knowledge.

Understanding these two things is a crucial step for planning an effective, educational, and informative communication towards the user, to allow him to be aware and be able to make reasoned choices and with the ultimate aim of supporting the transition to a new type of mobility. The other stakeholders involved in the process are those who have interests of various kinds and nature in the introduction of the AV, people that, sometimes in a self-referential way, are responsible for the communication processes of the phenomenon.

Given the perspective from which it has been chosen to examine the phenomenon, it is necessary to relate the end-users with two other fundamental stakeholders, namely governance and the automotive industry. They play a crucial role in the dissemination of the product. The governance being responsible, at various levels, of the adjustment of the infrastructure, of road and drivers' safety and of the approval and adjustments of regulation, it is the guarantor of the indispensable services as well as of the preparatory and complementary structures for the circulation and dissemination of AVs. The automotive industry, as actual producers as well as vendors of the new technology, is therefore source of operational change and it is the subjects that will be most affected by the acceptance (or not) of the AVs by the end users.



Both stakeholders, respectively from a point of view oriented towards marketing and sales and from a point of view oriented towards civic education and dissemination, are active actors in the communication landscape. They are providers of information used by the media to build communication campaigns and are direct distributors of informative material. For this reason, the understanding of the perception of information by users and its effectiveness is fundamental for the success of the operations of competence as well as for a successful and socially acceptable and feasible introduction.

It is important to incorporate the perspectives of other stakeholders that sooner or later will play a role in operating or deciding on the implementation of AVs. Literature often focuses only on the direct interaction between technology and user, underestimating the role and the propaedeutic actions actuated by these other relevant stakeholders[95].

Given the magnitude of the expected high-level benefits, as well as the economic repercussions of the process, national governments and international legislators have an interest in stimulating the market reach of the technology and therefore the successful introduction of AV. To support the transition, they can act through the implementation of complementary and preparatory services (for example both physical and digital intelligent infrastructures as we will see below), assisting the automotive industries in their R&D effort and above all in mitigating public concern. For the latter, there are a lot of different approaches, and the possible actions are innumerable. It is in fact possible for the authorities to perform the role of legislative mediators and, acting as a bridge between society and industries, support a technological implementation closer to the expectations of the population, and not pushing for a too much disruptive change of paradigm all together[96]. Another solution on which we will focus our attention is the possibility of providing widespread information through the available channels.

About the category of stakeholders represented by the automotive industry and car manufacturer, it is necessary to underline that it is also in their interest to understand in depth the reasons that move users towards or against the technology and in particular the motivations of different types of users. Having a clear vision, manufacturers can focus on a specific audience and try to meet their needs or preferences. This aspect would be very helpful as currently most of the innovative developments in the field are pushed by the developers themselves in response to a weak market demand in the field. For this reason, directing the initial marketing efforts towards well-defined categories of early adopters and technology enthusiasts can be a key strategy to access the remaining part of the market and feed the synergy given by the consequent word of mouth, feelings sharing, brand advocacy and so on. Starting from the benefit of industry and a slice of consumers, it is possible to aspire to collective well-being in terms of repercussions.

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[95] S. Nordhoff, B. van Arem, R. Happee, "A conceptual Model to Explain, Predict and Improve User Acceptance of Driverless Vehicles", the 95th Annual Meeting of the Transportation Research Board, 2016.
[96] A.M. Khan, A. Bacchus, S. Erwin. "Policy challenges of automation in driving". IATSS Research, 2012

4.4 The importance of informing the stakeholder for the acceptance process

The experimentation of autonomous vehicles is currently underway in various locations, European and non-European, and with different degrees of progress.

The types of vehicles tested are of different nature and range from personal AVs, AV taxis, autonomous public transport, and autonomous land, rail, and sea freight.

Like all the great changes that have altered daily life, there is no successful change without a solid preparatory infrastructure aimed at facilitating a transition that will take place one step at a time. In many cases, the technology for change is ready well before the mental state of the society that will have to welcome it, and that is why, parallel to the technological advances in progress, it is important to develop a growth in the social awareness of the phenomenon.

Many studies analyze the possible obstacles that slow down the acceptance process, but just a few of them focus on suggesting solutions that are synergistically suitable in the area to cure the phenomenon under different aspects.

One of the advantages of the introduction of the AV has been recognized in encouraging the mobility of categories that are often discriminated, such as the disabled, the elderly or children, not to mention the whole slice of the population that does not have a driving license and therefore organizes their working life accordingly. These are usually categories less informed about the latest news on vehicles and the most exposed to mediatic effects.

In the collective thought it is common to imagine two extreme cases, namely the vehicles currently in use (and therefore vehicles with driver and some ADAS support) or a completely autonomous vehicle that does not require assistance (level 5). Between the two extremes there is a whole series of nuances applicable to different cases which, regardless of their practical utility, could affect the perception that the population has of this phenomenon. Their correct communication could be an important topic for expanding the reference framework of the average user and stimulating critical reflection on the matter.

Users accustomed to driving or, more properly, to the use, even passive, of vehicles see in the introduction of the AV a simple vehicle replacement, therefore positive, but probably far from what will be the first experience with an autonomous vehicle: a public service or services dedicated to goods. Many users declare that they fear the mixed transition phase, but only a few of them are actually aware of modalities and infrastructures that are being planned to

guarantee the safety of insertion. Few, for example, are aware of the hybrid phenomenon of platooning, both for goods and for the public.

4.4.1 The Social Framework

Digital and physical infrastructures are not the only ones that need to be tested: the social framework, in some respects comparable to an enabling infrastructure, must be built, powered, updated, and tested. Because of a cultural bias, it is much easier for the collective to imagine physical and infrastructural development than it is with the social one, that needs to be faced with delicacy, inclusiveness and with the right tools in the arsenal.

If we look at the phenomenon from a different perspective, marketing strategies come to our aid by providing some notions and ideas to reflect on. If we want to consider, simplifying it, the AV as a product and then extracting it from the network of connections it carries with it, we can analyze it at the toe of the purchase funnel.

The purchase funnel is a marketing model that focuses on the consumer and highlights the path (or rather the journey) of the consumer towards the purchase of a specific product. This journey can be summarized in five successive phases: Awareness, Opinion, Consideration, Preference and Purchase. A specific model, conceived by Elmo Lewis and called AIDA[97], approaches this same issue by summarizing the buyer behavior into 4, more general, steps: Awareness, Interest, Desire and Action. This model is used as basis of many developments in the marketing sector.

The AIDA model has undergone changes and updates, adapting to changes in market logic, dictated by the introduction of technology, the multiplicity of channels and changes in people's purchasing habits. In a new context, the one of web 2.0, the AIDA model was questioned and Derek Rucker, advertising strategy professor at the Kellogg School of Management, proposed a replacement, the 4A model (fig. 23)[98]: aware, attitude, act, act again

- the two central phases of the AIDA model, interest and desire, merge into a single phase: opinion (attitude);
- a further phase is added, the repeated action (act again) to respond to the introduction of the concept of customer loyalty, which is pushed to repeat the purchase action.

[97] Montazaribarforoushi, A. Keshavarzsaleh, T. Ramsoy, “On the hierarchy of choice: An applied neuroscience perspective on the AIDA model”, Cogent Psychology, 2017
[98] D. Rucker,S. He, “The role of attitude in advertising”, 2019

In this way, the customer follows his purchase path in a linear way: starting from the knowledge of the brand (Aware), the customer creates his opinion (Attitude), judging it pleasant or not compared to his expectations; if so, the customer will purchase the product or service (Act) and, if he had a positive experience, he would purchase again (Act Again).

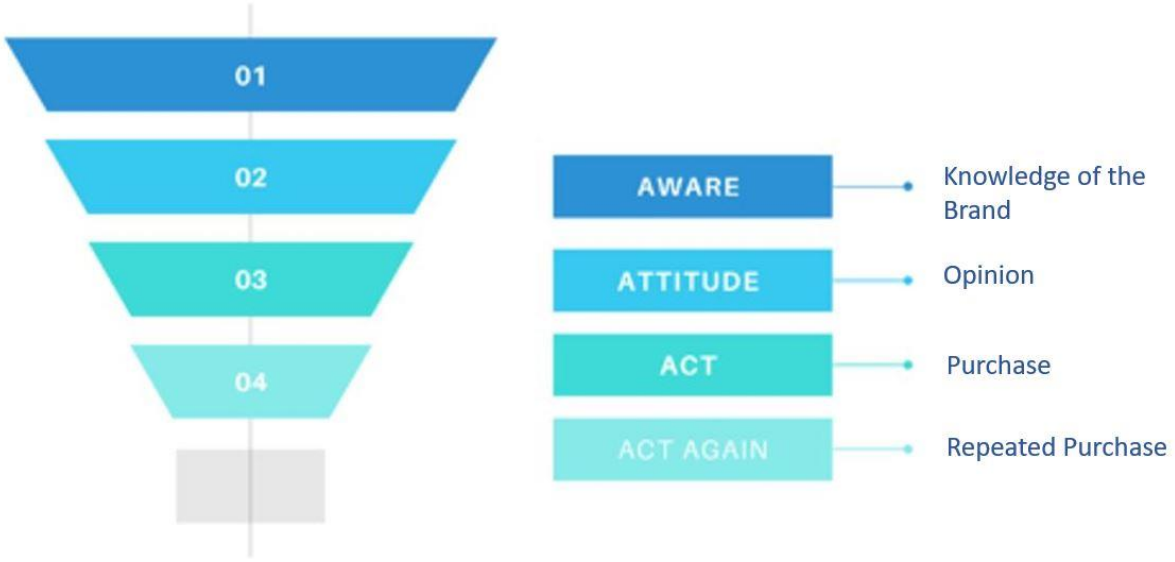

Figure 23 The 4 A Model

The number of people entering the knowledge phase will gradually skim down to a small number of *evangelists*, people who are so happy and loyal to a brand that they will repeat the purchase and, perhaps, recommend it to their acquaintances.

With the spreading of the use of digital devices and social media, this last action plays a fundamental role in the management of the customer's purchase path by companies. The “journey” is no longer directly influenced by the company's actions, but also by the opinions of other customers or potential customers who have different experiences with the brand. Furthermore, even the *touchpoints*, multiply, creating a multi-channel and multi-experiential purchase path, therefore, the concept of *advocacy* fits in. In the past, each customer has always had the potential to become the source or propagator of what was once a simple personal recommendation of a product or "word of mouth". But everything remained detailed on an extremely limited network or geographic basis.

Today, thanks to social media (but without neglecting other means of digital communication: online reviews, blogs, etc.), each of us sees this potential multiplied by the global penetration of new media.

For this reason, the "four A" model undergoes a new evolution outlined by Philip Kotler in three steps:

1. the opinion towards a brand or product is no longer relative to the individual person, but is influenced by the digital community that revolves around it; in this case, therefore, the attitude phase is divided into *appeal* and *ask*, in which the brand respectively conquers a certain level of attractiveness and people ask questions
2. customer loyalty is no longer judge based on the number of repeated purchases, but on the customer's propensity to recommend the product to other people; here the *act again* phase translates into *advocate*
3. customers and potential customers activate ask-and-advocate dynamics, in which customers give the necessary information to potential customers who are still in the exploratory phase[99]

We therefore see the transformation of the 4A into 5A (fig.24).

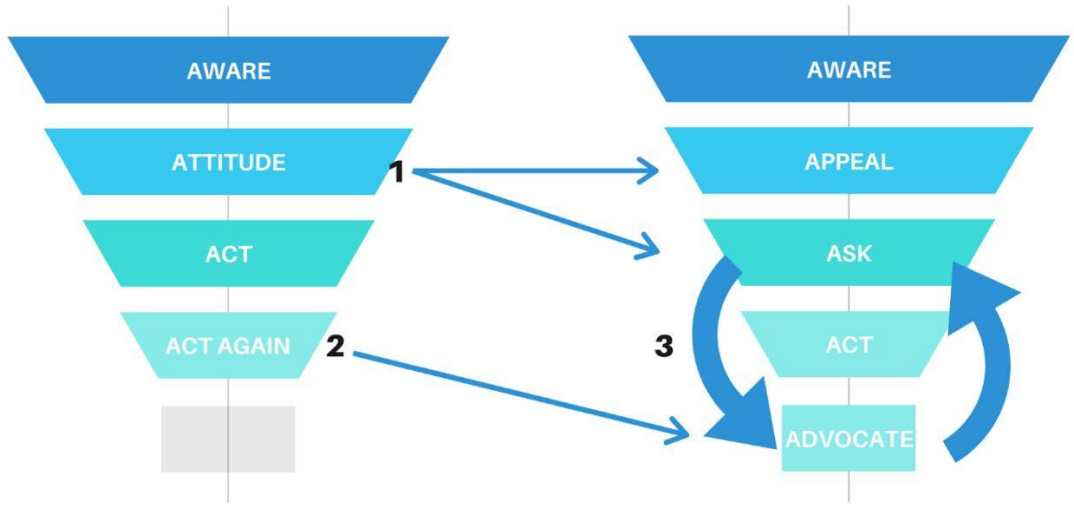

Figure 24 The New Customer Journey

[99] P.Kotler, "Marketing 4.0 Dal tradizionale al digitale", Hoepli, 2017

• Aware: In this phase, customers are exposed to brand messages through advertising and past experiences.

• Appeal: in this phase, customers actively receive the messages of the brands and feel attraction or rejection towards them, depending on their experience or feeling.

• Ask: attraction leads to curiosity and therefore to the search for more information or opinions on the shopping experience provided by loyal customers.

• Act: convinced by the responses received, customers decide to purchase a certain product or service, use it and experience customer service.

• Advocate: customers who have a particularly positive experience tend to become attached to the brand and to recommend it to other people, also helping those who are in the Ask phase.

The theories and methodologies set out above give us indications on the different stages of the buyer's journey. Understanding users and understanding at what stage of their journey they are and with what attitude can be an important guide for a more careful study of the contents and information materials they need.

In AVs case we address a particular range of stakeholders, that is the end users. Therefore, it is necessary to support awareness and interest while trying to understand which complementary actors can deal with the awareness and interest creation and in what way (considering that having the Av does not simply translate in the purchase of a product but promotes a disruptive change in mobility as we know it today).

And therefore, which are the communication channels to turn to for the new 2.0 training on autonomous vehicles? How to inform the user?

Before answering, some of the many variables involved in the communication process, and responsible for the social response to the change are analyzed in the following paragraph.

5 The Communication of Innovation

The communication of innovation cannot be separated from innovation itself, but rather represents a constitutive aspect of it.

The diffusion of new products is always linked to the consumer's ability to understand their use value and to acquire the logic and methods of operating with them. Even the most revolutionary products, with the greatest promise for users, can be commercial flops. For this reason, social practices are fundamental in determining how particular technologies are used and if they can be successful. Indeed, the scholar Pierre Lévy even argues that the social use of technologies derives from interfaces rather than from specific performances: it is not the constitutive principle of a machine that determines its use, but the ways in which this principle is articulated in the relationship between man and machine.

The ability to explain a new technology or a new product becomes more and more important than just having the "technological muscles". Therefore, distribution channels are assuming an increasingly important role, becoming real transmission belts for innovation. Furthermore, the dissemination of knowledge (and therefore of innovation) is the founding aspect of our society, named "knowledge society" for this precise reason.

Technological communication plays a central role in the economy as a necessary (indeed indispensable) tool that allows both those who use knowledge and those who produce it to identify, qualify, explore and evaluate their ability to multiply value. Finally, it must be remembered that communicating innovation is inherently difficult. People are naturally driven away from innovation: man is habitual and always looks at novelties with suspicion, especially complex ones. Furthermore, man has always feared technology itself. Literature and cinema are full of stories where technology turns against humanity: robots that rebel against their creator, in vitro molecules that spread epidemics, software that no longer accepts the commands of its programmer, chemicals that reveal to be harmful when they are already widely spread.

Effective communication requires the right choice of media and timing to give the news the visibility it deserves. The obsessive pursuit of the scoop does not pay, nor does the compulsion to fill the pages of newspapers at all costs.

"Authentic innovator is not the one who has the ideas or owns the techniques, but the one who translates them into concrete facts and above all it disseminates them and therefore, in a certain

sense, "communicates" them. In this sense lies the difference between invention - technical fact - and innovation - economic, social but also cultural fact. "[100]

At the base of the citizen-centered communication system there is a bilateral interchange of information between the issuer and the recipient of the message obtained by listening to and collecting feedback from citizens to adjust the contents and be more performative in the events to come.

As Rodney Turner writes in 1993:

How will Feedback be Encouraged? Communication should not be one way; you should talk with people, not at people. If you want people committed to your project and the change it will introduce, they must feel involved, and feel that they have some influence over the design. But for this reason, it is important that you are seen to be looking for and listening to feedback.

What will be Done with the Feedback? So, it must be obvious to the stakeholders that their feedback is being used. The best way of achieving this is of course to be seen to be answering the stakeholders' questions. Not straight away as they give their feedback in a way that convinces nobody that you are actually listening; but later in a considered way, perhaps by making changes to the design of the project, but particularly by incorporating responses to the feedback in later communications. If you incorporate responses in future communications, it demonstrates that you have actually heard and remembered what was said, remembered well enough and long enough to actually incorporate responses into the later communications.[101]

The application of the principle of transparency in communication helps to create a new relationship with the citizen who, in return, provides feedbacks to build a virtuous bilateral communication that can reduce the cultural and lexical distance that separates technical language from the common one.

Today, citizens, also due to the high use of new communication tools (as social networks), require professionalism and transparency, they want to be informed, listened and to have an active and proactive role.

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[100] A. Granelli. "Comunicare l'innovazione. Perché il successo del nuovo dipende dalla capacità di comunicarlo", CNIPA, 2009.
[101] J.R. Turner. "The handbook of Project based management: Leading strategic change in organizations", McGraw-Hill, 1993.

On the part of those who provide the communication there must be an interest in creating a synergistic process in stages: communicating the results of innovation, sharing information with citizens, listening to feedback, improving communication with the final consequence of acting positively on the same results that are communicated by the community.

For their part, citizens have the objective of understanding the results, understanding the strategic choices of the project, forming the basis for participating and giving informed feedback on the subject, becoming active users, able to improve the quality of communication itself.

It is important to remember the dual nature of the object in question: as a product and, as such, a bearer of profit to the manufacturing companies as well as a wide range of stakeholders, but also an element of public interest as a catalyst for changes in collective habits and consequently, as we have seen in the ripple diagram, broad spectrum changes.

In relation to more affirmed collective procedures of public interest it is more natural to think of interactions with the community as it is interested. An example of this is the urban regulatory masterplan open to citizenship feedback during the five-year review period.

The challenge will be to find a balance between the promotion of what is, in effect, a product and the training / information on technology that in the not-too-distant future will change our way of conceiving the road and which, very likely, will also take on the garments of public service and direct to goods.

It's fundamental to find a balance between the awareness process (or "communication for information") and the call to action (or "communication to make someone do something").

If the results of an innovation process are disseminated correctly, i.e., as services useful to the community and to improve the lives of all citizens, it is highly probable that the latter will understand the validity of the investments made and that they share, becoming themselves bearers of a positive message in the context of their social network. Another concept that can be borrowed from the world of marketing is the brand ambassador or brand advocate: if the communication and the underlying strategy start in a convincing and structured way, it is possible to trigger an effect of dissemination among peers via a chain reaction. However, this technique has also its caveats, since word of mouth can introduce distortions of reality that can

get worse with every iteration. The synergistic and positive effect can only occur if starting from a clear and well-defined type of communication, aimed at training through information.

The driver for using a new product is usually its ability to answer a specific question or, in other words, to solve a problem. The marketing strategy that focuses on the problem, to clearly show how the product can overcome it, is sufficient to generate in the citizen a curiosity that drives:

- first: in-depth study (i.e., to learn about the innovative process and the used technologies)
- second: usage of the product
- third: sharing via social network (offline and online).

To succeed in applying this strategy, it is important to use some marketing techniques:

- communicative and linguistic style aimed at those who need to know the result to appreciate the project
- reversing the point of view: citizens deepen the knowledge of the project and results only if they have understood the value
- communicating the benefits that arise from the object in question (services / products)

But what does it mean to create a communication strategy?

A strategy is how one decides to engage the audience, to transmit the subject of the communication.

Outlining a strategy means choosing the right path for achieving the objectives of the communication and choosing the correct tools to do it. Implementing a strategy means choosing communication models to be composed to put it into action. Any communicative model provides for the use and exploitation of different tools.

As Turner reminds, communication has very specific but above all articulated objectives:

- To raise awareness of the project and thereby gain commitment from key stakeholders
- To inform other business areas and promote key messages about the project, particularly the benefit to the organization, demonstrating the planned performance improvement
- To make two-way communication to ensure a common understanding of the project and its objectives to negotiate agreement with the stakeholders

- To maximize the benefits from the project by having everybody working for its success

Like many of his contemporaries, Turner addressed corporate stakeholders, but the concept is perfectly adaptable and functional for the design of autonomous vehicles communication and introduction.

Of course, the choice of the communication channel is also of primary importance: different channels can convey the same message in different ways and can trigger different cognitive mechanisms. Depending on the type of message, the expected audience and the nature of the communication, certain channels can act as catalysts more than others and will be best suited to hypothesize a road map and identify the possible actors acting in the context.

5.1 Effects of Media and Communication on potential AVs Users

As evidenced by G. Zhu in his study[102] and as underlined in the section dedicated to the acceptance models of technology, many studies have highlighted the relationships between willingness to use and social-demographic variables, just as many have used valid models, such as TAM, to predict the user's intentions based on specific determinants (p.25). Fewer studies instead consider the effect of the communicative variable seen in its different channels and methods, in the process of forming the perception of AV in the user. Since AV is a not yet deployed technology (except for the various ADAS currently in use on some vehicles), future potential users can only get information from public and social media and from promotions coming from different automotive players.

According to the social cognitive theory of Bandura [103] the various environmental determinants, including communication channels, influence the personal determinants that in turn act on the behavioral determinants in the process of adopting innovation. The object of adoption and its determinants are a necessary factor to be considered within the framework of innovation adoption.

[102] G. Zhu, Y. Chen, J. Zheng, "Modelling the acceptance of fully autonomous vehicles: a media-based perception and adoption model", Elsevier Transport Research Part F, 2020.
[103] A.Bandura, "Social cognitive theory of mass communication", Media effects Routledge, 2009

As shown in (fig.25), before an innovation is adopted, the solid arrows denote how external environments affect the perception of human (R1) and product (R2), and how personal factors act on product (R3) and behavior (R4) as well as the relationship between product-related factors and behavior determinants (R5). After the innovation has been adopted, the dotted arrows indicate how human's usage behavior acts upon product recognition (R6) and user's self-recognition (R7), and how product perceptions affect user's recognition (R8) and environment (R9), and the reaction of human to environment (R10). In the present theoretical frame, the relationship between environment and behavior is mainly mediated by human and product instead of the direct relationship as in tripartite reciprocal determinism. From pre-adoption to post-adoption, then to repetitive adoption, the progress might be dynamic and repeated.

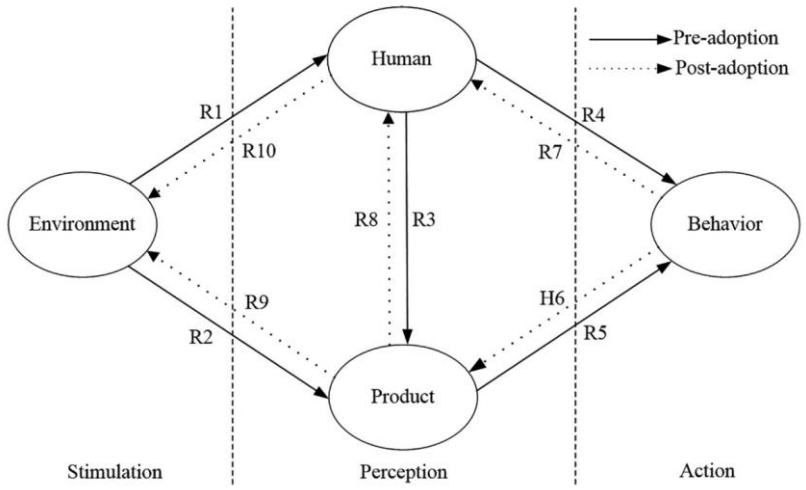

Figure 25. A dynamic theoretical framework for innovation adoption

Self-efficacy and subjective norms are chosen as human determinants while perceived risk and perceived usefulness represent product determinants. The term self-efficacy is defined as one's beliefs in his or her capability to travel with fully AVs, it is a proactive motivational state while subjective norms, as cognitive factor, is the consumer's perception of support or opposition for people who are important for them.

They are both self-perceptions: the first is more of an active kind, related to a spontaneous cognition of one's own ability and the second is more passive and linked to perception of others.

Many researches have dealt with the two identified determinants and the result, as effectively summarized by Zhu, is that self-efficacy can diminish uncertainty, increase perceived value, and predict behaviors, it has been proven to negatively impact the risk perception or strengthen trust significantly. A strong self-efficacy feeling pushes people to take the risks to have advantages and even perceived usefulness and perceived functional value are influenced. Subjective norms, as already mentioned, have been proven to have positive effects on the behavioral intention to use AVs in the TAM model. This can be interpreted as a kind of peer pressure or social restraint and derives from others' cognition related to the subject.

As extensively argued in the previous sections, the model is based on the proven axiom that human behavior can be widely predicted by construct of intention (Davis).

As demonstrated by the research of Anania, the use of information on the AV influences the perception of them respectively in a positive or negative way.

Different media stimulate different processes and can influence the resulting adoption rate.

Users have had no direct experience of the product and have not had the opportunity to share firsthand opinions or feelings (fundamental from the author's point of view as cognitive markers), many are not even aware that the ADAS currently in use can be framed in the automation framework and therefore the processing of information from the media is based on deductive considerations. Much of the communication that revolves around AV often risks having a sensationalist meaning and this takes users away from the idea of a progressive approach to technology (which is already in place). Considering that any failure in one of the components can cause a fatal accident or crash, it should not come as a surprise that any negative information is magnified or publicized by the media, on the other hand, as highlighted by Sanbonmatsu[104], the most negative news has the most powerful influence on those who have the least information on AVs. This underlines the importance of filling the informative gap in the population to prevent the spreading of misinterpreted knowledge.

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[104] D. M. Sanbonmatsu, D.L. Strayer, Z. Yu, F. Biondi, J.M. Cooper. "Cognitive underpinnings of beliefs and confidence in beliefs about fully automated vehicles", Transportation Research Part F: Traffic Psychology and Behaviour, 2018

Research such as that of Fraedrich and Lenz[105] indicates that approximately 80% of potential users who say to be concerned about AV, declare to have obtained the information they built their opinion upon primarily from the mass media.

It is not clear if this result is linked to the kind of information transmitted and the format used or to the typology of user reached through mass media.

That underline once again the importance of the structured message and the format used to communicate and spread information, and the necessity to address different targets.

The information of the user, his training and the related macro-category of structured communication are fundamental to have informed opinions.

As demonstrated by the research of Mao and Lyu[106] and those of Zhu [107], based on prospect theory and value perception theory, people make decisions balancing the gains and losses with the expected outcomes and risks: when considering buying a product, consumers compare the benefits they could get to the sacrifices they should make based on the perception of what is received and what is given. This type of reasoning might be strongly biased, if not supported with all the necessary information.

Depending on the communication and the way in which the information is structured, the AV topic might be perceived as a vague, far subject or as a concrete issue that will become part of everyday life in a near future.

As resulted by a more recent work of Zhu[108], media information is a pillar of human self-perception and product value perception. Information from mass media and social media have different effects on users: mass media can enhance one's self-efficacy of AVs and social media have a strong impact on social norms. This difference reveals that these two types of information channels have various emphases on the formation of potential user's self-perceptions. This, according to past findings, prove the mass media to be the most powerful and efficient mean to create awareness but their effect is moderated by social media that insert

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[105]E. Fraedrich, B. Lenz, "Societal and individual acceptance of autonomous driving. In Autonomous driving" Berlin, Heidelberg: Springer, 2016

[106] Z. Mao, J. Lyu, "Why travelers use Airbnb again? An integrative approach to understanding travelers' repurchase intention." International Journal of Contemporary Hospitality Management, 2017.

[107] G. Zhu, K.K.F. So,S. Hudson. "Inside the sharing economy: understanding consumer motivation behind the adoption of mobile applications", International Journal of Contemporary Hospitality Management, 2017.

[108] G. Zhu, Y. Chen, J. Zheng, "Modelling the acceptance of fully autonomous vehicles: a media-based perception and adoption model", Elsevier Transport Research Part F, 2020

peer pressure and social influence, contributing in forming social norms. Mass media significantly strengthen perceived usefulness of AVs, and at the same time, enhance perceived risks of AVs.

These interesting results emphasize that different media channels may have opposite effects on product value perception.

Starting from the importance of managing the effects of the different channels as effectively as possible, it is the author's opinion that it is necessary to open a parenthesis on the management of information on multiple channels.

5.2 Multimedia, Multimodality and Cross modality

In an era in which the mass media are perpetually side by side with social media as main interfaces through which users and public opinion approaches innovative concepts, it is not possible to talk about social and user perception without clarifying the concepts of multimedia, multi-modality, multi-channel, and cross-media.

The new requirements for the use of contents dictate the pace of what is the winning trend of communication. The distribution and production of information are adapting and evolving quickly and even the educational system has recently started to try to keep up.

The concept of **multimedia** indicates the coexistence and interaction of different media in the same information context or the distribution of content through different channels with adaptations and changes designed for the characteristics of each channel.

This approach, which for a long time was the leader of innovation, is no longer enough. The dissemination of information and innovation today needs new ways and methods.

Multimodality means having the possibility to access the same content in alternative but equivalent ways that meet the needs and preferences of the user. By now, especially in the educational context, it has long been established that people can be divided into three main categories: synesthetic, auditory, or visual. And that is the reason why the education and formation system is evolving towards a blend method able to reach different kinds of target people. Communication works in the same way and is necessary, especially if the target audience is the whole population, to learn how to vehiculate the information in the more

efficient way. In this sense, as reported by Jewitt [109], it is possible to highlight three premises of multimodality:

1. meaning is made with different semiotic resources, each offering distinct potentialities and limitations
2. meaning making involves the production of multimodal wholes
3. if we want to study meaning, we need to attend all semiotic resources being used to make a complete whole

The field of Multimodality in the last two decades expanded itself at a great extent and as consequence we can rely on four different assumptions:

- all communication is multimodal
- analysis focused solely or primarily on language cannot adequately account for meaning
- each mode has specific affordances arising from its materiality and from its social histories, which shape its resources to fulfill given communicative needs
- modes concur together, each with a specialized role to meaning making, hence relations among modes are key to understand every instance of communication[110]

The even broader concept of **cross modality** holds all this together and redistributes it across the internet. The cross-media approach requires (...) to have a plurality of digital resources available to be used, based on an intelligent design work, in the construction of original formats that "re-travel" on different devices (television, telephone, internet). The combination of the digitization of resources (texts, photos, drawings, audio and / or video recordings, etc. ...) and the multimedia and multi-channel distribution of products / services to users reconfigure the methods and system of communications, which in most cases induce the transformation of users into interactive content producers.

Starting from the concepts expressed above and wanting to get at the construction of a structured knowledge, it is also necessary to consider inherent limits to human nature such as the (already mentioned) concept of **Rational Ignorance, Neophobia** and the **Principle of Relevance**.

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[109] C. Jewitt, J. Bezemer, K. O'Halloran. "Introducing Multimodality", Routledge,2016
[110] Edited by O. Garcia, N. Folores, M. Spotti, "The Oxford Handbook of language and Society", Oxford University Press, 2016

- Neophobia[111]: fear of anything new, of innovation, an irrational fear of new situations, places, or things. All phobias are unreasonable sorts of fear that can cause avoidance and panic. They represent a relatively common type of anxiety disorder. The word "neophobia" comes from the Greek "neos", meaning new, and "phobos" meaning fear. Extreme or irrational fear or dislike of anything new or unfamiliar, in its milder form, it can manifest as the unwillingness to try new things or break from routine
- Rational ignorance[112]: it can be considered a heuristic and means intentionally choosing to remain uninformed on a topic because the cost of acquiring the information is greater than the estimated potential benefits, it's a cost-benefit estimation, it's the deliberate choice of a person not to acquire a certain kind of information because of its cost in terms of time and effort that yields little or no perceived benefit
- Principle of relevance: it is responsible for the process of selective learning. According to the principle of relevance as outlined by Sperber and Wilson[113], human cognition is geared towards maximizing the cognitive effect gained from acquiring a piece of information versus the effort required to process the information. A relevant utterance, or piece of information, is one in which an individual has determined that the likely gains of interpreting the utterance or learning the piece of information are greater than the efforts required to process them[114]. According to these theories, relevance judgments offer a quick way of determining what gets attended to and what does not. For instance, we do not attend to every sound in our environments – it is only the distinctive sounds, such as an alarm, that we judge to be relevant and thus, attend to. According to this theory, rooted in the field of linguistics and pragmatics, communicators usually convey much more information with their utterances than what is contained in their literal sense, the receiver decide which piece of information is relevant for his understanding trying to connect the new one with the information that he already has and the one given by the context, (according to the principle of relevance, some cognitive anchors, something that he considers important and sensible for him outside of his own references and on which to start building new knowledge). Therefore, to be considered relevant by an individual, an information needs to find the

[111] MedicineNet: https://www.medicinenet.com/neophobia/definition.htm
[112] Edited by H. Landemore, J. Elster, "Collective Wisdom. Principles and Mechanisms", Cambridge, 2012
[113] D. Sperber, D. Wilson, "Relevance. Communication and Cognition", Blackwell, 1996.
[114] S.C. Levinson, "A review of Relevance", Cambridge University, 1989

correct collocation in his internal or external network of information, otherwise it gets discharged and labelled as irrelevant.

5.3 Role of Communication and Synergetic

Acquiring new knowledge requires a lot of effort, or at least this is the perception.

When the cost of acquiring information is greater than the benefits to be derived from the information, it is rational to be ignorant, as expressed in the theory of rational ignorance.

Unless one has reason to believe that the benefits of acquiring certain information will be greater than the costs of acquiring it, it is rational to remain ignorant.

The biggest problem with the rational ignorance theory is that we do not always know how much a piece of information will be worth until we have acquired it. We must make judgments based on the expected costs and benefits of acquiring information, and those expectations are based on experiences that sometimes lead us astray.

This brings us to the following deductions which highlight the relationship between rational ignorance, neophobia and the principle of relevance.

Making the communication and information related to a product widespread, as well as clear and understandable, avoiding elitisms, is the key to achieve two main results:

a) demonstrating to the average citizen, potential user, that using the right channels and methodologies, the effort required to acquire new knowledge on which to formulate a thought and an intention of action is reduced to a minimum,

b) contributing to the dissemination of information on the AV topic can support the creation of a layer of meta-knowledge in the user, useful to act as fertile ground and to offer cognitive hooks to which the new information that the user gets in contact with can anchor. According to the principle of relevance in semantics and pragmatics, the communication process involves not only encoding, transferring, and decoding of messages, but also numerous other elements, including inference and context. For this reason, creating a context and a reference framework for new information can make the difference. In this way, the user will perceive the new information as more pertinent to his sphere of action and not a complete alien and new item, making their assimilation less burdensome and, at the same time, the minimum effort required

will be interpreted in the light of new knowledge, as useful for achieving a personal benefit and therefore worthy of note.

The relevance theory in a certain sense includes the theory of rational ignorance. In the work of Sperber and Wilson we can read as follow:

"Relevance theory defines cognitive effects for an individual as adjustments to the way an individual represents the world. Seeing a robin in my garden means that I now know that there is a robin in my garden, so I have changed the way in which I am representing the world. Relevance theory claims that the more cognitive effects a stimulus has, the more relevant it is. Seeing a tiger in the garden gives rise to more cognitive effects than seeing a robin so this is a more relevant stimulus.

The more cognitive effects a stimulus has, the more relevant it is. But we can assess relevance not only in terms of the number of effects derivable from a stimulus. Processing effort also plays a role. Sperber and Wilson claim that the more mental effort involved in processing a stimulus the less relevant it is”

From here two important considerations can be drawn:

The first lies in the quality and weight of the information. The information must be such as to guarantee an adequate supply of knowledge comparable to a cognitive effect: it must make us look at the world through a different and updated scheme.

The second, on the other hand, coincides with the concept of equilibrium, in fact good information must be perceived as relevant and must therefore bring content to the receiver, considered interesting but must do so in such a way as not to require too much processing effort. An effort that is too burdensome for the user, although the information is perceived as interesting, will have the opposite effect: it will be labeled as irrelevant and therefore will not achieve its goal of providing new knowledge to the user.

Transferring these notions into the reality of autonomous mobility means paying attention to information in a broad sense and therefore not only to the narrow content but also to the channels, to the methods and to the actors involved to transmit the notions of cognitive and educational nature, related to the product in question but also to all effects linked to it in a less immediate way, in the most effective and efficient way.

In the light of what has been said, the importance of communicating information effectively and efficiently and of laying the foundations for a structured knowledge necessary to accommodate the innovations of daily living and, in this case, of mobility habits, emerges.

Having examined some of the most recurring variables related to user acceptance and having analyzed the function of communication and the effects of communication channels, we have done a qualitative research based on surveys and aimed at assessing the knowledge of what is dealt with by the potential users as well as the sources of their knowledge.

6 Questionnaire Design

6.1 The Questionnaire Structure and Respondents Information

6.1.1 Structure

The Survey has been developed on the platform Survey Monkey by Momentive Inc., which allows the creation of analysis with a multiple questions structure that grants the possibility to dive deep into the respondents' knowledge and opinions.

The Survey presents 5 types of questions:

- **Multiple Options with Single Answer**: the question presents a set of predefined answers the respondent needs to choose from. Only one answer can be selected
- **Multiple Options with Multiple Answers**: the question presents a set of predefined answers the respondent needs to choose from. Many answers can be selected at a time, with a predefined maximum (i.e., 3 out of 6)
- **Cloud of Words**: the respondent is given the possibility to write freely up to 5 words or short sentences that represent their opinion regarding the topic of the question
- **True or False**: a set of sentences the respondent can identify as correct (true) or incorrect (false)
- **Level of Agreement**: a set of sentences the respondent can evaluate on a subjective level, on a scale from 1 to 5, where 1 is "strongly disagree" and 5 is "strongly agree"

The respondent is presented with 37 question entries, but some of them contain information about different aspect of the research, so a total of 39 sub-questions can be identified and grouped into 6 categories:

- **Demographic**: contains 11 questions regarding gender, age, level of instruction and other personal data that can be used to see if there is any bias related to this in the answer given to the other categories
- **Information Mean**: contains 6 questions regarding how the respondent got (or didn't get) information regarding AVs and the most used information means in general

- **Perception**: contains 7 questions regarding the subjective perception the respondent has regarding AVs, or, in other words, if they tend to be in favour or against wide spreading and usage of AVs
- **Knowledge**: contains 8 questions about the objective hard knowledge the respondent has regarding AVs and their current state of development and usage in real life contexts
- **Willingness of Use**: contains 4 questions regarding the subjective idea about personally using AVs or the intention of start using them when the technology will be more accessible
- **Trust**: contains 3 questions about the trust the respondent has in AVs technology. This is divided into 2 sub-categories:
    - **Trust in general**
    - **Trust on safety**, that also includes perception of risk related to the introduction of AV in a real-life scenario

6.1.2 Data Gathering

Questions and answers are written in Italian and meant for the Italian audience.

The survey was distributed digitally, via the major social media platforms and mailing lists. A simple Exponential Non-Discriminative Snowball Sampling was favoured, but not enforced.

Respondents were able to complete the survey via browser, both on computers (fig.26) and on mobile devices (fig.27). Results have been collected in an anonymous way but keeping track of the used browser and Ip address, to ensure that each person could give their contribution only once.

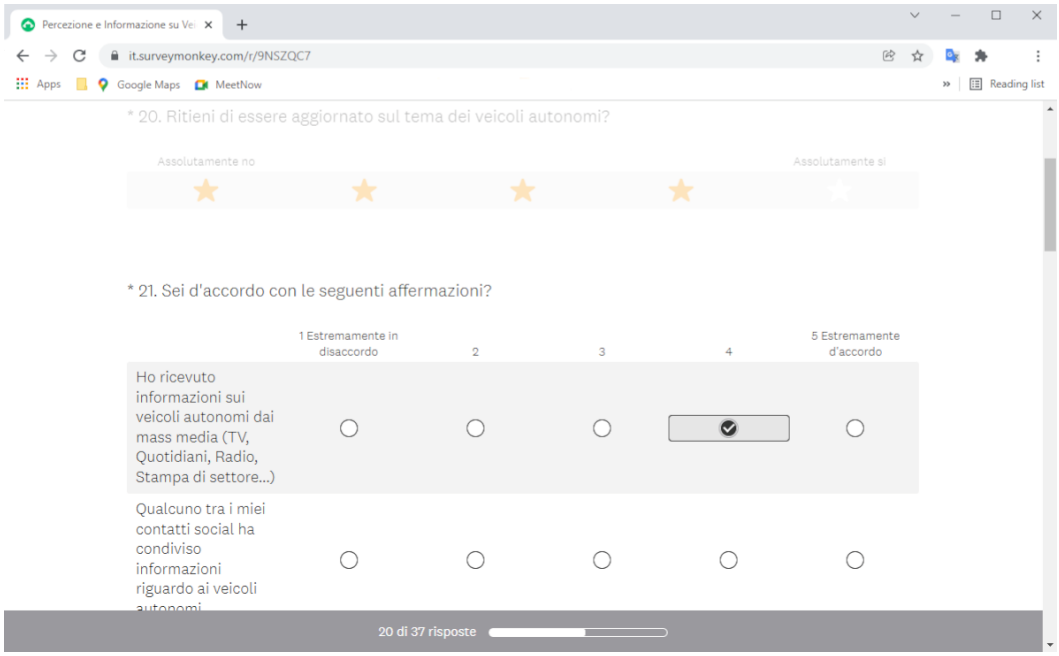

Figure 26 Appearance of Survey on Desktop

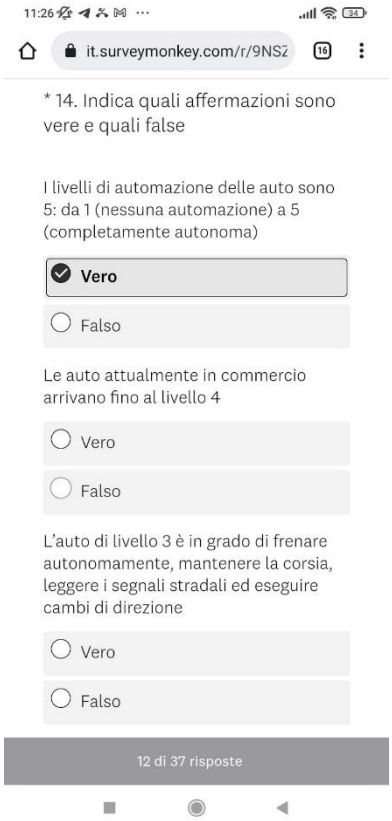

Figure 27 Appearance of the Survey on Mobile

The survey was opened on the **29th of July 2021** and closed on the **30th of November 2021**, for a total of **125 days**.

A total of **258 answers** from unique respondents were collected and analysed. Not all respondents answered to all question as will be indicated in the general data comments.

In the tables below, the number of total questions, sub questions and entries (tab.6) and the number of actual respondents for each category (tab.7) are shown.

Table 6 Number of Questions, Sub questions and Entries of the Survey

Survey's numbers	
Number of Questions	37
Total number of entries	101
Demographic sub questions	11
Demographic question entries	11
Knowledge sub questions	8
Knowledge question entries	17
Perception sub questions	7
Perception question entries	31
Information Mean sub questions	6
Information Mean question entries	21
Willingness of Use sub questions	4
Willingness of Use question entries	8
Trust sub questions	2
Trust question entries	6
Trust on Safety sub questions	1
Trust on Safety question entries	7
Days Open	125
Number of Respondents	258
Unique Words collected	1659

Table 7 Number of Respondents contributing to score for each Category, considering the questions participating to the scoring process and excluding the facultative or qualitative ones

Category	N° Answers
Demographic	258/258
Knowledge	244/258
Perception	217/258
Willingness of use	193/258
Information means	258/258
Trust	193/258
Trust on Safety	193/258

6.1.3 Data Evaluation

To analyse results, the Survey Monkey's "Results Analysis" web tool, a custom made c# data analysis application and the Statistical Computing software "R" were used.

Excluding Demographic questions and answers of type Cloud of Words, all other answers have been associated with a specific score to be able to evaluate respondents' performance on each category of interest.

To compute the score, raw data has been exported from Survey Monkey in the format of CSV (fig.28) and loaded into a custom made c# application that automatically associated the scores to each respondent's answer. A new CSV with scores per question instead of single answers was produced (fig.29) and analysed in the software R.

	A	B	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX
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5	13165921416	407828016	4	3	3	4	4	4	3	2	3	4	2	meno code	aumento parche	meno smog
6	13165816188	407828016														
7	13165786449	407828016	5	4	5	4	5	3	3	1	3	5	2	tutti si possono r	meno traffico	meno incidenti
8	13162660155	407828016	2	2	2	2	2	2	2	4	2	2	4	più soldi all'econ	forse meno inqui	problemi
9	13162642195	407828016	5	4	3	4	4	4	3	3	2	4	2	mobilità egualita	miglioramento st	miglioramento pa
10	13162614533	407828016	2	2	1	3	2	2	2	2	2	4	5	più soldi a Elon I	nessuno	nessuno
11	13162565716	407828016	5	4	3	5	3	3	3	3	1	5	2	parcheggi liberi	meno inquiname	più sicurezza
12	13157280577	407828016	3	3	2	3	2	1	3	5	3	2	4	Protezione pedo	Salto di corsia	Distanza di sicur
13	13156645859	407828016														
14	13156100505	407828016														
15	13155417038	407828016	4	4	4	3	3	3	4	4	3	4	5	La non voglia di	?	?
16	13155131982	407828016	2	2	2	5	4	4	4	4	4	3	1	riduzione emissi	riduzione code	maggiore sicurez
17	13155141762	407828016	4	4	4	4	3	2	4	4	3	4	4	.	.	.
18	13155140297	407828016	5	5	5	3	3	4	3	3	5	3	3	Comodità nel via	Ridurre lo stess	....
19	13155137375	407828016	3	1	3	1	3	2	5	3	5	3	5	Sicurezza	Tranquillità	Versatilità

Figure 28 Example of original CSV file: each element of each question contains the selected answer of the user, in plain form for Could of Words questions or as an index for Multiple Choice, Level of Agreement and True or False questions

	A	B	R	S	T	U	V	W	X	Y	Z	AA	AB
1	Respondent Data						MezzoDiInforma	Percezione				PercezioneSicur	Fiducia
2	respondent_id	collector_id	17: Quale è sec	18: Hai mai sent	19: Hai mai visto	20: Ritieni di ess	23: Sei d'accord	25: I veicoli a gu	26: Secondo te i	31: Rispondi alle	34: Sei d'accord	35: Sei d'accord	29b: Sei d'accor
3	13166003859	407828016	3	2	1	2	6	2	9	3	-1	9	3
4	13165980100	407828016	1	0	1	0	1	0	-1	1	-1	-6	-1
5	13165921416	407828016	1	2	1	1	1	1	6	1	0	4	2
6	13165816188	407828016	0	0	0	0	3						
7	13165786449	407828016	1	2	1	1	7	2	11	1	2	4	7
8	13162660155	407828016	0	0	0	0	0	-1	-8	3	-3	-5	-7
9	13162642195	407828016	3	2	1	1	8	2	7	3	1	5	4
10	13162614533	407828016	0	0	0	0	-3	-1	-5	-1	-4	-9	-5
11	13162565716	407828016	1	2	1	2	7	2	8	1	1	6	5
12	13157280577	407828016	1	0	0	0	2	0	-8	-1	-1	-3	-5
13	13156645859	407828016											
14	13156100505	407828016											
15	13155417038	407828016	0	0	0	0	12	1	1	-1	-1	-4	-3
16	13155131982	407828016	1	0	0	0	-7	-1	3	1	2	2	-4
17	13155141762	407828016	3	2	1	1	1	1	2	1	1	-1	2
18	13155140297	407828016	3	0	0	0	4	2	3	1	1	-3	-1
19	13155137375	407828016	3	0	0	0	4	0	-7	1	-2	-4	-2

Figure 29 Example if score CSV file: one single number is present per question, representing the score the respondent got in that question

The scoring system has been built as follows:

- For Knowledge questions based on data, correct answers have been associated with a positive score, while wrong answers have been associated with a null score
- For knowledge questions that implied a self-evaluation of the respondent, the score has been built to increase with a positive evaluation and stay null for all negative evaluations
- For Perception, Willingness of Use and Trust questions of type Level of Agreement, an increasing positive score was assigned to well correlated answers, a decreasing negative score was assigned to inverse correlated answers and a null score was assigned to the agnostic answer
- For Perception, Willingness of Use and Trust questions of type True or false, a positive score was assigned to answers that was straightening the resulting feeling and a negative score was assigned to the answer that was weakening the resulting feeling
- For Information Mean questions, the score is usually not taken into consideration, with the sole exception of question 23, which brings positive score for answers that represent high desire of receiving information about AVs and negative score for answers that represent low interest in information about AVs

It is important to note that, to avoid cognitive biases of the respondents, not all Level of Agreement questions were prepared so that a positive agreement implies a straightening of the feeling, and a negative agreement implies a weakening of the feeling. As an example, question 26, which belongs to the Perception category, is considered. In this question, the sentence "AVs will reduce the number of road accidents" conveys a positive perception of AVs if the respondent agrees with it, while the sentence "AVs will increase the risk of cyber-attacks" conveys a negative perception of AVs if the respondent agrees with it. For this reason, the scoring system is calibrated to give positive scores to high level of agreement and negative scores to low level of agreement for the first sentence, while it does the opposite for the second sentence.

By summing up the score of each question in a certain category, the "category score" is computed. The Category Score does not have a specific predefined scale but grants the possibility to represent a general trait of the respondent with a single number, that can be easily compared with the ones of the other respondents to be able to draw conclusions and compute

correlations between different categories. Note that the chosen scoring system does not allow a comparison of scores between different categories: 10 points in the Knowledge category have nothing to do with 10 points in the Perception category.

Here is a list of score ranges per category of questions and what that score represents:

- Knowledge: from 0 to 25 points. A high score in this category means that the respondent knows well the world of AVs, they are informed about the technology and the current state of the art. A low score means that the respondent is not well knowledgeable of AVs, they lack information about the state of the technology and the current progress in the field. For data presentation purposes, scores have been grouped in 3 blocks: low (0 → 8), medium (9 → 16) and high (17 → 25)
- Perception: from -29 to 29 points. Positive scores represent a positive and optimistic approach to AVs, the respondent is interested in them, and AVs give rise to positive feelings in them. Negative scores represent a negative and pessimistic approach to AVs, the respondent fears them or dislikes them. For data presentation purposes, scores have been grouped in 4 blocks: very negative (-29 → -15), negative (-14 → -1), positive (0 → 14) and very positive (15 → 29)
- Willingness of Use: from -18 to +18. Positive scores represent a good will of usage of AVs: the respondent would like to try them, use them, and take advantage of them, for himself and/or for the community. Negative scores represent a reluctance to use AVs for fear, lack of interest or other problems. For data presentation purposes, scores have been grouped in 4 blocks: very negative (-18 → -10), negative (-9 → -1), positive (0 → 9) and very positive (10 → 18)
- Trust (in general): from -12 to +12. Positive scores represent a high level of trust in the AVs' technology, high confidence that they will work well and bring a positive impact to society. Negative scores represent a low level of trust in the technology, meaning that the respondent might believe that AVs will be unreliable and not trustworthy. For data presentation purposes, scores have been grouped in 4 blocks: very negative (-12 → -7), negative (-6 → -1), positive (0 → 6) and very positive (7 → 12)
- Trust on Safety: from -14 to +14. Positive scores represent a high level of trust in the safety of AVs and confidence that risks connected to their usage are low (or at least lower than without their usage). Negative scores represent a low level of trust in safety,

meaning that the respondent thinks that AVs might be a threat for his own or the community's safety. For data presentation purposes, scores have been grouped in 4 blocks: very negative (-14 → -8), negative (-7 → -1), positive (0 → 7) and very positive (8 → 14)

- Information Mean: from -12 to 12. Used only for question 23, this score is connected to the general willingness to receive frequent and up to date information about AVs, their technology, and their usage. The category Information Mean also contains more details about the channels via which the respondent would like to receive (or received in the past) such information, but this is evaluated answer by answer and not enclosed in the scoring system. For data presentation purposes, scores have been grouped in 4 blocks: very negative (-12 → -7), negative (-6 → -1), positive (0 → 6) and very positive (7 → 12)

The complete survey is available in appendix I and the csv file with raw data and scores are available for consultation via the link at the end of the survey in appendix I.

7 Results and Discussion

7.1 Data General Overview

Of the 258 respondents, 53.10% are male, the remaining 46.90% are female. The respondents are concentrated in the age range born between 1982 and 2002 (66.28%) Not all respondents answered to all questions.

The 90.70% have a driving license. Most of the respondents have a university degree (46.90%) or high school diploma (34.11%) and are mainly workers (68.99%) or students (18.60%).

Figure 30 Demographics

The respondents are mainly concentrated in large urban centers (43.80%) and in the medium-sized ones (20.93%) (fig. 30).

Most respondents spend less than an hour in front of the TV (41.09%) or between 1 and 2 hours (41.86%). The time is slightly longer for social media: less than an hour 32.17%, between 1 and 2 hours 44.57% and between 3 and 4 (17.05%).

With a score of 3.6 out of 5 it can be said that respondents like to drive a car on average and that 70.54% own one. On average, out of a score from 1 to 5, respondents feel up to date on the topic only 2.1.

When asked about the intended use of autonomous vehicles, the average is 3.4 points out of 5, while when asked whether the AVS are the mobility of the future we go up to 3.9. (fig. 31)

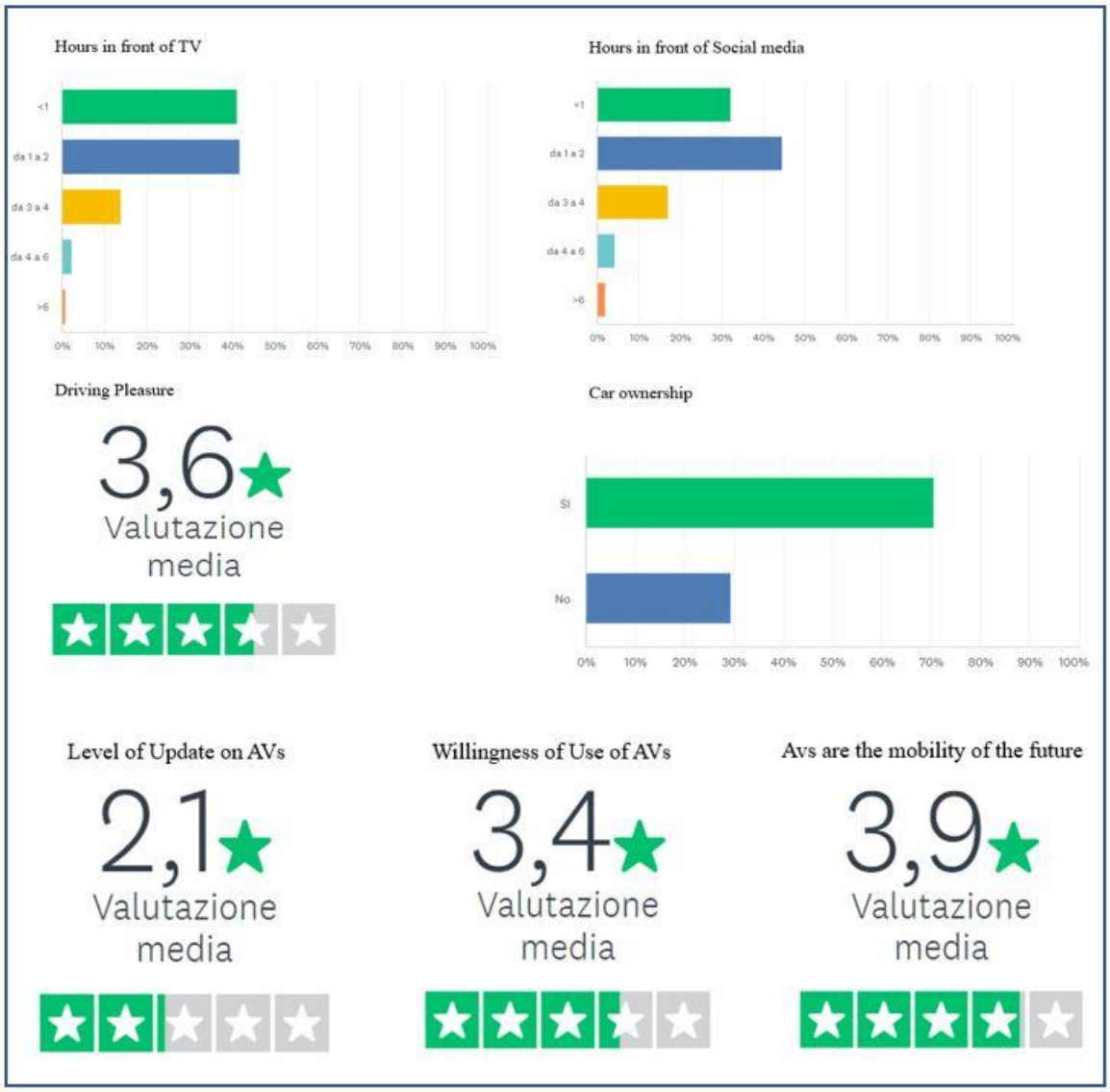

Figure 31 Summary of Respondents scores

Question 11 asked respondents if they knew what ADAS are. Of the 181 respondents, 58.56% answered "yes" and 41.44% "no". (fig.33)

Question 12 asked respondents whether or not their car had ADAS devices. Of the 181 respondents (those who own a car), 26.52% answered "yes", 41.99% answered no and 31.49% "I don't know". (fig.32)

From these results it emerges the not negligible number of respondents who claim to have a car without ADAS and of those who do not know what ADAS are.

According to the literature, having experience with ADAS facilitates the transition to higher levels of automation. This means that a significant percentage of respondents will have a greater gap to fill in terms of intent to use and trust. Those who do not know what ADAS are and consequently have not been able to say whether or not they were present in their car, present an even greater gap to fill as they have no idea of the functions that these devices can perform for the safety of the driver and of the passengers. According to the principle of relevance and the theory of rational ignorance, they will therefore more difficulty in understanding and accepting information on autonomous vehicles, finding the highest entry barrier due to the lack of cognitive connections.

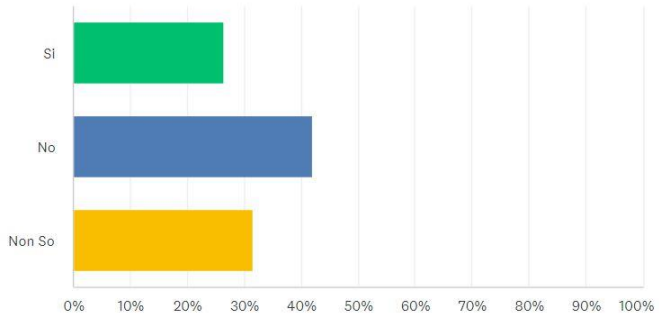

Figure 32 Presence of ADAS in owned car

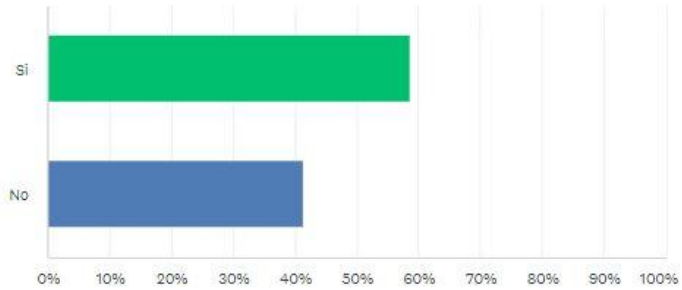

Figure 33 Knowledge of ADAS

The same response is presented with the theme of platooning, as we have seen also applicable to public transport of people but almost completely unknown to the respondents (91.71% and 9.29%)

Question 14 asked whether several claims about autonomous vehicles were true or false. If on some of them there was a marked majority of correct answers, that is:

- the automation levels are 5
- the level 3 car is able to brake autonomously, keep the lane, read the road signs and make direction changes
- In the automation level 5 the car is completely autonomous, but the driver can take control at any time

In others the knowledge seems more confused.
In particular:

- 43.52% of respondents, against 56.48% think that cars currently on the market reach level 4,
- the 52.34% against 47.66% argue that level 4 cars cannot communicate with other cars and
- the 58.53% against 41.47% think that in Italy there are no self-driving public vehicles in circulation.

Question 15 asked, in true or false mode, which of the various means of transport listed have autonomous driving, and what emerged, also in this case, is a confused knowledge of the phenomenon. If we consider the car as an example, 46.54% answered "true" and 53.46% answered "false".

This response can be interpreted in the light of the smoky communication that is being made around the ADAS. Users are increasingly finding it difficult to compare the levels of autonomy recognized by SAE with the different degree of support provided by the increasingly advanced ADAS.

In general, respondents believe that using an autonomous vehicle would not be frustrating (77.20%) nor difficult to learn (83.94%). A greater degree of uncertainty emerges when asked

whether using a self-driving vehicle is adequate or not for their driving habits, 51.30% believe that it would be adequate, compared to 48.70% who answered that it wouldn't.

Investigating the willingness of use, of the 193 respondents it emerged that the 33.16% will buy a self-driving car only when they will be sure of its safety, followed by the 25.91% who will buy an autonomous car when available on the market at an affordable price and a 22.80% that it does not intend to buy a self-driving car but will use the transport services based on it (10.88% will evaluate whether to buy a self-driving car based on the judgments of those who have already tried it, 4.66% do not intend to buy or use self-driving vehicles and 2.59% will definitely buy a self-driving car as soon as it is on the market).

When asked "Have you already been in contact with an autonomous vehicle?" 76.68% of 193 respondents answered "no", the remaining 23.32% "yes".

The 148 who replied no, were asked what kind vehicle they thought their first contact with an AV would be with. The 60.40% replied "Public transport in my city", the 27.52% "Individual vehicle", 6,71% freight transport and 5.37% "Other" (fig.34).

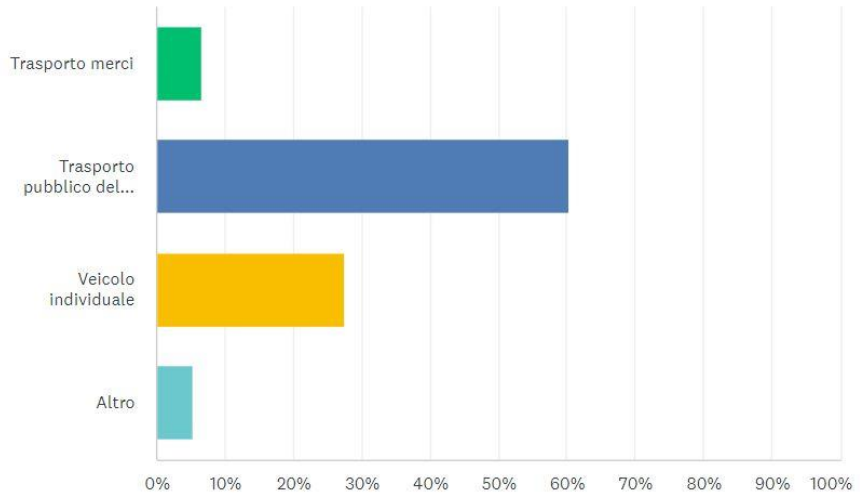

Figure 34 With what type of vehicle do you think your first contact with an autonomous vehicle will be?

7.2 Data Analysis

Analyzing the general perception of Av's is possible to notice a tendence to positive meanings. Question 13, the first of the section dedicated to the knowledge of autonomous vehicles, asked respondents to write down five attributes which, according to them, identify an autonomous vehicle. Perception Cloud of Words

Figure 35 Cloud of Words of Perception: Attributes about AVs

As can be seen from the graphic info (fig.35) created according to the cloud of words method, on 217 respondents, the most recurring attributes were: Safe (68), Comfortable (34), Expensive (24), Innovative (27), Autonomous (27) Technological (24), Useful (20), Futuristic (20), Intelligent (14), Fast (13), Reliable (10). It is necessary to reach the fifteenth place to find the first attribute markedly negative, that is Dangerous with a frequency equal to 8.

Continuing in the questionnaire, the same type of inquiry is found in question 27 and 28 (fig. 36), where respondents are asked to list, from the most relevant to the least relevant,

respectively the 5 most important benefits that autonomous vehicles can bring to society and the 5 major obstacles to AVs introduction.

In question 27, on 193 respondents, the most frequent answer is “Less accidents” with a frequency of 59, followed by Safety (58), Less Stress (51), Less Traffic (45), Less pollution (40) More free time (21), Easier mobility for impaired people (17), Less Emissions (15), Comfortable (12).

As can be seen from question 13 and question 27, the concept of safety seems to be relevant for the sample considered, both when they were explicitly asked to list positive effects and when they were asked to express representative attributes of the AVs in general. However, despite this evidence, the actual knowledge of driving safety and statistics on the most frequent causes of accidents is not particularly high: in question 17, (which is the percentage of road accidents caused by human error), of the 217 respondents just 35,48% of people actually know that more than 90% of accidents are caused by human error, 42,86% believe that the percentage is between 80% and 90%, 21,66% believe that it is between 50% and 70%. (fig.37)

In question 28, on 193 respondents, costs appear to be the most relevant answer with a frequency of 57. Following: Roads (25), Disinformation (24), Ignorance (12), Cybersecurity (21), Fear (20), Distrust (20), Unemployment (19), Ethics (18).

Figure 36 Cloud of Words Benefit and Obstacles

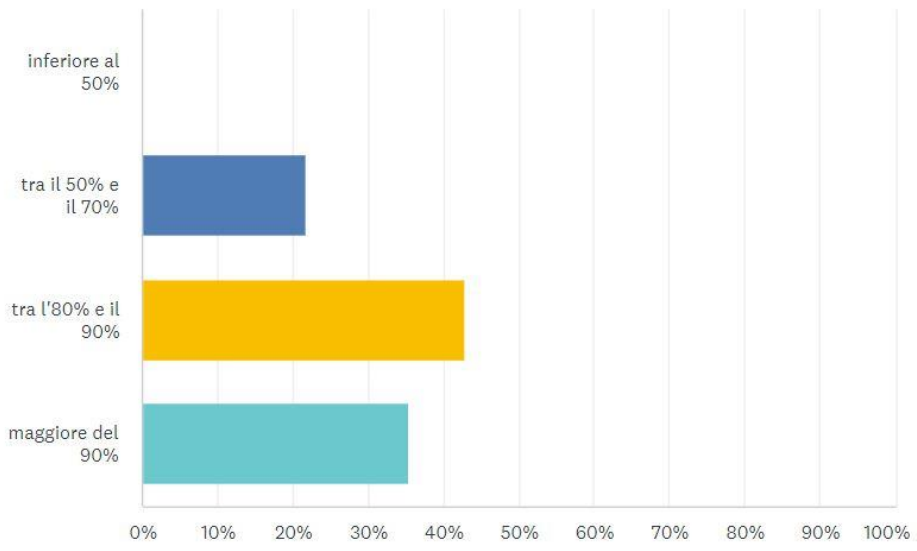

Figure 37 Question 17, knowledge about role of human error in accidents

From what emerges from the qualitative questions indicated above, the most important benefits for respondents are limited to a narrow range. For example, almost no one mentioned the possibility of a different usage of lands or the forecasted positive economic repercussions. On the other hand, it is interesting to note that in the barriers the most mentioned aspect was the cost, and therefore not a perceptive obstacle but a factual one. There are few and negligible references to the lack of standards and dedicated infrastructures. A short distance away, elements of a social nature such as fear, mistrust and ignorance emerge.

7.2.1 The Influence of Previous Experience

Question 12 asks the respondent if their car has ADAS or not. The answer to this question was used to group respondents into 3 categories: the ones that have ADAS onboard, the ones that don't have them and the ones that don't know. The scores of the categories Willingness of use (fig.38), Trust (fig.39) and Trust on Safety (fig.40) have been analysed for the three different groups of users to investigate if a previous experience with ADAS could influence the mentioned constructs.

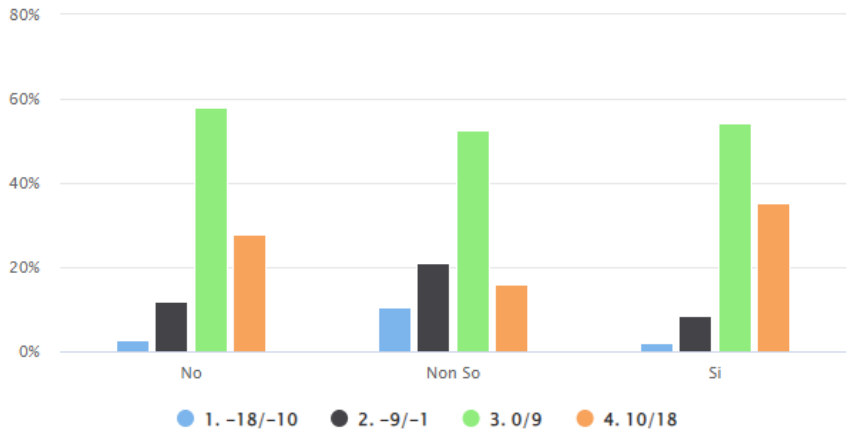

Figure 38 Willingness of use scores based on ADAS experience

Answer to question 12	Very Negative (-18→-10)	Negative (-9→-1)	Positive (0→9)	Very Positive (10→18)
Yes	2.08	8.33	54.17	35.42
I Don't Know	10.53	21.05	52.63	15.79
No	2.63	11.84	57.89	27.63

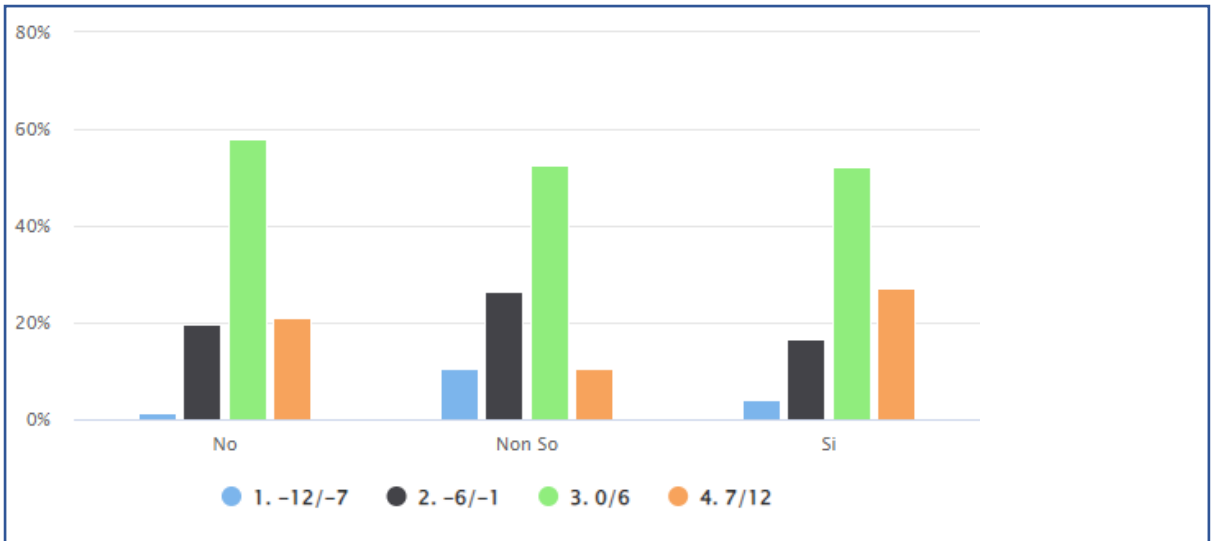

Figure 39 Trust scores based on ADAS experience

Answer to question 12	Very negative (-12→-7)	Negative (-6→-1)	Positive (0→6)	Very Positive (7→12)
Yes	4.17	16.67	52.08	27.08
I Don't Know	10.53	23.32	52.63	10.53
No	1.32	19.74	57.89	21.05

Both schemas clearly show how previous experience with ADAS has an impact on both willingness of use and trust in AVs.

In both cases, respondents who answered "yes" to question 12 have higher percentages of Very Positive scores (orange bar) and very low percentages of Negative (black) and Very Negative (blue) scores.

Respondents who answered "no" have on average lower performances than the ones who answered "yes", having both lower Very Positive scores and higher Negative ones, but they are still better than the respondents who answered, "I Don't Know".

This answer leads to the lowest Very Positive scores and the highest Negative and Very Negative ones. The letters are significantly more massive than in the two other groups of respondents.

One possible interpretation is that not even knowing what ADAS are, or how they contribute to our daily life while driving, is correlated with ignorance about this kind of assisted driving system and its possible evolution: full autonomous vehicles. This ignorance leads to less trust and faith in AVs and, subsequently, more fear of using them. Instead, people who are more aware of ADAS are more open and trustworthy towards AVs and, within them, who experienced the usage of ADAS directly is even more inclined towards positive feelings on AVs.

Knowledge and direct experience are positively connected to being more open towards the evolution of the technology.

Knowledge and direct experience → **openness** *towards the evolution of the technology.*

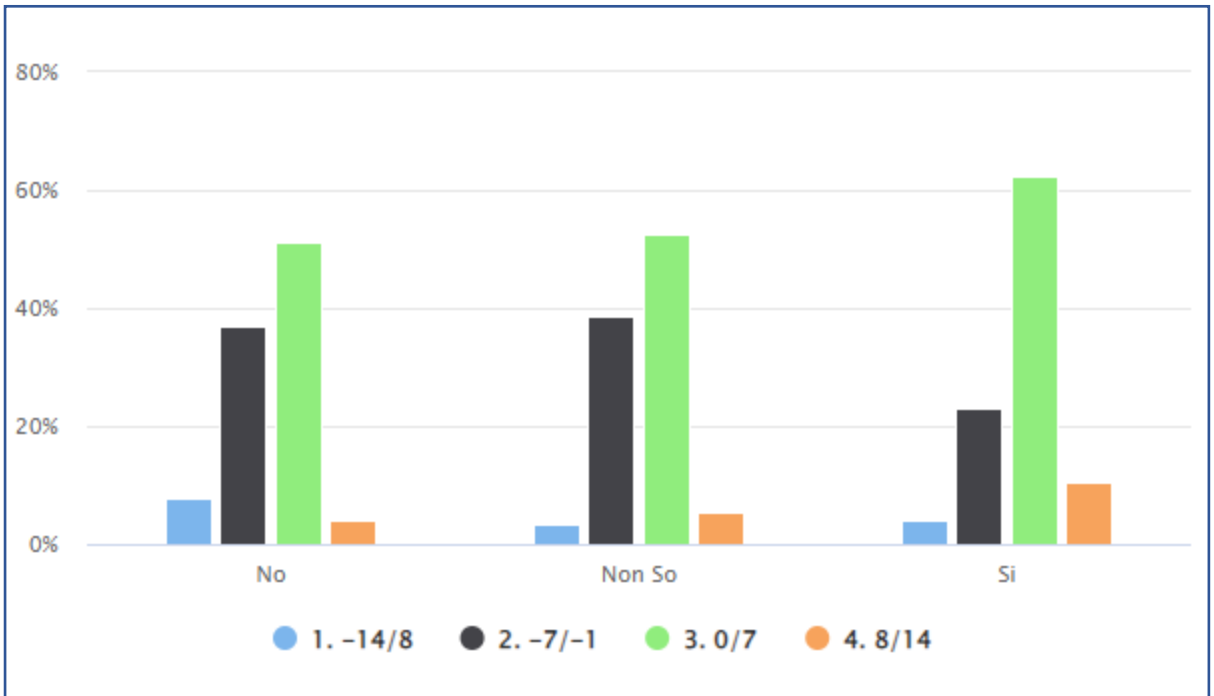

Figure 40 Trust on Safety based on ADAS experience

Answer to question 12	Very negative (-14→-8)	Negative (-7→-1)	Positive (0→7)	Very Positive (8→14)
Yes	4.17	22.92	62.50	10.42

I Don't Know	3.51	38.60	52.63	5.26
No	7.89	36.84	51.32	3.95

Focussing only on the Trust on Safety category, values are lower. Considering that safety is one of the hottest topics when talking about AVs, it is probably not a surprise that averages are lower than in the other categories, but still, even if in this case the outcome of the groups "No" and "I don't know" are more similar to each other, if not slightly inverted, the group that answered "Yes" to question 12 has significantly higher "Positive" and "Very Positive" scores and significantly lower "Negative" and "Very Negative" ones, confirming again that direct experience of a similar technology has a positive impact in embracing the new tech.

7.2.2 Constructs Correlations

Looking the categories involved in the survey and looking and their correlations (fig.41) it is possible to affirm that there is a strong correlation between:

- Positive perception of AVs and trust (0,76)
- Positive perception and willingness of use (0,83)
- Willingness of use and trust (0,81)

Knowledge and Willingness to use, as well as Knowledge and Trust are mildly correlated, respectively 0,44 and 0,42, therefore nothing certain about their relationship can be assumed. An average (0,54) correlation emerges instead between Mean of Information and willingness of use. An high score in the category "mean of information" suggests the willingness to receive information on the AVs topic therefore those who wants to receive more information have a higher willingness of use and those who have a high willingness of use wants to receive more information.

Therefore, it is possible to affirm that:

- The higher the degree of positive perception of autonomous vehicles the greater is the trust in them, and vice versa: the lower the degree of positive perception towards the AVs, the lower the trust in them.

  + Perception → + Trust

- The higher the degree of positive perception of autonomous vehicles the higher is the willingness to use them, vice versa: the lower the degree of positive perception, the lower the willingness of use.

  + Perception → + Willingness of Use

- The higher the level of trust in autonomous vehicles the higher is the willingness of use and vice versa: the lower the degree of trust, the less the willingness of use.

  + Trust → + Willingness of Use

	Conoscenza	MezzoInformazione	Percezione	PercezioneSicurezza	Fiducia	Intenzione
Conoscenza	1.00	0.27	0.39	0.11	0.42	0.44
MezzoInformazione	0.27	1.00	0.44	0.06	0.43	0.54
Percezione	0.39	0.44	1.00	0.42	0.76	0.83
PercezioneSicurezza	0.11	0.06	0.42	1.00	0.31	0.29
Fiducia	0.42	0.43	0.76	0.31	1.00	0.81
Intenzione	0.44	0.54	0.83	0.29	0.81	1.00

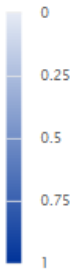

Figure 41 Correlation Matrix

Conoscenza = Knowledge
Mezzo di Informazione = Information Mean
Percezione = Perception
Percezione Sicurezza = Trust on Safety
Fiduci=a Trust
Intenzione = Willingness of use

Other relevant reflections come from the analysis of questions directly linked to the level and the channels of information.

7.2.3 Communication and Information Channels

Question 22 "which of the following information channels do you consider most important" refers to the channels perceived as more relevant by the respondents and has been analyzed considering the different degree of knowledge of the respondents. Each respondent could

choose up to 3 channels. Looking at the graph in (fig.42) it is possible to see that for the 92% of respondents that have an high score (17-25 pt) in the knowledge category, the most important information channel is “social media and blog articles” (91,67%), followed by “events” (58,33%) and newspaper articles (50%) and then “television programs” (25%). Completely unmentioned the games.

It is interesting to notice that also for the low knowledge-scored respondents (0-8) the most important information channel remains “social media and blog articles” (33,02%), and “newspaper articles” (32,08%), with just a percentage point of difference, followed by “television programs” and “events”, almost with the same percentage with respectively 27,36% and 26,42%. The 2,83% mentioned the games.

So, from the data we can say that the discriminating factor in terms of media between those with a high and a low knowledge score is that those who are more informed identify "social media and blog articles" as the mean of information that is clearly more important than the others.

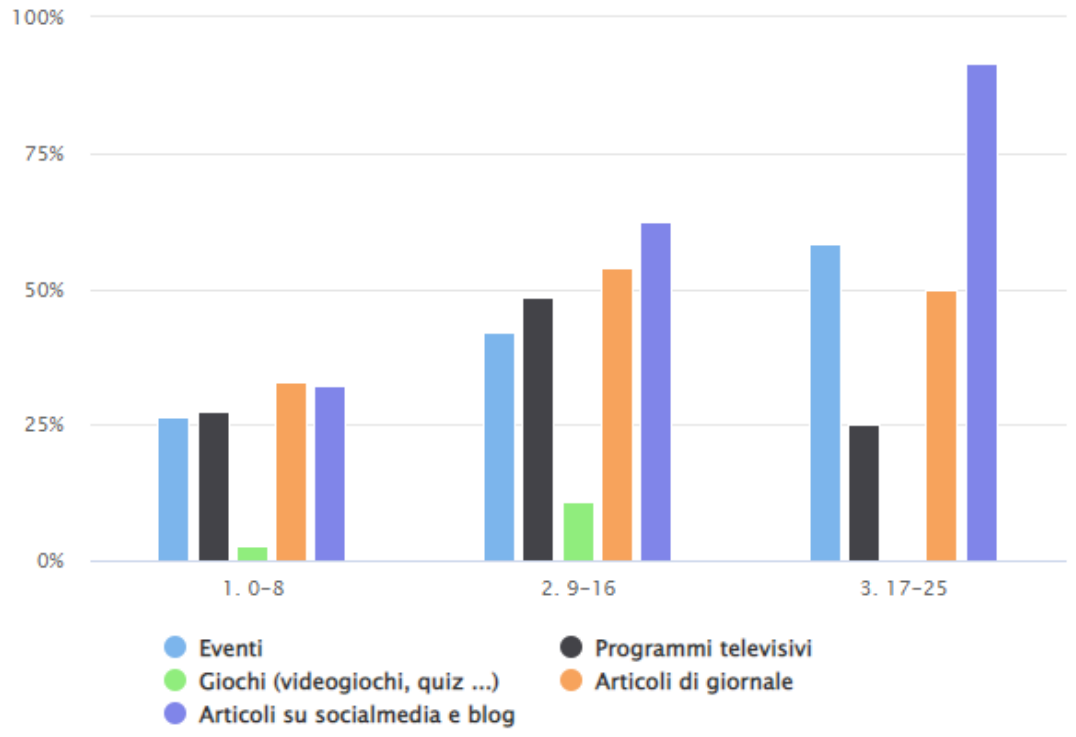

Figure 42 Relation level of knowledge and favored channel

Eventi= Events
Giochi = games
Articoli su social media e blog = Social Media and Blog Articles
Programmi televisivi = TV programs
Articoli di Giornale = Newspaper Articles

Knowledge Level	Events	Games	Social Media articles and Blog	Television Programs	Newspaper Articles
0-8	26,42	2,83	32,08	27,36	33,02
9-16	42,19	10,94	62,50	48,44	53,91
17-25	58,33	0	91,67	25	50

Continuing the reflection on information channels, it is interesting to analyze the relationship between question 20 and question 21. In question 20 it was asked to respondents their level of update on AVs on a scale from 1 to 5. In question 21, the degree of agreement on having received information through different strategies and information channels was asked (mass media, social media, social media contacts, self-research and social circle).

The first visible result is that, as expected, in each category who thinks to be not up to date on AVs extremely or strongly disagrees with having received information from these sources whereas who believes to be well informed strongly or extremely agrees with this. In particular, ranking the entries from the most voted to the least voted from informed people, we get:

1. Having searched info by himself
2. Having read information suggested by social media
3. Having talked about this subject in his social circle
4. Having received information by mass media
5. Having read information shared by social media contacts

Figure 43 section D clearly shows, in a “V” form graph, that who thinks to be not updated on AVs, extremely disagrees on having searched information by himself, whereas who thinks to be updated, extremely agrees on having searched information by himself.

Looking at the mass media results (fig.43, section A), it is possible to notice that, despite all the channels investigated have recorded bad feedback from those who do not consider themselves informed, the mass media are those that have generated less disagreement in this category, while they have generated less agreement that other categories among those who consider themselves up-to-date.

A possible explanation could be the following:

Those who consider themselves up to date have proactively searched information, probably driven by interest in the topic, while the uninformed have not invested time and energy in research. The fact that uninformed respondents have a lower disagreement rate related to mass media, rather than the other categories, could be linked to the passivity of the channel. Thanks to this, traditional mass media have a high rate of permeation in all social classes, thus also reaching those not interested through reports in current affairs programs, newscasts, radio comments or newspaper articles. On average, the most spread mass media provide information suitable for a wide range of users and therefore more generic. This is perhaps the reason that pushes the most up to date to seek less information in the mass media, seen as generic and passive, and more information on their own through research and social media, perhaps using key words and filters, looking for more specialist and targeted information.

Section B,C and E of fig.43 target Social Media Contacts, Social Media as channel and Social relations (outside of the web). In C, it possible to notice that social media received a score of 69% of agreement and 21% of disagreement from those who consider themselves informed and a score of 2.13% of agreement (and 88% of disagreement) from those who do not consider themselves updated.

In section E, the 45% of updated respondents agree or strongly agree on the having exchanged information with their acquaintances and 21% disagree or strongly disagree, while the not updated respondents agree or strongly agree only at 11% and disagree or strongly disagree at 71%.

On the other hand, considering the information shared by social contacts (section B), it can be seen that the 45% of the updated agree or strongly agree on having read information shared by social contacts and 36% disagree or strongly disagree, while in the not updated category the 4% agree or strongly agree and 84% disagree or strongly disagree.

This gives rise to a reflection. Probably the topic is starting to be sufficiently widespread to allow an exchange of opinions / information between friends and acquaintances, spurred by a topical idea or linked to the news of a brand or car manufacturer rather than another. While it is not widespread enough to stimulate the sharing of articles or information on social media. In this case the entry barrier is higher: there should be a proactivity in reading, understanding and subsequently sharing what has been read that is probably still missing in the general public, leaving this type of topics to dedicate groups. Deciding what kind of contents to share on social media is strongly related to the concept of "public social face"[115]: with the aim to preserve it people make an effort to decide the contents to share and that their contacts will see.

Following what has been said, comparing the results of graphs B and C it is possible to affirm that even those who receive information from the mass media receive it from dedicated pages or news updates much more than from posts or sharing of social contacts.

By comparing the graph in figure 43 section C with that in fig. 42 it is possible to make the following consideration: given the present cultural period, permeated by digital culture, when the respondents were asked which they believe to be the most important channel, regardless of the level of knowledge about AVS, social media have been successful, albeit with different percentages. This is probably because social media are frequently visited, however, given the scarce presence of AV-themed posts on social media, those who do not carry out independent searches will hardly come across dedicated informative contents.

[115] X.Zhang, Q Cao, N. Grigoriou, "Consciousness of Social Face: The Development and Validation of a Scale Measuring Desire to Gain Face Versus Fear of Losing Face", The journal of social psychology, 2011.

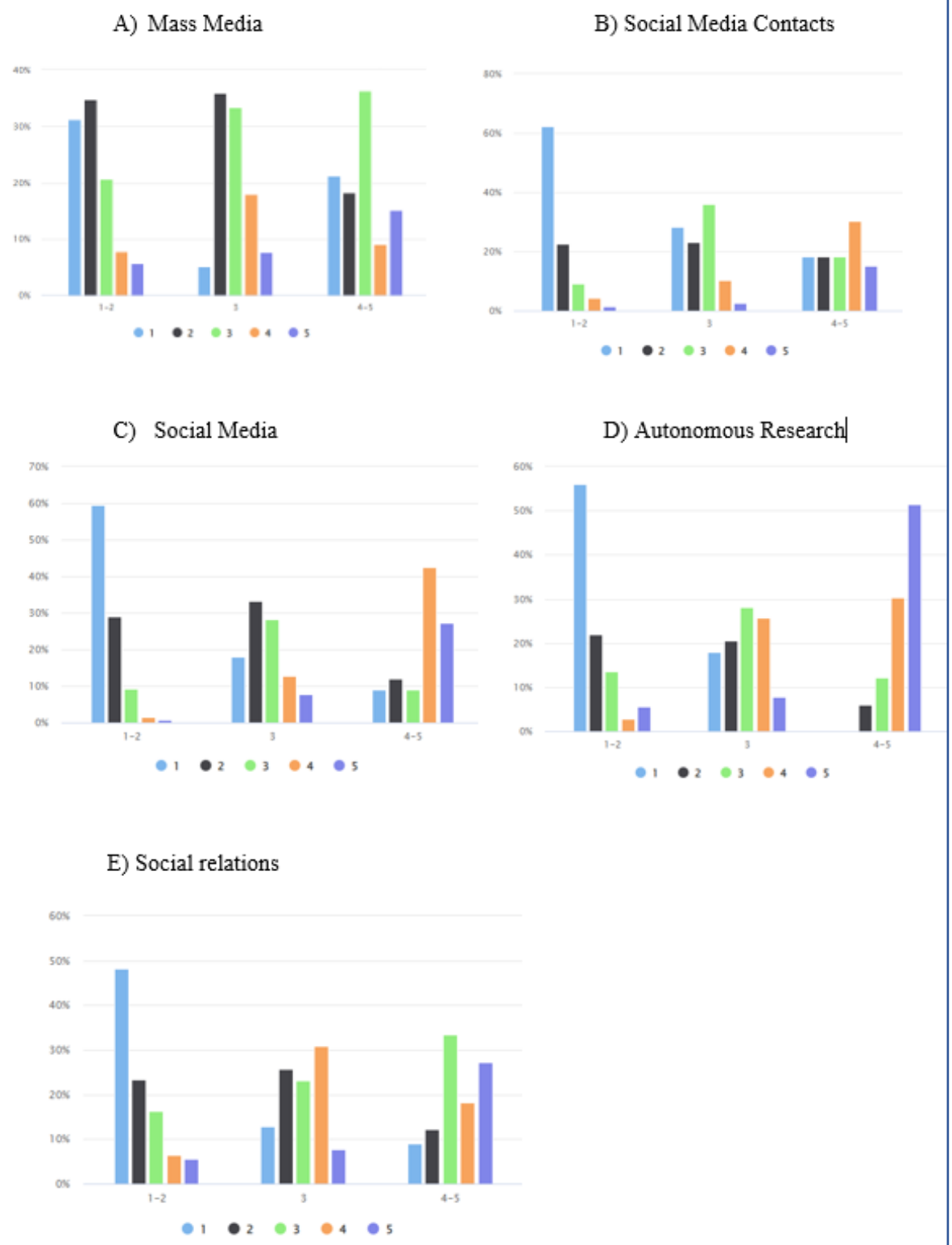

Figure 43 Relation question 20-21: level of update and channels

7.2.4 The Power of Visual Culture

We are immersed in a visual culture, where images teach us and frame us in reasoning frameworks. Certainly, also due to digital transformation, images play an increasingly important and omnipresent role in our lives. Example of this are the question 18 and 19. In question 18 the respondents were asked if they knew the "Moral machine", in the following question they were then asked if they recognized an image, perhaps the most typical and widespread graphic representation of the Moral Machine, from the data it can be seen that the 27.11% of those who replied that they did not know the moral machine then replied that they had seen the image that graphically represents the moral machine (fig.44). Here emerges strongly the concept of “the immediacy” of the image. This attribute can be taken advantage of to spread knowledge in a very fast and easy way, and if correlated with a small amount of relevant data can be the first step toward the educational path.

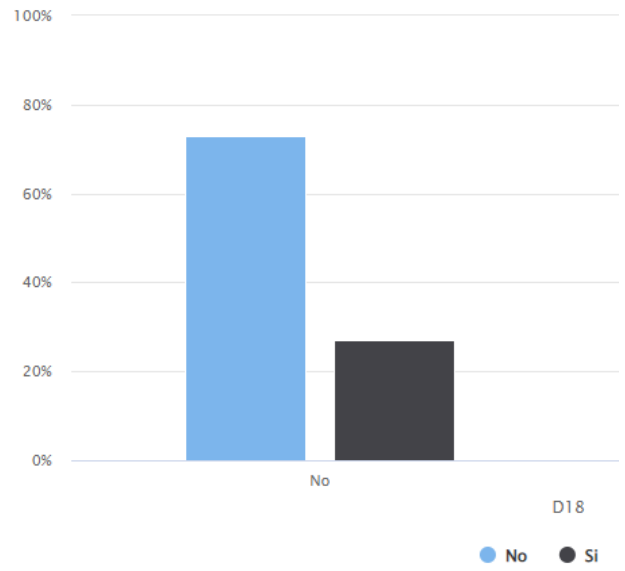

Figure 44 Question 18: Knowledge moral machine: Name vs Image

In the following paragraph the conclusions and recommendations conceived and drawn from the data and theories analyzed in this thesis will be set out and commented on.

8 Recommendations for efficient communication strategies

Communication plays an important role in the dissemination and adoption of innovation. As seen previously, it is necessary to organize effective and efficient communication strategies as each stage on the path towards innovation requires a different type of communication support. A wrong approach could reinforce the intrinsic resistance of the users, prompting them not to seek or accept more information in future.

The role of communication is therefore to inform, thus helping potential users to overcome their own internal barriers, minimizing the effort on the part of the users, and maximizing the benefits to combat the rational ignorance that impends the adoption of innovations. It must transfer the right information, which is relevant to the user, and which helps him to build adequate information structures around the decision to adopt or not an innovation, breaking down the fear of the new, exploring it with awareness.

From the study ten recommendations emerge, summarized in the following principles:

- Use of image and graphic info to convey clear and direct information
- Enhanced use of top-down communication means as they are fundamental in the first information and knowledge phase. The goal is to provide potential users with basic knowledge on innovation in order to prepare useful connections, according to the principle of relevance, to the construction of a more structured knowledge on the subject in subsequent phases, lowering the level of effort for the user and maximizing the yield
- Management of centralized information sources regarding the experimentation of autonomous vehicles infrastructural or complementary services on the Italian territory. They need to be rich in images and clear information that can be adapted for broadcasting on other channels (i.e., social media)
- Creation of specific content for each media and its target: shareable format for social media, privileged channels for more informed users, and generic formats for the more traditional and passive means of communication, privileged by less informed users
- Design of campaigns aimed at communicating information on the functioning of AVs and on the benefits of using them to support the perception of relative advantage of the adoption, supported by the organization of events and demonstration meetings to

facilitate the observability and trialability of innovation for those who have active resistance and need to be informed to evaluate the innovation

- Capillarization of communication and information through catalysts or change agents who act as leads and communicators of innovation (i.e. teachers, instructors, science communicators)
- Structuring of incremental information campaigns, supported by simulations and comparative analyzes between old and new products, for those presenting passive resistance and therefore an attachment to the status quo
- Be ready to design and exploit emotionally engaging information mechanics to be implemented in the persuasion phase, in which users are more emotionally than rationally involved and therefore they need an emotional contribution to be linked to the informative one
- Designing of an ad hoc educational and informative structure for the younger categories. They, being closer to the digital world and having the digital connections necessary to open up to the innovative topic, require information based on digital and less mediated or filtered means. They can cover the role of communicators themselves, being change agents towards family units

As emerged from the survey, different channels reach different types of potential users, making a risky parallel between the path of knowledge of autonomous vehicles and the journey of the buyer (p.92), we could say that users who have no knowledge are in a stage of different realization than those who consider themselves up-to-date or have a medium-high level of knowledge on the matter.

As seen in the models, the mass media (and in general all those tools whose variables can be managed and partially controlled by marketers) play a decisive role in the early stages of the introduction of innovation. After this first phase, the most active sources of information, the ones to which the potential user listens most, become the bottom-up sources, that is, those that involve comparison with other known users or through repost of unknown consumers. Despite autonomous vehicles being a technology not yet tangible for the mass and therefore difficult to metabolize, the information path on these technologies has been going on for years and it is in a certain sense evolving following these same dynamics.

For this reason, it is important not to waste time and to use these pre-innovation phases to determine and shape communication methods for different categories of the population. As previously analyzed, the contents must be designed and calibrated differently depending on the channel to act effectively.

It is necessary to devise formats dedicated to means of passive use such as traditional media, and of generalist nature to inform and start educating the population groups who, due to lack of interests or skills, do not receive nor seek information from more active and specialized sources.

A starting point is to follow the American example and produce clear and pleasing graphic info, following the rules of cognitive ergonomics, useful for visual learning. The same contents can be sources of material to be shared in form of public campaigns, articles, but mostly, posts and stories on social media. This path could be followed in several ways.

Surely, keeping a centralized knowledge, that is, above all, easy and immediately understandable, of all the past and present experiments on the Italian territory can help to make a concept, that is still abstract for many, more and more concrete, helping to realize the fact that AVs are a current phenomenon, concrete and close in time.

The realization of these contents at the same time helps to create material that, adapted to the purpose, can be shared on social media. As a result of the survey, social media is one of the most used information media by those who inquire and, in general, 68.61% of the respondents spend at least one hour every day on social media (and usually even more).

The creation of posts based on infographics inherent to the experiments has the potential to contribute to the make the information “viral”, making communication more immediate and taking away from the one who shares the effort, intended as a barrier to entry, of having to spend time in reading and judging the reliability of the article before sharing it. This can be the first preparatory step for approaching the general public to the topic, raising curiosity and disseminating short pills of knowledge.

In a similar way it is useful to identify agents and figures that can act as informative catalysts. As far as large-scale communication is concerned, the phenomenon of science communicators, that is increasing in size and fashion, is a new, effective introduction method, more demanding than single social post but still attractive for a large audience. The figure of the science communicator, acting as a filter between the scientific notion and the user, provides a scientific

and correct culture on innovation that is already suitable for comprehension, lowering the effort required and minimizing the action of rational ignorance. Those who are part of the social media communities of science communicators see their membership as a status quo, and for this reason they often share the materials produced, contributing to the dissemination of information.

The stories that can be created on social networks are another simple and quick way to post and acquire information. There are many users, including renowned brands who use this method to promote products or share information. it is possible to create quick polls, lasting a few seconds, through which to test knowledge or ask for opinions and then release a pill of content. They are certainly a good option to spread the knowledge of the many and different benefits related to the introduction of AVs. A good example of this is the video of Derek Muller in the YouTube channel Veritasium, and his collaboration with Waymo. He managed to make reflections on the technology, with verified data, accreditable sources available for the public and had reached more than 2.5 million visualizations as of January 2022.

The approach to the idea of this innovative product is certainly easier for well-known brands with a reliable reputation in the eyes of the users, in fact 53.36% of respondents agreed or strongly agreed with the statement "My confidence in autonomous vehicles is influenced by the manufacturers' reputation for reliability and safety ".

The practical and concrete approach with autonomous vehicles through thematic events and public meetings or demonstrations would be very useful. As suggest by Rogers the heterogeneity is a key value in innovation diffusion, for this reason and interdisciplinary approach could be the best way to present the AVs innovation from different point of views, widening the target audience. The 55.92% of respondents said they agreed or strongly agreed with the following statement "I would like local authorities to organize demonstration events on autonomous vehicles", the 45.07% indicated the events as a useful communication channel, the 73.58% agree or strongly agree with wanting to test an autonomous vehicle before buying it while the 54.4% agree or strongly agree on wanting specific training before buying an autonomous vehicle. This kind of communication can help reducing performance uncertainty and the related risk barrier.

Also, the attributes of trialability and observability would benefit by events.

From the data, the importance of positive perception and trust factors towards AVs to increase the intention of use emerged. To create trust and positive perception, it is useful to give a clear

vision of the functioning of autonomous vehicles and an in-depth insight into the benefits they could bring to society (it has been seen through the cloud of words that the benefits considered are generally restricted to a lesser circle). It’s relevant to underline not only the social and collective benefits but, being the western society an individual one, also and mainly the individual benefits and the improvements that each single user can achieve. To do this in a targeted way, it is necessary to know the different targets or buyer personas and develop contents that act on the specific gaps as suggested by Hohenberger.

A clear example of targeted communication is the one based on demographic data. Promoting AVs for men means elicited status motives, underlining the hedonistic and self-enhancement factors, whereas for women it's important to reinforce the safety feeling, emphasizing the comfort in terms of protection and safety conditions. Given the pronounced difference of perception in young men and women, a practical and specific training to mitigate the relevant gap between sexes should be conduct in a proper and specific way. Elderly people seem to be less prone to pay for automated technology, it's important to underline the enhancement of their mobility conditions, creating a specific program oriented to smooth the first approach between elderlies and AVs.

As already said, emotions are powerful markers. They have an important role in communication, especially in the persuasion stage. If in the knowledge stage KPIs, information, benefits, trials, and experience are key elements, in the persuasion stage the user is involved from an emotional point of view. At this specific point the potential user nurturing aims at involving perception of joyfulness, easiness linked to the AVs, envisioning a future where all the benefits will be implemented giving positive emotions in return. In this case gamification and simulations can help in an easy and funny way. These kinds of tools can also be very useful in reducing cognitive passive resistance by minimizing the initial barrier and working on the self-perception of the individual.

What has just been said can help possible users in the path towards the knowledge of AVs, supporting them in the construction of perception and trust in this new technology, allowing them to get at the evaluation of it with the appropriate tools to do so. Giving information, underling benefits and explaining the functioning and technology can support the user in overcoming the functional barriers of active resistance. However, it does not solve the problem of passive resistance. In this case, the principle of permeating information and the one of relevance can be useful.

Those who make passive resistance aim to maintain an unaltered status quo, linked to habits, values and objects. For this reason, the perception of a disruptive innovation could reinforce their fear, enlarging the gap to be filled. With them, providing information does not work: they refuse to evaluate innovation, rejecting it a priori. For this reason, continuity can be a good approach: do not weaken traditional values but give them continuity towards innovation. Starting from the known products, communication must be done gradually, through constant references and comparisons: lowering the effort to imagine a new concept and following the principle of relevance, providing information that has previous notions in the context of these individuals to connect to and to start building an information education process, rather than promotion. This kind of communication can help also in reduce situational resistance linked to status-quo perception.

Another issue of relevance is communication towards the youngest. Seen as indirect agents of change or as future users, depending on the time horizon relating to the forecast, they require adequate communication. Being digital natives and recently involved in the digital transition itself, it is easier for them to find traits of continuity between their daily life and information on innovations. A person in the role of change agent such as a civics teacher or driving school trainer can be the suitable information vehicles, highlighting social changes and possible evolutions and preparing young people for new information on innovation. Young people can be information catalysts in their social relations, encouraging the exchange of opinions within their own social circle, sharing on social networks, and playing the role of promoters towards family members.

9 Conclusions

The aim of the research project was to investigate the perception of autonomous vehicles by potential users and the public in general, with a focus on communication, information, and distribution channels, with the scope to propose adequate ways to vehiculate information.

Various principles and theoretical models have been taken into consideration, the most important of which are the diffusion of innovation theory, the active and passive resistance theory, and the technology acceptance model, with the aim of understanding the variables involved in the process and responsible for the perception of innovation and consequently for its adoption.

A state of the art on autonomous vehicles has been exposed as regards the levels of automation, the effects of AVs on society, the possible introduction barriers, the experiments in progress abroad and on the Italian territory of both autonomous vehicles and preparatory infrastructures. The innovation stakeholders have been presented before investigating the potential user-buyer, the fulcrum of the communication process in terms of information and marketing. A reflection was therefore made on communication as an active actor in the introduction process and on its potentials, if well exploited.

A survey was designed and administered in the Italian territory to understand the perception that possible users have of the AVs, the level of information and knowledge, the information channels used and favorited, the level of trust, expectations, trust on safety, willingness of use and their correlations.

From the analysis of the responses and with the support of the literature, conclusions and guidelines have been drawn, including suggestions for the creation of information material, strategic communication campaigns and preparatory actions.

The study confirmed the high positive correlation, already expressed in literature, between perception and trust, perception and willingness of use and between trust and willingness of use, and a medium correlation between willingness of use and requests of information. Hence the need to provide informative material and to support the creation of trust and positive perception in potential users to solicit the intention of use. To achieve this result, the communication actions to be performed are different according to the target audience.

Also, the fact that previous experience with ADAS has a positive impact on both willingness of use and trust in AVs has been confirmed, leading to the conclusion, according to the importance of experience and the principle of relevance, that creating an a-priori knowledge can be useful to generate hooks and markers to which future knowledge can be linked with minimal effort on the part of the user and thus minimizing the phenomenon of rational ignorance.

From the qualitative questions emerged that the knowledge of the benefits brought by the AVs is limited to the most resonant themes while the greatest barrier mentioned is the cost. It is relevant to notice that cost is an implementation barrier and not a perceptive one.

About communication, the predominance of the image over written information was clear, and this led to suggest, following the American example, a massive use of educational info graphics for the dissemination of data and useful information.

The responses showed a markedly proactive attitude on the part of those who are more informed and a consequent preference for social media, while the diffusion of traditional and more passive means of communication is predominant in the less informed categories. It is therefore useful to differentiate the communication contents to be distributed on the various media according to the degree of information of the target audience.

Despite the widespread use of social media, the practice of sharing remains limited, it is therefore useful to lower the entry barriers by creating sharable and accountable material based on visual information and on clear and direct messages to support the widespread diffusion of informative posts. The use of catalysts or change agents is recommended, they are to be identified in figures who can support communication such as science communicators, very popular on social networks and beyond, and people considered to be a reference by users as teachers or instructors.

The observability and trialability attributes result as relevant from the survey, for this reason the organization of informative demonstrations and road-testing events must be encouraged.

The concept of relative advantage is discriminating for those who actively resist: for these subjects information campaigns are essential. In the presence of passive resistance, it is instead necessary to emphasize continuity with a type of incremental information that does not deviate excessively from the status quo but guides it towards evolution. The use of gamification and

simulation is recommended in this case to make them imagine and envision the possible development and positive changes in their life, making them self aware.

The category of new generations is an important target both as future users and as possible dissemination agents, useful for introducing information into households. Thanks to their digital background, according to the principle of relevance, finding markers to link new information to is easier than in other generations. For this reason, a more digitally based information mean is recommended.

In conclusion, we can affirm that the suggestions can be understood as guidelines of a roadmap relating to communication and information of potential users on the topic of autonomous vehicles.

That of autonomous vehicles is a peculiar phenomenon, which could be interpreted as a product or as a service, but for sure as a life changing technology. The Avs' introduction will be complex and the perception and role of the user will be fundamental.

For this reason, the various stakeholders involved have a great responsibility, namely that of communicating and supporting a reality that has the potential to influence the entire social context but which, as a product, is also a business element.

Talking about ethics and responsibility in the context of autonomous vehicles seems to lead to moral choices and on legal liability in the event of an accident.

The term 'responsibility', in this case, is to be interpreted as the need to assist a synergistic process in order to cooperate on a theme that can have wide-ranging effects in everyone's future.

The sellers of this technology and, to follow, all the stakeholders of complementary services will be the first to tackle this challenge, followed by the local actors who, through dissemination, will support the phenomenon as a service aiming to obtain the numerous positive effects on different social levels of which you talked about in this study.

But the issue of responsibility goes much further, in fact the correct strategies for creating awareness in the user must come from different sources which he considers authoritative and important in his daily life.

All stakeholders, at different levels, must therefore participate in the construction of the communication structure that will have to support the phenomenon of autonomous vehicles in the times to come.

In doing so, it will be essential to select the right channels and the right content for the different specific targets, because sometimes trying to communicate for everyone means communicating for no one.

Starting from the knowledge of the different categories of users, synergistic and effectively targeted strategies must be built.

Clearly, especially in the initial period, those who are going to get information at a dealership will need a different level of information than those who are preparing to take an autonomous bus for the first time or those who watch a news program on television.

Unscrupulous saturation of communication channels is not always the best way to get the desired message across.

Knowing the proven and potential implications of a successful introduction, ethical commitment becomes a pillar of the aforementioned responsibility.

All stakeholders have the responsibility, in this case more than ever, to approach the topic in an interdisciplinary way. Both for the sake of the development itself and for the design of informative content that is complete and supported by valid data.

The AV have repercussions regarding legal, environmental and economic issues, territorial planning, safety and much more.

In addition, to ensuring that development and research continue to be a bulwark of this phenomenon, this requires a 360° communication regarding the various disciplinary fields involved. Also in this case the targets and priorities are to be adequately assessed the contributions of the different disciplines will be essential in the near future.

In the era of fake news and disinformation, communicating in an ethical and conscious way is a challenge that must take many factors into account.

The results shown in this thesis aim to provide strategic suggestions on the channels and methodologies useful for conveying the communication of the phenomenon. These methodologies can therefore be adopted by stakeholders belonging to different sectors, who

are at different levels of interest in the topic and whose objective is the dissemination of contents that are different in nature and impact.

9.1 Limits of the research and future development

Despite the number of responses received, higher than expected given the type of channels used, the conclusions derived are based on a small and not sufficiently representative sample. The age range is biased towards the millennial generation, while it would be very interesting to analyze the responses of older and younger respondents, firstly because their responses would be based on different knowledge and logical structures and secondly because respectively, as possible beneficiaries of services of autonomous mobility and potential future buyers and users, they can give an in-depth insight on topics and issues that need to be addressed for a smoother introduction.

Another aspect to consider is the inclusion of questions specifically designed for the construct of active and passive resistance, with the aim of understanding the discriminating variables possessed by users in the current era, in which the concept of status quo and possession of products merges with the idea of digital and all-as-a-service.

From the point of view of communication strategies, once the guidelines of action have been identified, it is necessary to design and investigate different Personas and test the conclusions drawn using a / b tests containing visual and communicative variables. The aim is to further refine the typology of communication addressed to the various categories of users and therefore to design data-driven campaigns.

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APPENDIX I “The Survey”

CIELI
Centro Italiano di Eccellenza sulla Logistica i Trasporti e le Infrastrutture

Percezione e Informazione su Veicoli Autonomi

Benvenuto in questa indagine!

Sono Martina Sciaccaluga, Phd presso il Centro Italiano di Eccellenza sulla Logistica, i Trasporti e le Infrastrutture (CIELI) dell'Università di Genova.

La mia ricerca è incentrata sui veicoli autonomi e sulla percezione e la conoscenza che i potenziali utenti hanno riguardo a questa innovazione.

L'indagine a cui stai per partecipare è completamente anonima, richiederà 9 minuti del tuo tempo.

Sapere cosa pensi dei veicolo autonomi, che informazioni hai, da dove provengono e che informazioni vorresti ricevere è importante per affinare le ricerche in questo settore e aiuterà i ricercatori a comprendere meglio il punto di vista del potenziale utilizzatore e a proporre soluzioni ed alternative più vicine ai bisogni degli utenti.

Grazie per il tuo prezioso contributo

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Percezione e Informazione su Veicoli Autonomi

Chi sei?

* 1. Di che genere sei?

- M
- F

* 2. In che anno sei nato?

- prima del 1943
- tra il 1943 e il 1963
- tra il 1964 e il 1981
- tra il 1982 e il 2001
- dopo il 2001

* 3. Possiedi la patente?

- Si
- No

* 4. Quale è il tuo livello di istruzione?

- Licenza elementare
- Licenza media
- Diploma
- Laurea
- Post laurea

* 5. Quale è la tua attuale occupazione?

- Studente
- Lavoratore
- Disoccupato
- Pensionato

Altro

* 6. In che zona vivi?

- Grande centro urbano (>250000 abitanti)
- Medio Centro Urbano (50000-250000 abitanti)
- Piccolo Centro Urbano (10000-50000 abitanti)
- Periferia
- Centro Non Urbano

* 7. Quante ore al giorno trascorri in media davanti alla TV?

- <1
- da 1 a 2
- da 3 a 4
- da 4 a 6
- >6

* 8. Quante ora al giorno trascorri in media sui social?

- <1
- da 1 a 2
- da 3 a 4
- da 4 a 6
- >6

* 9. Mi piace guidare l'auto

Estremamente in disaccordo — Estremamente d'accordo

★ ★ ★ ★ ★

* 10. Possiedi una macchina?

- Si
- No

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Percezione e Informazione su Veicoli Autonomi

* 11. Sai cosa sono gli ADAS (Advanced Driver Assistance Systems) ?

- Si
- No

* 12. La tua macchina è dotata di dispositivi ADAS (Advanced Driver Assistance Systems)?

- Si
- No
- Non So

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Percezione e Informazione su Veicoli Autonomi

Quanto ne sai sui Veicoli a Guida Autonoma?

* 13. Scrivi i 5 attributi che secondo te identificano un veicolo autonomo

1)
2)
3)
4)
5)

* 14. Indica quali affermazioni sono vere e quali false

	Vero	Falso
I livelli di automazione delle auto sono 5: da 1 (nessuna automazione) a 5 (completamente autonoma)	○	○
Le auto attualmente in commercio arrivano fino al livello 4	○	○
L'auto di livello 3 è in grado di frenare autonomamente, mantenere la corsia, leggere i segnali stradali ed eseguire cambi di direzione	○	○
Nel livello di automazione 5 l'auto è completamente autonoma, ma il conducente può prendere il controllo in qualsiasi momento	○	○
L'auto di livello 4 è in grado di comunicare con le altre auto	○	○
In Italia attualmente circolano trasporti pubblici a guida autonoma	○	○

* 15. Indica quali tra le seguenti tipologie di mezzo di trasporto attualmente in circolazione dispongono della guida autonoma

	Vero	Falso
Treni/Metropolitane	◯	◯
Aerei	◯	◯
Auto	◯	◯
Mezzi Pesanti	◯	◯
Navi	◯	◯

* 16. Sai cosa significa il termine platooning ?

◯ Si

◯ No

* 17. Quale è secondo te la percentuale di incidenti su strada causati esclusivamente da errore umano?

◯ inferiore al 50%

◯ tra il 50% e il 70%

◯ tra l'80% e il 90%

◯ maggiore del 90%

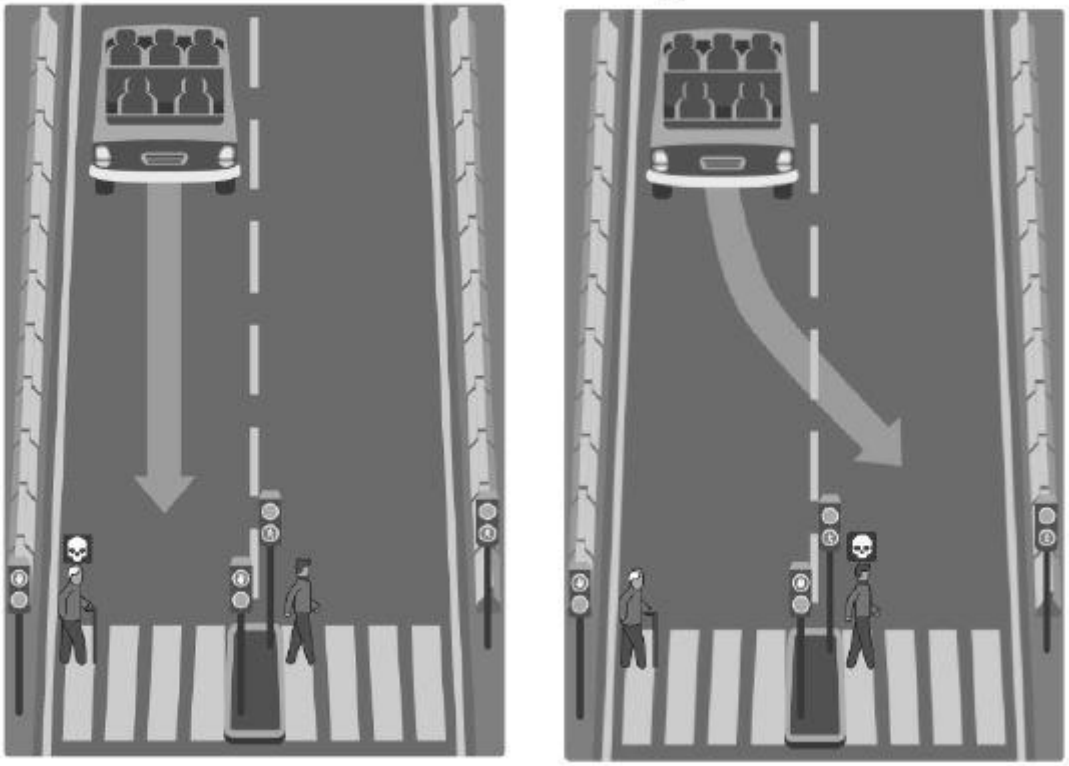
* 18. Hai mai sentito parlare della Moral Machine?

◯ Si

◯ No

* 19. Hai mai visto un'illustrazione come la seguente ?

What should the self-driving car do?



- Si
- No

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Percezione e Informazione su Veicoli Autonomi

Come reperisci informazioni sui Veicoli a Guida Autonoma?

* 20. Ritieni di essere aggiornato sul tema dei veicoli autonomi?

Assolutamente no				Assolutamente si
★	★	★	★	★

* 21. Sei d'accordo con le seguenti affermazioni?

	1 Estremamente in disaccordo	2	3	4	5 Estremamente d'accordo
Ho ricevuto informazioni sui veicoli autonomi dai mass media (TV, Quotidiani, Radio, Stampa di settore...)	○	○	○	○	○
Qualcuno tra i miei contatti social ha condiviso informazioni riguardo ai veicoli autonomi	○	○	○	○	○
Ho letto report e articoli sui veicoli autonomi consigliati sui social media	○	○	○	○	○
Ho cercato informazioni sui veicoli autonomi per conto mio	○	○	○	○	○
Ho affrontato il tema dei veicoli autonomi nell'ambito delle mie relazioni sociali (famiglia, amici, colleghi...)	○	○	○	○	○

* 22. Quali fra i seguenti canali informativi ritieni più importanti? Seleziona fino ad un massimo di tre elementi.

- [ ] Eventi
- [ ] Articoli di giornale
- [ ] Programmi televisivi
- [ ] Articoli su socialmedia e blog
- [ ] Giochi (videogiochi, quiz ...)

Altro

* 23. Sei d'accordo con le seguenti affermazioni?

	1 Estremamente in disaccordo	2	3	4	5 Estremamente d'accordo
Vorrei ricevere più informazioni sui veicoli autonomi	○	○	○	○	○
Vorrei che le autorità competenti (Ministero dei trasporti, case automobilistiche, produttori, ricercatori...) mi fornissero materiale informativo e linee guida affidabili sui veicoli autonomi	○	○	○	○	○
Vorrei che le autorità locali organizzassero eventi dimostrativi sui veicoli autonomi	○	○	○	○	○
Vorrei avere la possibilità di esprimere i miei dubbi e feedback sui veicoli autonomi	○	○	○	○	○
Vorrei avere la possibilità di porre le mie domande sui veicoli autonomi alle autorità competenti (Ministero dei trasporti, case automobilistiche, produttori, ricercatori...)	○	○	○	○	○
Mi fido dell'opinione degli esperti competenti sul tema dei veicoli autonomi	○	○	○	○	○

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Cosa ne pensi dei Veicoli a Guida Autonoma?

* 24. Prenderesti in considerazione l'utilizzo di un veicolo a guida autonoma?

Assolutamente no	Con scarsa probabilità	Non so	Con molta probabilità	Certamente
★	★	★	★	★

* 25. I veicoli a guida autonoma rappresentano la mobilità del futuro?

Estremamente in disaccordo				Estremamente d'accordo
★	★	★	★	★

* 26. Secondo te i veicoli a guida autonoma:

	1 Estremamente in disaccordo	2	3	4	5 Estremamente d'accordo
Ridurranno lo stress legato al viaggio	○	○	○	○	○
Aumenteranno il piacere di viaggiare	○	○	○	○	○
Ridurranno gli incidenti	○	○	○	○	○
Ridurranno la congestione del traffico	○	○	○	○	○
Ridurranno il tempo di viaggio	○	○	○	○	○
Ridurranno il consumo di energia e l'emissione di CO2	○	○	○	○	○
Ridurranno il piacere di guidare	○	○	○	○	○
Aumenteranno il rischio di attacchi informatici	○	○	○	○	○
Faciliteranno la mobilità delle persone	○	○	○	○	○
Aumenteranno la disoccupazione di autisti di professione (autista camion, autobus, tassisti, ecc)	○	○	○	○	○

* 27. Elenca, dal più rilevante al meno rilevante, i 5 benefici più importanti che i veicoli autonomi possono apportare alla società

1

2

3

4

5

* 28. Elenca, dal più rilevante al meno rilevante, i 5 maggiori ostacoli che ritieni esserci all'introduzione dei veicoli autonomi

1

2

3

4

5

* 29. Sei d'accordo con le seguenti affermazioni?

	1 Estremamente in disaccordo	2	3	4	5 Estremamente d'accordo
Considererò di acquistare un veicolo autonomo quando usciranno sul mercato					
Incoraggerò gli altri ad usare i veicoli autonomi					
Confido nel fatto che un veicolo autonomo possa guidare senza assistenza da parte mia					
Confido che i veicoli autonomi siano sicuri ed affidabili					
Mi fido più delle abilità di guida di un veicolo autonomo che di quelle di un conducente					
Mi fido più delle abilità di guida di un veicolo autonomo che delle mie					

* 30. Sei d'accordo con le seguenti affermazioni?

	1 Estremamente in disaccordo	2	3	4	5 estremamente d'accordo
La mia fiducia nei veicoli autonomi è influenzata dalla reputazione dei produttori in termini di affidabilità e sicurezza	○	○	○	○	○
La mia fiducia nei veicoli autonomi si basa sull'affidabilità della tecnologia	○	○	○	○	○
Se avessi un'idea chiara di come funziona un veicolo autonomo considererei di usarne uno	○	○	○	○	○
Attualmente proverei un veicolo autonomo se ne avessi la possibilità	○	○	○	○	○
Prenderò in considerazione l'acquisto di un veicolo autonomo se il prezzo sarà adeguato	○	○	○	○	○
Ho intenzione di utilizzare mezzi pubblici autonomi in futuro	○	○	○	○	○

* 31. Rispondi alle seguenti Domande

	Vero	Falso
Usare un veicolo autonomo sarebbe adeguato alle mie abitudini di guida	○	○
Usare un veicolo autonomo sarebbe frustrante	○	○
Usare un veicolo autonomo sarebbe difficile da imparare	○	○

32. Quali fra le seguenti alternative rispecchia maggiormente le tue attuali intenzioni?

- ○ Comprerò sicuramente un'auto a guida autonoma non appena sarà sul mercato
- ○ Comprerò un'auto a guida autonoma solo quando avrò la certezza sulla sua sicurezza
- ○ Comprerò un'auto a guida autonoma quando sarà disponibile sul mercato ad un prezzo accessibile
- ○ Non intendo comprare una auto a guida autonoma ma utilizzerò i servizi di trasporto basati su di essa
- ○ Valuterò se comprare un'auto a guida autonoma in base ai giudizi di chi l'ha già provata
- ○ Non intendo comprare nè utilizzare veicoli a guida autonoma

33. Sei d'accordo con le seguenti affermazioni?

	1 Estremamante in disaccordo	2	3	4	5 Estremamente d'accordo
Prima di comprare un veicolo autonomo vorrei provarne uno per qualche giorno	○	○	○	○	○
Prima di comprare un veicolo autonomo vorrei ricevere un training o frequentare un corso su come usare un veicolo autonomo	○	○	○	○	○

* 34. Sei d'accordo con le seguenti affermazioni?

	1 Estremamente in disaccordo	2	3	4	5 estremamente d'accordo
Credo che che usare un veicolo autonomo permetta di risparmiare	○	○	○	○	○
Le persone importanti per me pensano che sarebbe utile usare i veicoli autonomi	○	○	○	○	○

* 35. Sei d'accordo con le seguenti affermazioni?

	1 Estremamente in disaccordo	2	3	4	5 Estremamente d'accordo
La sicurezza di un veicolo autonomo potrebbe non rispettare le mie aspettative	○	○	○	○	○
Mi preoccupa che i veicoli autonomi non mi forniscano il livello di benessere che mi aspetto	○	○	○	○	○
Mi preoccupa che attacchi hacker o errori di sistema possano far perdere il controllo al veicolo autonomo	○	○	○	○	○
Il pericolo può essere causato da un uso sbagliato del veicolo autonomo da parte dell'utente	○	○	○	○	○
La probabilità di investire un pedone aumenta con i veicoli autonomi in circolazione	○	○	○	○	○
Le conseguenze legali di un incidente in cui sono coinvolti veicoli autonomi sono troppo incerte per me	○	○	○	○	○
Le scelte etiche in caso di incidente con veicolo autonomo mi preoccupano	○	○	○	○	○

* 36. Sei già entrato in contatto con un veicolo a guida autonoma?

○ Si

○ No

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Percezione e Informazione su Veicoli Autonomi

* 37. Con che tipologia di mezzo pensi sarà il tuo primo contatto con un veicolo a guida autonoma?

- Trasporto merci
- Trasporto pubblico della mia città
- Veicolo individuale
- Altro

CSV file with raw data and scores:

https://drive.google.com/drive/folders/1ZbivRTgnO4QffmG9a5Z9fDIFhqtykvPT?usp=sharing

APPENDIX II Table of AVs Focused Bibliography

N°	Authors	Title	Abstract – Summary of content	Year	Database	Key Words
1	G. Zhu, Y. Chen, J. Zheng,	Modelling the acceptance of fully autonomous vehicles: a media-based perception and adoption model	As the technology matures, fully autonomous vehicles (AVs) are on the corner. This calls for exploring the factors that might influence potential users' perception and acceptance of AVs. Limited existing studies related to acceptance modeling investigated the effects of media and human on fully AVs' beliefs. Hence, a media-based perception and adoption model (MPAM) is developed to investigate how information and opinion (from mass media and social media) affect human self-perception (including self-efficacy and subjective norms) and product value perception (including perceived usefulness and risks), which in turn drive users' adoption intention to private AVs and public AVs as well.	2020	Scopus	Fully autonomous vehicles; Social media; Mass media; Self-efficacy; Perceived risks; Innovation adoption
2	D Milakis, B. van Arem, B. van Wee ,	Policy and society related implications of automated driving: A review of literature and directions for future research	In this paper, the potential effects of automated driving that are relevant to policy and society are explored, findings discussed in literature about those effects are reviewed and areas for future research are identified. The structure of our review is based on the ripple effect concept, which represents the implications of automated vehicles at three different stages: first-order (traffic, travel cost, and travel choices), second-order (vehicle ownership and sharing, location choices and land use, and transport infrastructure), and third-order (energy consumption, air pollution, safety, social equity, economy, and public health).	2017	Google Scholar	Automated driving; First; Pol icy and societal implications; Ripple effect
3	D.J.Fagnant, K.Kockelman,	Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations	Autonomous vehicles (AVs) represent a potentially disruptive yet beneficial change to our transportation system. This new technology has the potential to impact vehicle safety, congestion, and travel behavior. All told, major social AV impacts in the form of crash savings, travel time reduction, fuel efficiency and parking benefits are estimated to approach $2000 to per year per AV, and may eventually approach nearly $4000 when comprehensive crash costs are accounted for. Yet barriers to implementation and mass-market penetration remain. Initial costs will likely be unaffordable. Licensing and testing standards in the U.S. are being developed at the state level, rather than nationally, which may lead to inconsistencies across states. Liability details remain undefined, security concerns linger, and without new privacy standards, a default lack of privacy for personal travel may become the norm. The impacts and interactions with other components of the transportation system, as well as implementation details, remain uncertain..	2015	Scopus	Vehicle automation; Autonomous vehicles; Cost-benefit analysis; Safety; Congestion; Market penetration
4	S.Li, P.C.Sui, J.Xiao, R.Chahine,	Policy formulation for highly automated vehicles: emerging	Highly automated vehicles (HAVs) generate the optimistic prospect of future smart mobility together with the disruptive influence of traditional policies. This paper analyzes the emerging importance and research frontiers in	2019	Google scholar	Autonomous driving; Highly automated vehicle; Safety;

		importance, research frontiers and insights	formulating HAV policies and presents insights gained from three major methods of dealing with uncertain, dynamic, and evolving transport problems. First, the formulation of HAV policy is important for at least three reasons: it may accelerate the development and control of potential uncertainties of HAV, balance technology innovations with traffic security, and provide a steady and efficient migration from human drivers to automated driving systems. Second, current research focuses mainly on the role of government, licensing and testing standards, certification, reliability, policy interventions, public health, legal challenges, and restrictive or supportive policies.			Security; Policy
5	L. Buckley, S.A. Kaye, A.K. Pradhan	A qualitative examination of drivers' responses to partially automated vehicles	There has been an increase of automated vehicle (AV) technologies in recent years. Using qualitative methods, this study explored drivers' responses to the experience of AVs centered on theoretical themes of trust, particularly around ability, helpfulness, and integrity as well as individual factors of identity, norms, and efficacy. Participants (n = 68, Mage = 43.2 years) first completed a 20-minute drive in an advanced high-fidelity driving simulator that simulated driving an AV with intermittent periods of manual vehicle control. Participants identified consideration of financial concerns and described a need to trust that the AV system worked as expected and that it would function similar to human drivers, including their speed management. They also identified trust with regard to potential benefits (helpfulness regarding mobility and secondary task performance). Hacking and privacy were identified integrity issues, although primarily privacy was not considered relevant to their behavior. The findings from participant interviews also revealed that individual difference constructs around identity (as an early technology adopter or 'car' person), social norms, and efficacy were important factors in their intentions to drive or own a fully AV. Finally the participants described emotive outcomes, relating to benefits of relaxing or reducing stress and use being fun and safe. Overall, these findings provide some insights into the way in which drivers' describe the benefits and potential concerns associated with emerging AV technologies.	2018	Google Scholar	Automated vehicle; Trust; Qualitative; Simulated drive
6	E.Fraedrich, D.Heinrichs, F.J.Bahamonde-Birke, R.Cyganski,	Autonomous driving, the built environment and policy implications	This article seeks to clarify how autonomous vehicles (AV) could affect urban planning and the built environment, to what extent these effects are compatible with municipalities' existing objectives, and what lessons can be drawn from that. Results show that respondents are rather skeptical about the compatibility of AV with existing transport and urban planning objectives, above all to strengthen non-motorized transportation and to promote public transportation. Particularly, automating private motorized travel appears not to match municipal planning perspectives. On the contrary, transport planners think that shared autonomous vehicles as a complement to public transport systems are more appropriate to support urban development strategies.	2018	Google scholar	Autonomous driving; Systemic analysis; Transportation planning; Transportation policy; Built environment

7	M.Baertoncello, D. Wee,	Ten ways autonomous driving could redefine the automotive world	The development of self-driving, or autonomous, vehicles is accelerating. Here's how they could affect consumers and companies. Autonomous vehicles (AVs) represent a major innovation for the automotive industry, but their potential impact with respect to timing, uptake, and penetration remains hazy. While high levels of uncertainty currently surround the issue, the ultimate role that AVs could play regarding the economy, mobility, and society as a whole could be profound. The widespread use of AVs could profoundly affect a variety of industry sectors. To explore these implications in depth, we focused on three time horizons of AV diffusion: before such vehicles are commercially available to individual buyers, when they are in the early stage of adoption, and when they become the primary means of transport (exhibit)	2015	Google scholar	
8	S. Nordhoff, B. Van Arem, R. Happee,	A conceptual Model to Explain, Predict and Improve User Acceptance of Driverless Vehicles	This paper presents a synthesis of existing empirical acceptance studies on automated driving and scientific literature on technology acceptance. The objective of the study was to study user acceptance of SAE Level 4 vehicles or driverless pod like vehicles without a steering wheel and pedals that operated within the constraints of dedicated infrastructure.. Addressing the multidimensional nature of acceptance, a conceptual model that integrates a holistic and comprehensive set of variables to explain, predict, and improve user acceptance of driverless vehicles was developed. The model linked two dominant models from the technology acceptance management literature, the unified theory of acceptance and use of technology and the pleasure-Arousal-dominance framework, with a number of external variables that were divided into system-specific, user, and contextual characteristics.	2016	Scopus	Driverless Vehicles; user Acceptance
9	A.M. Khan, A. Bacchus, S. Erwin.	Policy challenges of automation in driving	This paper contributes knowledge on technological forecasts regarding automation, policy challenges for each level of technology development and application context, and the essential instrument of cost-effectiveness for policy analysis which enables policy decisions on the automation systems to be assessed in a consistent and balanced manner. The cost of a system per vehicle is viewed against its effectiveness in meeting policy objectives of improving safety, efficiency, mobility, convenience and reducing environmental effects.	2012	Google scholar	Transportation policy; Safety; Automated driving; Driver assistant Cognitive vehicle; Autonomous driving
10	M. Lupi, A.Pratelli, A. Farina	Modelling and simulation of a new urban freight distribution system based on automatic van platooning and fixed split up locations	A new freight delivery system based on automated vans is presented. Vans travel in platoons, whose first vehicle is driven and the others are driverless, during large part of their delivery routes. Each platoon moves from the Urban Distribution Centre (UDC) to a dedicated location close to the city centre, where the platoon is split up. At the split up location, the driver gets off the first van and each van of the platoon, independently from the others, carries out the last part of its delivery route moving without any driver. Meanwhile, the driver moves to	2019	Scopus	Delivery routes; Freight deliveries; Large parts; Modelling and simulations; Number of vehicles; Transport

			another split up location or to the UDC, where a driver is needed. After completing their deliveries, vans return to the same split up location and gather again in a platoon; a driver accesses the first vehicle, then the platoon returns to the UDC.			systems; Urban distribution; Urban freight distribution
11	M. Làd, I. Herman, Z. Huràk,	Vehicular platooning experiments using autonomous slot cars	The paper reports on an affordable experimental platform for vehicular platooning. The experimental platoon consists of several autonomous slot cars (typical experiments take 5 to 20 slot cars), hence it fits into an indoor laboratory. Each car is equipped with an onboard controller and it can measure its own velocity, acceleration, and distances to its nearest neighbors. Furthermore, each car can communicate with other vehicles including the leader of the platoon. A convenient user interface allows to store, analyze and visualize the experimental data in Matlab. The platform can be used for demonstrating various decentralized and distributed control strategies for vehicular platoons, such as predecessor following, (a)symmetric bidirectional control or cooperative adaptive cruise control.	2017	Scopus	Distributed control; vehicular platoons; predecessor following; bidirectional control
12	M. Sciaccaluga, I. Delponte,	Investigation on human factors and key aspects involved in autonomous vehicles - AVs - acceptance: new instruments and perspectives	An analysis based on the demographic differences -such as age, gender, culture, personal experience- and abilities of the users can give a huge contribution to the matter; in the paper, an investigation and a possible application of new instruments and techniques is also provided. The aim is understanding if an innovative approach like gamification can help in collecting the new kind of data and in analyzing user fears, limits and needs. With the support of cognitive ergonomics principles to formulate new synergic solutions, it could be possible to create a virtuous circle composed of preventive profiling -understanding how people perceive the AVs and what they want from them- and targeted training -to grant the necessary knowledge everyone need through emotional involvement	2020	Scopus	Human factors; Autonomous vehicle; User behavior
13	M. König, L.Neumayr	Users' resistance towards radical innovations: The case of the self-driving car	In this paper we unpack and examine attitudes and potential barriers of end-users towards the self-driving car. We explore whether drivers have (mental) barriers and/or show resistance towards the self-driving car and, given such barriers and resistance are identified, investigate the main underlying reasons. Further, we suggest potential strategic implications for automotive companies and avenues to overcome, or at least mitigate, drivers' barriers. The paper contributes to a better understanding of end-users' opinions on radical innovations such as the self-driving car and strives to add value by linking scientific insights from both psychology as well as innovation literature. Only a limited number of studies so far have dealt with the potential barriers of users towards the self-driving car; therefore, it is our intent to provide first empirical evidence to trigger further research and foster a broader discussion on this relevant topic	2017	Scopus	Self-driving car; Radical innovation; End-user attitudes; Barriers; Resistance to change; Strategic implications;
14	Kyriakidis, M., Happee, R., de Winter, J.C.F.,	Public opinion on automated driving: results of an	This study investigated user acceptance, concerns, and willingness to buy partially, highly, and fully automated vehicles. By means of a 63-question Internet-based survey, we collected 5000 responses from 109 countries (40 countries with at least 25 respondents). We determined cross-national differences, and assessed	2015	Scopus	Driverless car; Questionnaire Personality traits;

		international questionnaire among 5000 respondents	correlations with personal variables, such as age, gender, and personality traits as measured with a short version of the Big Five Inventory.			Cross-national differences; Intent to purchase;
15	H. Hahnenwald	SWOT Analysis of the connected and automated driving ecosystem in Europe	Within the SCOUT Project, the state of the art of connected and automated driving in Europe has been investigated by the use of a 5-layer model1 to illustrate the complexity of automated and connected driving and the interaction between different areas of influence. These areas respectively layers are: 1. Technical Layer 2. Human factors Layer 3. Economics Layer 4. Legal Layer 5. Societal Layer. Within each layer, the vehicle, the driver and at least the environment influence each other and have to be considered by introducing automated and connected driving functions.	2018	H2020 Avenue Project: SCOUT	/
16	C. Hohenberger, M. Spörrle, I. M. Welpe,	How and Why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups	Current research on willingness to use automated cars indicates differences between men and women, with the latter group showing lower usage intentions. This study aims at providing a first explanation of this effect. Research from other fields suggests that affective reactions might be able to explain behavioral intentions and responses towards technology, and that these affects vary depending on age levels. Our results suggest that addressing anxiety-related responses towards automated cars (e.g., by providing safety-related information) and accentuating especially the pleasurable effects of automated cars (e.g., via advertising) reduce differences between men and women. Addressing the anxiety-related effects in order to reduce sex differences in usage intentions seems to be less relevant for older target groups, whereas promoting the pleasurable responses is equally important across age groups.	2016	Google scholar	Automated cars; Emotions; Age; Moderated mediation; Willingness to use; Gender
17	C. Hohenberger, M. Spörrle, I. M. Welpe	Not fearless, but self-enhanced: The effects of anxiety on the willingness to use autonomous cars depend on individual levels of self-enhancement	The aim of our study is to examine how positive cognitive evaluations, anxiety-related affects, and the interplay between these two factors influence the willingness to use autonomous cars. We argue that the negative effect of anxiety as well as the interplay of positive evaluations and anxiety within the technology adoption process are contingent on a so far neglected facet of individual motivations, which plays a major role when dealing with anxiety towards unknown, yet status-laden, objects: self-enhancement.	2017	Google scholar	Benefits; Anxiety; Human values; Self-enhancement; Technology adoption; Autonomous cars
18	E. C. Anania, S. Rice, N. W. Walters, M. Pierce, S. R. Winter, M. N. Milner,	The effects of positive and negative information on consumers' willingness to ride in a driverless vehicle	Objectives: As automation becomes more prevalent in the transportation industry, driverless vehicles are appearing more frequently in the news. However safe or efficient these vehicles are touted to be, media portrayal has the potential to dramatically affect consumer perceptions. Consumer perceptions will ultimately determine the success or failure of driverless vehicles, and potentially drive policy changes as driverless vehicles become more common. In the first study, results showed that individuals are more willing to ride in driverless vehicles after	2018	Google Scholar	Driverless vehicles; Public perceptions; Media portrayal

			hearing positive information about them, and less willing to ride after hearing negative information about the vehicles. In study two, our results were similar to those found in study one regarding information type and willingness to ride. Additionally, there was a main effect of nationality because Indians were significantly more willing to ride in driverless vehicles compared to Americans. This main effect of nationality was qualified by significant interactions between nationality and gender as well as nationality and information type.			
19	B.Brown, E.Laurier,	The trouble with autopilots: Assisted and autonomous driving on the social road	As self-driving cars have grown in sophistication and ability, they have been deployed on the road in both localised tests and as regular private vehicles. In this paper, we draw upon publicly available videos of autonomous and assisted driving (specifically the Tesla autopilot and Google self-driving car) to explore how their drivers and the drivers of other cars interact with, and make sense of, the actions of these cars. Our findings provide an early perspective on human interaction with new forms of driving involving assisted-car drivers, autonomous vehicles and other road users. The focus is on social interaction on the road, and how drivers communicate through, and interpret, the movement of cars. We provide suggestions toward increasing the transparency of autopilots' actions for both their driver and other drivers	2017	Scopus	Automobile interfaces; Social road,Autonomous cars; Hum an-robot-interaction; Interaction; Self-driving; Social road; Video analysis
20	T. Jiang, S. Petrovic, U. Ayyer, A.Tolani, S. Husain,	Self-Driving Cars: Disruptive or Incremental?	Are self-driving cars in our near future? In what ways do Google's self-driving car project disrupt the auto-industry? How are the auto manufacturers addressing this challenge? What suppliers will benefit from this technological revolution? Will the standards and regulations industries be ready? This paper aims to answer some of these questions and describe an overall state of the market for self-driving vehicles	2015	Berkeley edu.	/
21	D. M. Sanbonmatsu, D.L. Strayer, Z. Yu, F. Biondi, J.M. Cooper.	Cognitive underpinnings of beliefs and confidence in beliefs about fully automated vehicles	A study investigated the cognitive underpinnings of consumers' beliefs and confidence in their beliefs about fully automated vehicles. Following previous research, opinions about self-driving cars tended to be mixed. The most negative views were held by consumers who had the least knowledge of self-driving cars. Low trust in technology was also associated with more negative views. Although consumers were generally confident in their views of self-driving cars, many were uninformed about them. Consumers' confidence in their beliefs was more strongly correlated with perceived knowledge and general confidence than real expertise. Thus, consumers' confidence in their opinions about fully automated vehicles appears to be driven by cognitions that are largely superfluous. A mediation analysis suggests that general self-confidence influences judgmental confidence by affecting perceived judgment relevant knowledge. Participants' confidence in negative beliefs about fully automated vehicles suggests their opinions will not be easily influenced via persuasion	2018	Scopus	Automation, Underpinnings, self-driving cars, trust in technologies

22	E. Fraedrich, B. Lenz,	Societal and individual acceptance of autonomous driving. In Autonomous driving	What attitudes and expectations do (potential) future users, and the public at large, bring to the new technology of autonomous driving? Alongside the technical and legal areas of research, this question is moving into ever-greater focus. The emerging debates assume that a switch from conventional to autonomous driving might bring about clear changes for all road users. From these perspectives—individual users and society—the question of acceptance arises. To what extent are individuals ready to use fully-automated vehicles, and to what extent are we as a society prepared to accept a transport system with fully automated vehicles on the road?	2016	Google Scholar	Road User; Autonomous Vehicle; Online Comment; Negative Social Consequence; Autonomous Driving
23	J. De Freitas, S.E. Anthony, A. Censi, A.G. Alvarez	Doubting driverless dilemmas	The alarm has been raised on so-called 'driverless dilemmas', in which autonomous vehicles will need to make high-stakes ethical decisions on the road. We argue that these arguments are too contrived to be of practical use, are an inappropriate method for making decisions on issues of safety, and should not be used to inform engineering or policy	2020	/	Autonomous vehicles, driverless dilemmas, ethics
24	C. Lucifora, G.M. Grasso, P. Perconti, A. Plebe	Moral Dilemmas in self-driving cars	Autonomous driving systems promise important changes for future of transport, primarily through the reduction of road accidents. However, ethical concerns, in particular, two central issues, will be key to their successful development. First, situations of risk that involve inevitable harm to passengers and/or bystanders, in which some individuals must be sacrificed for the benefit of others. Secondly, and identification responsible parties and liabilities in the event of an accident. Our work addresses the first of these ethical problems. We are interested in investigating how humans respond to critical situations and what reactions they consider to be morally right or at least preferable to others.	2020	Google Scholar	Self-driving Cars; Trolley Problem; Moral Choices; Moral Responsibility; Virtual Reality
25	A. Talebian, M. Sabyasachee,	Predicting the adoption of connected autonomous vehicles: A new approach based on the theory of diffusion of innovation	On the grounds that individuals heavily rely on the information that they receive from their peers when evaluating adoption of a radical innovation, this paper proposes a new approach to forecast long-term adoption of connected autonomous vehicles (CAVs). The concept of resistance is employed to explain why individuals typically tend to defer the adoption of an innovation. We assume that there exists a social network among individuals through which they communicate based on certain frequencies. In addition, individuals can be subject to media advertisement based on certain frequencies. An individual's perceptions are dynamic and change over time as the individual is exposed to advertisement and communicates with satisfied and dissatisfied adopters.	2018	Google scholar	Connected autonomous vehicles; Social network; Diffusion of innovations; Agent-based modelling; Simulation; Adoption