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SUSTAINABILITY IN THE AUTOMOTIVE SECTOR

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Inhalt

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SUSTAINABILITY IN THE AUTOMOTIVE SECTOR

The Social Recognition System

Improving Compliance by Integrity

Tim Kleinsorge, Fabian Kussmann and Matthias Walter

Keywords

Compliance, Moral-based Corporate Culture, Integrity, Pro-social Norms, Social Recognition System

Today, compliance standards are necessary for preventing behaviour that is both morally wrong and dysfunctional for the organisation as a whole. Following new evidence from psychological and organisational studies, this paper shows that compliance frameworks fail in providing a value-based corporate culture. In comparison to compliance, individual integrity is a much stronger driver for moral behaviour and thus for corporate culture. Corporate culture can be best triggered through effective pro-social norms, such as gratitude and trust. To foster these attitudes, we suggest implementing Social Recognition Systems (SRS). Typically, they are online-based platforms that allow participants to grant each other non-monetary rewards. Using Daimler as an example of a multinational company, we shall demonstrate how SRS can foster integrity and mutual social interaction within an organization, along with general productivity and performance.

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1. Introduction

What do effective compliance programs look like? This is a central question which arises theoretically and practically within today's management science and business ethics. Compliance is an issue in day-to-day business. Worldwide, firmsare challenged to avoid unethical and illegal corporate conduct. To have compliance programs is a minimum requirement of the law in most countries. Moreover, it is promoted for economic benefits such as reducing the risks of individual criminal behaviour which damages organisations.

Effective compliance programs have several advantages. The most economically significant advantage is the avoidance of financial losses, in terms of criminal prosecution costs caused by attendant prosecutions, private civil litigations and escalating fines, which interrupt daily operations (cf. Stucke 2013: 776). Moreover, firms have reasons for promoting moral behaviour within their organisations, as it allows for strategic competitive advantages and avoids competitive disadvantages. It also has internal organisational advantages, such as increasing the significance of employee tasks, well-being and motivation, which is important for maintaining productivity and profitability. The question is not whether we need compliance programs at all, but rather how an organisation can design such programs in order to promote and maintain moral behaviour, both effectively and in a sustainable way (cf. ibid.: 777).

Many firms have reacted to the challenge of containing unethical and illegal conduct. Over the last ten years, larger economic crimes with legal consequences and financial losses have run into the hundreds of millions, and many companies have undertaken essential steps towards more effective and sophisticated compliance systems. However, despite these efforts, most firms still struggle to achieve their own ethical benchmarks within their compliance programs. Some even have problems meeting the requirements defined by the law (cf. ibid.: 787 ff.). Hence, how compliance should work differs from the reality of compliance programs. Immoral and illegal corporate conduct is still pervasive (cf. ibid.: 782 ff.) In light of these persistent issues, we have serious reasons for rethinking standard compliance and opening a more general debate, questioning some of the main assumptions behind the conventional doctrines.

For this purpose, we will start by clarifying how standard compliance is usually presented and why it is being stretched to its limits. We have concluded that current compliance programs underperform, because they are overwhelmingly derived from what concept professionals call the "command-and-control" and "check-the-box" approaches. In light of recent empirical findings and behavioural studies in business ethics, it is obvious that the key to effective compliance is not deterrence, surveillance and prescriptions which come from the top. "[C]ulture is more than rule books determine how organisations [should] behave" as Warren Buffet states (cited by Killingsworth 2012: 961). Hence compliance can only function if it is flanked and complemented by a moral-based corporate culture, evolving from the bottom up. To be more precise, we counter standard compliance by using a moral-based culture that is mainly driven by personal integrity and pro-social norms, such as trust and gratitude, relying on the values the employees themselves bring to work day by day.

For the purpose of not only delivering a sounding theoretical framework behind more effective compliance, this paper also contains a practical part, tackling the question of how to implement and channel such a moral-based culture in concrete terms. In doing so, we will consider the example of Daimler AG, one of the world's biggest automotive companies. After paying financial penalties in the United States in 2010 totalling $130 million, due to corruption scandals from weak compliance, Daimler AG has significantly upgraded its compliance infrastructure. Now, the company belongs to top companies in Germany (cf. Hohmann-Dennhart 2014). However, even for Daimler AG, there is still room for improvement, since illegal conduct in the automotive industry remains, in general, pervasive, according to a recent PWC study.[1]

In order to improve the effectiveness of current compliance programs, we suggest establishing a Social Recognition System (SRS) as a management tool. Already successfully tested by companies in the U.S., an SRS is an online-based platform which allows employees to award each other for doing the right things. If deliberately modified to fit the special requirements of Daimler AG, we finally want to make plausible that the SRS can be an essential step towards the management vision of compliance, functioning on the grounds of integrity.

1 The PWC study revealed that – despite a shrinking tendency – 18% of all surveyed automotive companies study still suffer from corruption in at least one clear incident. 11% are still concerned with antitrust crimes, 9% suffer from corporate espionage. However, 39% expected a much higher number of cases. Last but not least, the PWC study identified the direct cost of white-collar crimes as running into millions. White-collar crimes, such as offences against property, corruption and violations of patents of trademarks, can cause indirect costs in terms of a damaged corporate reputation (cf. PWC 2014).

2. Rethinking Compliance

2.1 Compliance and its Limits

Many firms, both big and small, relate compliance to the so-called "command-and-control" approach (cf. Killingsworth 2012: 966). In general, command-and-control refers to compliance programs that use codes, policies, training materials, and procedures that aim to govern employee behaviour mainly by concrete external incentives and punishment. In doing so, firms create documents which explain rules and lay out specific processes for compliance. Moreover, they educate and instruct their employees on compliance requirements and establish built-in monitoring or auditing processes. In the end, command-and-control can be broken down to the simple message: follow the rules we teach you or pay the penalty. Or, in the words of Scott Killingsworth, a compliance professional

> "The command-and-control approach is based on the assumption that workers will behave like the "rational actors" of economic theory: they will weigh the costs and benefits of compliance versus rule-breaking and make a rational, self-interested decision to avoid the risk of punishment. The greater the emphasis on monitoring, detection, and punishment, the more this assumption rises to surface" (Killingsworth 2012: 966 f.).

Ultimately, the command-and-control approach implies that pursuing self-interest in terms of avoiding punishment is the right thing to do. For an employee, the question of right behaviour is simply reduced to the question of anticipating personal risks and rewards. As a result, misconduct is invited. If ethical behaviour only highlights monetary rewards and economic goals, employees will gamble it will work out. Moreover, framing ethical behaviour as an economic transaction can lead to view that ethical behaviour has a certain price (cf. Stucke 2013: 816). One implication could be that incentives are not relevant to compliance at all. This conclusion is in fact false. Incentives within compliance programs are important because people respond to them, to positive as well as to negative incentives, especially if the punishments or rewards are strong. The deciding point is that incentives send messages – messages which may have a greater impact than the incentive itself. What is really at stake here is the threat of a 'crowding out' effect, whereby the incentive's message displaces a competing social expectation or ethical norm (cf. Killingswoth 2012: 967). In particular, external work incentives can crowd out intrinsic motivation. As a result, compliance can be counter-productive in terms of motivation, when compliance guidelines are framed as mutual agreements between employees and the management board. Generally, these mutual agreements are in fact top-down approaches and involve only partial involvement of the employees. keeping just the hypocritical illusion alive that there is a consensus. Subsequently, employees can see such consensus as warning signal from the top, and revolt against these programs. Although compliance standards can be considered in open and ongoing debates with the employees, they miss out the aspect of moral commitment (cf. Paine 1994: 110 ff.). Lynn Paine determined that "even in the best case compliance is unable to unleash moral imagination and commitment and the law does not inspire humans to excellence" (ibid.: 111).

Besides criticism arising from overemphasising the aspect of control and initiating a negative crowding out of intrinsic motivation for doing the right thing, legal insights and statistics can be outlined which show how compliance cannot always ensure ethical behaviour. In 1991, the Federal Court of the United States promoted the Sentencing Commission's Organizational Guidelines for strong financial incentives to have effective ethics and compliance programs. While not bound to apply the guidelines, the Federal Court must take them into account when sentencing organisations for felony or erratic behaviour. In last 15 years, the number of corporations that have been sentenced under the Guidelines fluctuated yearly between 130 and 304.

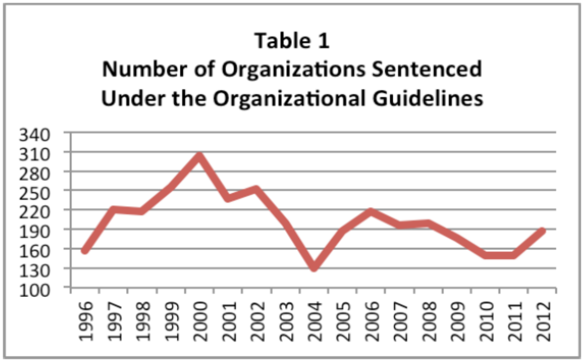

FIGURE 1: NUMBER OF ORGANISATIONS SENTENCED UNDER THE GUIDELINES (CF. STUCKE 2013: 782)

This indicates that corporate crime did not ease. If corporations had been fined, only 0.0873% of them would have been considered to have an effective compliance program. Furthermore, between 1996 and 2012, only three times did the court reduce the corporation's culpability due to their having an effective ethics program (cf. Stucke 2013: 783). Thus, the question arises as to why there are so few effective programs. One explanation is that firms with effective compliance programs are more likely to avoid criminal prosecution. In contrast to this is the that if a corporation had a working compliance program, the corporation would not have been found guilty, due to such an effective compliance program. Nevertheless, this does not explain the small number of corporations with effective compliance programs. One major reason for so few effective compliance programs is that many corporations aim at only minimum requirements. The compliance industry itself complains about ineffective, check-the-box compliance:

> "In short, the management of to many companies aim for what they perceive as minimum required when it comes to compliance/ethics- in the essence, they aim for the bottom. A major flat thinking is that- quiet apart from the question of what good corporate citizens should be doing on their own without the treat of enforcement" (Stucke 2013: 788).

Even although this data only represents the situation in the United States and cannot be taken as globally representative, they indicate that the current compliance mechanism does not deliver what it is supposed to. Against this backdrop, it could be argued that we need to replace existing compliance programs. As argued before, more compliance is automatically bound to more command-and-control, including more monitoring which is ineffective and crowds out intrinsic motivation.

The core issue remains: ethical norms cannot be dictated from the management board through top-down mechanisms. Summarising the criticism from discussion about command-and-control and remarks on legal evidence, we conclude that compliance has its limits and should be complemented. In fact, this gives rise to the question of how we can ensure right ethical behaviour. Here, we see the demand of a moral-based corporate culture that takes into account the values and integrity of the employees.

2.2 *The Demand for a Moral-based Corporate Culture*

> "Culture, more than rule books, determines how an organization behaves."Warren Buffet (cited by Killingsworth 2012: 961)

In evaluating the command-and-control approach, we have concluded that a pure rule system fails to make a difference in organisational behaviour. Carefully defined rules are necessary, but useless if an organisation fails to effectively motivate people to stay within these boundaries (cf. Stucke 2013: 799). The challenge arises when defining how human beahviour and organisational behaviour is *really* determined and driven. Here, behavioural findings, empirical work and studies in business ethics (cf. Palanski et al. 2011) from the last 30 years, not to mention Warren Buffett, a very successful investor, give us one central answer: in the end, it is an organisation's 'moral culture' that leads an organisation towards better moral and functional results. In order to approach moral-based corporate culture more systematically, we should first define 'corporate culture', then 'moral-based corporate culture'.

According to the 'soft' definition, culture is "the set of enduring and underlying assumptions and norms that determine how things are actually done in organization" (cf. Killingsworth 2012: 965). If a culture wants to be coherent, it needs to be based on shared values and beliefs, as well as on the proof that those values and beliefs are shared and that they shape behaviour across the organisation. However, the 'soft' definition is not very helpful when we aim to understand how a culture's "enduring assumptions and norms" can be instilled and modified. In other words, it is not a good starting point for explaining cultural change. Dan Sperber has provided a more precise and functional definition, saying that culture is the summed effect of communications within a group over history, the 'precipitate of cognition and communication in a human population'(Sperber 1996: 32). Culture is predominantly about communication. With regard to cultural change, we then conclude that, in principle, change happens in two ways: firstly, cultural change happens if someone within the organisation makes an idea or other mental representation public, meaning by communication. Secondly, cultural change happens if external experience, message, or communication is internalised. Keeping this perception of culture in mind, we end up with the understanding that organisational behaviour is finally communication via countless individual interactions and messages. On the one hand, communication is the mean by which group's instantiate ideas, norms, and beliefs in individuals. On the other hand, communication is the mean by which individuals change a culture. Finally, a group of people shares a culture in accordance to the extent they internalise the same messages that are beliefs, values, ideologies, aesthetics, symbols and stories (cf. Sperber 1996: 1 ff.).

Having defined corporate culture as the sum of communication of individuals, we shall focus on clarifying our conception of a 'moral corporate culture'. While the term 'moral' in philosophical debate is rather broad than narrow, 'moral' has to be seen as an applicable tool. Thus, a moral-based corporate culture is "maintained through a complex interplay and alignment of formal [i.e., policies, leadership, authority structures, reward systems, training programs] and informal organizational systems [i.e., peer behaviour and ethical norms]" (Schwarz 2012: 2). A moral-based corporate culture can lead to expected moral behaviour over two basic mechanisms. Firstly, there is the possibility to act in accordance to the firm's moral behaviour through socialisation, as employees feel expected to behave to a particular norm. Obviously, this works through the mechanism of compliance, which is necessary but, as we have shown, has limits. Secondly, moral behaviour occurs then through internalising values, by adopting moral norms as their own (cf. ibid.). This is a much stronger driver for ensuring a moral-based corporate culture, since moral norms are strongly influenced by the values and beliefs of the employees themselves. In conclusion,

> "a person's behaviour in a given situation is not influenced solely by communications that explicitly address the situation, such as workplace rules, policies, and procedures. Our decisions are also influenced by values and beliefs that we bring to work, by a broad range of incentives, disincentives, and internal and social motivations, and by cues in the work environment that 'nudge' our behaviour in one direction or another" (Killingsworth 2012: 962).

The question is not if morals are relevant for corporate culture in general, but how to internalise values within the informal system of a company most effectively. To answer this, we refer to Tom Tyler and his colleagues, who have investigated compliance in the workplace over two large-scale studies (cf. Tyler et al.: 2008; Tyler/Blader 2005). According to these studies, over eighty per cent of compliance choices were motivated by internal perceptions of the legitimacy of the employer's authority and by a sense of right and wrong. Less than twenty per cent of compliance choices were motivated by fear of punishment or expectation of reward (cf. Killingsworth 2012: 969). This implies that the employee's motivation to make the right decision is more derived from internalised moral values than by external factors of command-and-control, such as monitoring and the possibility of detection, rewards, and punishments. Employees are intrinsically motivated to do things for their own sake, because they are inherently enjoyable or satisfying. Employees fulfil a duty because they really believe in it and advance a goal because they really want to achieve behaving in accordance with values that are important to them. The ideal is to achieve 'voluntary compliance' in an ethical corporate culture that primarily relies on the internalised moral and the intrinsic motivation of its employees.

However, internalising the moral of employees is challenging if these values are not consistent. For this reason, internalised morals only go with the concept of "personal integrity". In following, we will outline what is meant by personal integrity. Afterwards, we will investigate whether personal integrity is embedded in a complex interplay of pro-social norms, such as gratitude and trustworthiness.

2.3 Personal Integrity, Trust and Gratitude

The term 'integrity' was first introduced by the virtue philosopher Aristotle. Many thinkers within business ethics still refer to integrity as an important part for authentic moral performance. In general terms, integrity appears as virtue within moral philosophy, referring to "the consistency of an acting entity's words and actions" (Palanski/Yammarino 2007: 17). In more concrete terms, by having a special emphasis on the individual level, integrity is present if there is an alignment between words and deeds in the perceived behaviour patterns of an actor.

Peter French has provided a more precise explanation of personal integrity by detecting the lack of integrity in people's behaviour. He identifies four types of people who lack integrity. Firstly, there are 'the moral chameleons', who are quick to change or abide to previous moral statements. Moral chameleons have no core set of values and are linked to social pressure. There is no dependency on them, simply because they have no moral compass. Secondly, there are the opportunists. The opportunist's values are fluid as the chameleons. However, the motive for shifting values here differs. While the chameleons will shift their values since they have none, the opportunists vary their behaviour if they believe that this will lead to a personal gain or advantage. Thirdly, there are the hypocrites. Hypocrites are characterised by having a displacement of values for public affairs and a hidden set of values and the motivations behind them, which actually drive them. They pretend to be committed to a particular set of values, but in reality, they only pursue their real intentions. The fourth type of integrity failure are self-deceivers. Self-deceivers are confronted with a discrepancy between the values according to which they like to act and the actual behaviour they adopt. Their actions differ from their desires. Resolving this tension, self-deceivers emulate an idealised self-conception as justification for pursuing opposing actions to their desires (cf. French 1996: 42 ff.).

To define personal integrity negatively by referring to French's elaboration of the lack of integrity is a useful basis, but not sufficient for understanding the concept deeply. For this purpose, we have to point out that personal integrity is a holistic idea. As such, integrity cannot be thought of without regarding the integrity of an overall group as well as other so-called pro-social norms like trustworthiness, gratitude and honesty. Following recent insights, there is a distinction between the integrity of individual team members and the integrity of the overall team, whereby group level integrity and personal integrity influence and modify each other mutually (cf. Palanski et al. 2011). In order to understand personal integrity, we have to understand the interpersonal relationships of the peer-group shaping personal integrity. Ultimately, interpersonal relationships between the individuals and their peer-groups can be regarded as the 'roads' along which integrity prospers. For the purpose of integrity, the underlying interpersonal relationships must aim to reach two particular consistencies, namely a consistency of espoused and enacted values and a consistency between promises made and kept. Returning to the business organisation as the realm at stake, there are several approaches to how these consistencies can be achieved, such as 'team transparency' leading to 'behaviour integrity', subsequently to 'team trust' and then to 'team performance' (cf. Palanski et al. 2011: 209). However, we want to focus on the idea of achieving integrity by pro-social norms, as they influence our daily lives significantly. In order to break down the wide range of pro-social norms, we will focus on trustworthiness and gratitude as essential parts for building and strengthening interpersonal relationships. Countless scholars have emphasised the importance of general trust within society, personal relationships and cooperation (cf. Luhmann 1973; Cook 2005). Sustaining trust within cooperation is problematic if either party exploits it for egoistic gains. As a consequence, both or one party often withholds trust, in order not to be exploited. Without trust, cooperation can never get off the ground. Without trustworthiness, potential gains from cooperation can never be realised. Trust and trustworthiness is crucial for interpersonal relations (cf. Harrell et al. 2013: 1531). The literature has highlighted the importance of gratitude. For Cicero, gratitude is "not the best, but the parent of all other virtues" (Cicero 1851: 139). Empirical insights emphasise that gratitude is a powerful component of reciprocity and encouragement. In particular, gratitude is key in building and nurturing social relationships, as well as for the purpose of overcoming the commitment problem, which describes the fear of engaging of investing into a relationship without any return. Trustworthiness and gratitude are thus examples of the importance of pro-social norms and their essential components in building up interpersonal relationships.

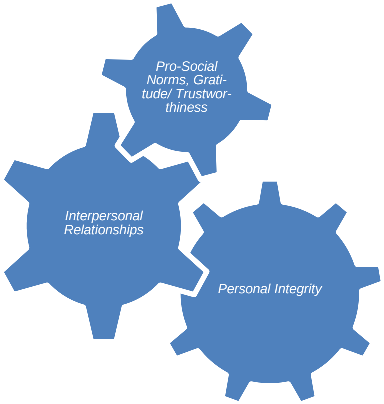

FIGURE 2: INTERPLAY OF PRO-SOCIAL NORMS AND INTEGRITY (SOURCE: OWN ILLUSTRATION)

Without pro-social norms like gratitude and trustworthiness, there can be no group integrity and no personal integrity. Likewise, without personal integrity, there can be no group integrity, trustworthiness or gratitude. Thus, strengthening and stabilising the employees interpersonal relationships on the grounds of trustworthiness and gratitude is an essential target for every corporation that aims to achieve voluntary compliance by integrity. Against this backdrop, we have to turn to the question of how to effectively foster these two approaches and further pro-social norms, such as mutual recognition, honesty and enthusiasm.

2.4 *Framing Integrity by Trust and Gratitude*

Over the course of empirical work during the last 30 years, behavioural scientists have pointed out that human decision-making is affected by something they call the 'framing effect'. Framing means that people react to a particular choice in different ways, depending on how it is presented (cf. Kahnemann 2011). How framing works can easily be shown by considering Prisoner's Dilemma games, which are about making a decision with two players, either cooperating or going it alone, without knowing what the other player will do. Here, we can simply double the cooperation rates by framing, in the sense that we change the name of the game from the 'Wall Street Game' to 'The Community Game'. For each player, the name 'Wall Street' functions as a first cue that the appropriate response to a situation is the competitive pursuit of self-interest, whereas 'Community' signals that the game is about achieving the best total outcome for the participants.[2] In the context of compliance and ethics programs, the framing effect can be utilised to promote personal integrity. The challenge is to frame integrity by using pro-social norms that function as effective cue signals and 'nudges'. Coined by Richard Thaler and Cass Sunstein, the term 'nudge' refers to the empirical insight that human decision-making is not fully rational and influenced by the its context (decision architecture). Hence, nudging is about influencing human decisions by influencing the factors of the particular context behind these decisions (cf. Thaler/Sunstein 2009). In doing so, pro-social norms like gratitude and trust need to be set in the right light to be activated.

2.5 *The Demand for a Social Recognition System*

We started off by analysing the current status quo of compliance programs, which is insufficient for promoting moral behaviour and prohibiting criminal conduct. Compliance mechanisms are mostly based on the command-and-control approach, that crowds out intrinsic motivation. We demanded a moral-based corporate culture, which focuses on internalising the values of the employees related to their personal integrity. Subsequently, we defined personal integrity as being

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2 The framing effect was investigated by Amon Tversky and Daniel Kahnemann. In one of their experiments, they asked participants to choose between two treatments for 600 people affected by a deadly disease. Treatment A was framed positively ("saves 200 lives") whereas Treatment B was framed negatively ("400 people will die"). As a result, despite delivering the same outcome, 72% chose Treatment A, whereas only 22% chose Treatment B. (cf. Kahnemann 2011).

coherent in words and deeds. Coherency can only be seen in the connection to other pro-social norms, such as gratitude and trustworthiness. In order to foster pro-social norms, we emphasise framing them in the right way.

3. Daimler and the Social Recognition System

3.1 Integrity and Compliance at Daimler

Having shown in the previous chapters that compliance has it limits and has to be complemented through a moral-based corporate culture that builds on the integrity of every employee, we are now faced with the establishment of our conception in practical terms. As a result, we want to implement a Social Recognition System (SRS), which enables employees to reward each other for pro-social behaviour and mutual cooperation. Before exemplifying how such a system would be composed, we will start our investigation with a brief look at the current situation at Daimler and sort out the challenges and demands for an SRS.

As mentioned before, Daimler is an international corporation which produces worldwide, with over 280,000 employees. Against this backdrop, ensuring correct moral behaviour by strict compliance is challenging, if not impossible. The immediate face-to-face control of moral behaviour can only be done with enormous cost. A dense network of costly surveillance institutions, a high inclination towards whistleblowing, and a large amount of work time spent to ensure compliance would be the prevalent requirements for making individual control possible. Daimler has experienced this challenge with compliance in the past ten years. As a result, legal requirements and the claim "the best or nothing" as an expression of a high commitment to performance in every company-related issue have led to vast developments in the field of compliance. During the first compliance endeavour in 2006, Daimler became one of the leading companies, establishing themselves as having a 'gold standard' in compliance. But it is not only within the field of compliance that Daimler set benchmarks. The general principle "together we want to give our best, deliver the best and be the best – in every way" (Daimler 2011: 6) has influenced Daimler's efforts in integrity. Daimler's managing committee of compliance and integrity is called 'Integrity and Law', and several integrity-related projects (such as the worldwide integrity dialog of 2011) have been launched. However, integrity-based approaches are relatively new at Daimler, and in general underrepresented.

The general idea of an SRS is based on an award mechanism promoting pro-social behaviour. As shown, pro-social norms such as gratitude and trustworthiness play a crucial role in interpersonal relationships, which are strongly connected to personal integrity. An SRS takes this into account and enables employees to reward positive pro-social behaviour through online-based platforms. In fact, the SRS is purely based on the wish for appreciation and social recognition by others. It does not rely on coercion and deterrence elements, as standard compliance used to do. Instead, the idea is to create a positive feedback mechanism between employees. The awarded person, in turn, feels confirmed and even more motivated to continue with their behaviour. As a result, if an award mechanism is repeated in the loop in the course of time, it can stabilise and catalyse pro-social behaviours within an organisation.

With regard to the concrete mode of operation, the SRS is designed in a way that all Daimler employees have the opportunity to register voluntarily for the system on an online platform. By the means of a virtual profile of their person, they can both reward others and be rewarded by others. Depending for which and how often a single employee is rewarded, he or she gets a special amount of SRS points, which are collected in her or his online account. After a certain amount of SRS points is collected, the employee can change the SRS points into certain gifts or services, defined and provided by the company. However, in order to avoid a destructive economic framing of moral behaviour and thus a negative crowding out effect of intrinsic motivation, the provided gifts and services are provided in a way that they imply only small material benefits. Instead, the idea of the SRS is to motivate employees to do the right thing for non-material motives, derived from their personal integrity and their desire to be recognised socially. For the management board, the SRS system can be seen as a more effective monitoring that creates transparency and a lot of useful data. If every reward is saved in a database and can be seen publicly, the management board gains insights about the moral and spirit on the employee's level, by quantifying who is rewarded for what. As a consequence, managers can harmonise their internal policies and thus increase the likelihood of a coherent ethical culture that, in turn, shows compliance. In the United States, SRS solutions have gained popularity steadily, and there are already enterprises that supply SRS online platforms. The most well-known ones are Bonusly©, Kudos© and YouEarnedIt©.[3] If we turn to

3 Kudos©: http://kudosnow.com/; YouEarnedIt©: http://youearnedit.com/; Bonusly©: https://bonus.ly/-peer-to-peer-recognition-program.

their customers, not only small firms but also transnational companies are concerned. These include Oracle, one of the biggest software companies worldwide.[4]

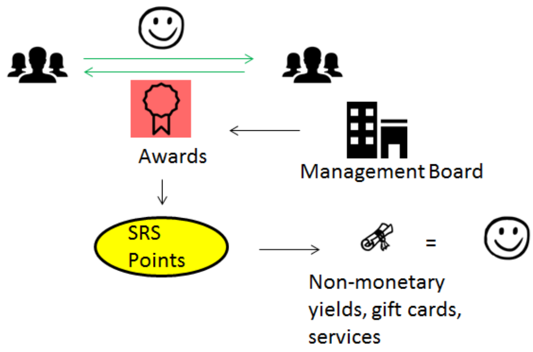

FIGURE 3: ILLUSTRATION OF THE SRS (SOURCE: OWN ILLUSTRATION)

3.3 Awards

Awards play an essential role in the SRS and for an ethical corporate culture. Peter Drucker has outlined:

> "[C]hanging habits and behavior requires changing recognitions and rewards [and awards] People in organizations, we have known for a century, tend to act in response of being recognized and rewarded — everything else is preaching. . .. The moment they realize that the organization rewards for the right behavior they will accept it" (Peter Drucker 1991, cited by Murphy 2011: 17).

It is advisable to explain the importance of awards in more detail. In general terms, an award can be defined as a symbolic gratification with positive feedback and social recognition, both provided by colleagues or senior staff (cf. Neckermann/Frey 2012: 3). It can be seen as an expressive act or signal that indicates what the rewarding institution or person regards as valuable behaviour. Whether an award changes a person's behaviour depends on certain conditions. The effects of

4 Oracle is listed as a customer of bonus.ly: https://bonus.ly/resources (accessed 07/2015).

rewards are a priori ambivalent. On the one hand, they could be of no effect at all, or even diminish the awarded individual's performance. On the other hand, awards can provide positive incentives with a high impact if things are done in the right way. They can be the reason for increased identification with a firm or enhance the core performance of an employee. This can be explained with the image concerns of the recipient, as well as effects caused by peer interaction or mood changes (cf. ibid. 2012: 7).

Ultimately, awards offer several advantages. Firstly, they are more advantageous than rewards because they are cheaper, since awards have a symbolic meaning and consist of little material value and even only virtual exist, like in the SRS (cf. Frey/Neckermann 2006: 4 ff.). More importantly, awards trigger intrinsic motivation, because they do not invoke the recipient's feeling of being under performance control. Likewise, awards do not diminish self-esteem and self-determination, which otherwise would cause negative effects in terms of intrinsic motivation. Instead, the awarded action receiving social valuation can be interpreted as social appreciation for the agent (cf. ibid. 2006: 7 ff.).

Giving and receiving awards involves a mechanism of reciprocity. Fehr and Frey provide evidence that the urge to avoid social disapproval and to reciprocate shape human behaviour, even in the absence of pecuniary motives (cf. Fehr/Falk 2002: 2). Awards clearly draw on this deeply entrenched human inclination. They serve as the foundation of binding social relations, as the awarded person identifies with the person, society and company that awarded them. The recipient often encounters a strengthened feeling of loyalty and commitment towards the awarding person or institution (cf. Frey/Neckermann 2006: 5). The awarding person or institution also takes responsibility by signalling to fellow colleagues that they think the awarded person is sufficiently qualified for the criteria of the award. This mechanism gives way to voluntary cooperation among a social collective.

Moreover, it is not obligatory to connect core job performance and awards in a direct way (cf. ibid. 2006: 6). Awards can be used to decorate someone for achievements outside their core working rules or environment. This allows for the design and use of awards with regard to tasks that are hard to measure, quantify and monitor. Nevertheless, awards for tasks outside the core job performance must not be ends in themselves. There is empirical evidence that awards can produce a spillover effect, albeit mostly only short term, by enhancing key job performance (cf. Neckermann/Frey 2012: 15). These characteristics render the application of awards in an SRS extremely attractive.

Having outlined the attractiveness of awards, the question of the most effective implementation of awards arises. Frey provides an answer by proposing three conditions for the effective employment of awards in sophisticated construction. Firstly, he holds that employees must be granted equal opportunity to attain an award. This in turn requires the construction of a system enabling the greatest possible number of employees to nominate their colleagues for awards. Secondly, it must guarantee a close connection between effort and probability to be nominated. A transparent communication of the criteria that qualify for the award is thus essential. Thirdly, awards must be a scarce good to denote a certain positional value to the recipient (cf. ibid. 2012: 15 ff.).

3.4 The Implementation of SRS at Daimler

Having outlined the general idea of an SRS and the importance of awards, we will now outline how an SRS could be implemented in practical terms within Daimler. We are faced with two crucial questions: how can awards be designed properly to full fill their purpose, and how can awards be related to the core values of Daimler as strengthening their integrity efforts? After clarifying potential awards, we propose potential gains from receiving these awards and further challenges of the implementation.

To account for Frey's conditions of 'equal opportunity', 'close connection' and 'clear communication', we worked out seven different and transparent awards. These awards represent values in accordance with Daimler's 'Code of Integrity' So, they are an essential part of their corporate culture. In 2011, Daimler launched this on-going integrity initiative, which covered all areas and hierarchical levels of the corporation. As a result of intensive discussion of management and employees, this code is based on shared values (cf. Daimler 2011: 3). Secure that the Code of Integrity represents Daimler's core values, we took our awards from the employee award system of the Harvard Law School

The Daimler Mindset Award

This general award relates to those who promote Daimler's four core values: enthusiasm, discipline, appreciation and integrity through actions of good spirit**.** This entails respect, mutual appreciation and the development of a high level of commitment, motivation and team spirit (cf. ibid. 2011: 12). This award category is for an individual who fosters the Daimler community by building bridges for individuals or groups to come together for intellectual or social connections within the corporation.

Commendable Colleagueship Award

In particular, this award regards the dedication someone has for their fellow teammates, expressed through outstanding performance of team spirit, collegiality and thoughtfulness. The category is for an individual who positively influences others in working towards particular objectives or goals, actively participates in fostering others, invests time and efforts beyond the duty or coaching, or mentoring or teaching others, thereby serving as a role model that positively influences others.

The Best or Nothing Award

Related to Gottlieb Daimler's claim, this award refers to the claim for brilliant knowledge, abilities, ideas and propositions in pursuing the success of the corporation (cf. ibid. 2011: 12). Transforming complex problems into creative solutions, being innovative and inspired by delivering the best product in ever manner, (cf. ibid. 2011: 17) this award gives credit to high intellectual proposition and performance.

Lateral Thinking – Against the Tide Award

This award category is for an individual who breaks down boundaries of stagnation or creates valuable new relationships in improving the way work gets done. Moreover, it gives credit to see mistakes as opportunities, acknowledging them as a valuable part of corporate learning (cf. ibid. 2011: 13). Critical thinking and creative approaches to hang-up issues are rewarded, too.

Hard Worker Award

Delivering work before the expected time, endurance in solving a particular issue, and on-going efforts of challenging difficulties characterise this award. This category is for an individual or individuals who achieve a desired outcome despite adversity (e.g. limited resources, time constraints, and an unexpected challenge).

Sustainability at its Best Award

Referring to the claim for sustainability (cf. ibid. 2011: 21), this award acknowledges outstanding product responsibility, production responsibility, contractor relations, employee relations, ethics and responsibility for society. This award is for an individual that contributes to a culture of sustainability peer-to-peer outreach, office resource conservation and efficiency actions, or sustainability projects, saves costs, creates operational efficiencies by reducing, reusing and recycling resources.

Unsung Hero Award

This award category is for an individual or individuals who consistently provide high quality, reliable and critical work, without being directly seen. Working behind the scenes is the foundation that allows for the smooth operation of every corporation.

Restrictions on Awards?

Of course, these awards are far from complete in representing the values of Daimler. However, they should function as insights and inspiration for how awards can be designed in the nexus of corporate values and existing awards. Awards, as mentioned, must be sufficiently scarce, in order to have a sufficient value for the recipient to produce any effect at all. If the awards are over-utilised, the awarded person sees no unique selling proposition, and therefore the conception is failed. To ensure the scarcity of awards in the SRS, one can argue that awards should be restricted. For this purpose, one idea is to design restrictions on awards similar to a central bank or a certificate trading system. The administrator of the SRS constrains the number of awards which can be allocated each month. In particular, the actual number of awards is dependent on the number of people that participate in the SRS. As the SRS is not applied within Daimler, there are no verified numbers of efficient award allocation, and have to be sorted out practically. However, it can be questioned whether such absolute restrictions are target-based. It is possible that the number of employees who really deserve an award is higher than the total number of awards available. In this scenario, some employees will get nothing due to the restriction system, although they actually deserve it. Hence, the idea of restricting awards in an absolute way should be treated with caution. It may even be advisable to begin without an absolute restriction system, in order to see whether it is really needed.

Having a basic idea of the SRS and the awards it contains, we can now proceed to the gratifications of awards. Awards can vary greatly but can generally be separated into monetary and non-monetary. In order to avoid destructive behaviour, we suggest emphasising non-monetary elements. Underlining and framing awards only in the light of monetary gains bears the risk of seeking Daimler-designed awards only for personal self-enrichment, rather than rewarding pro-social behaviour. Therefore, we have designed non-monetary prizes related to Daimler for received awards in order to foster inter-hierarchical engagement, knowledge transfer and career development. If an employee awards a teammate with, for instance, the Commendable Colleagueship Award for being a role model, the awarded person gets a corresponding amount of points that are added to their personal account. If the person exceeds a certain threshold of points, they can be granted the following proposals:

Ethics Certificate

An ethics certificate indicates, on paper, that an employee is able to handle complex moral dilemmas.

Tribute in the Daimler Intranet

The Daimler Intranet is the suitable platform for acknowledging outstanding performance within the SRS to a broad range of employees. This could be a short report about their efforts.

Tribute at the Company's Christmas Party

In an informal atmosphere, employees can be rewarded for pro-social behaviour. In particular, the purpose of the award can be described in detail. The awarded employee thus feels appreciated.

Dinner with the Superior/Department Manager

Having dinner with a superior fosters knowledge exchange and switches perspectives. In addition, they can solve business-related issues on a different level.

Interactive Ethic Seminars

High performing employees within the SRS naturally show an affinity for moral questions. Why not offer them the opportunity to further develop their ethical skills in order to function as a role model?

Of course, these are only outlines of proposals which have to be further investigated. To ensure the overall proper function of the SRS, we suggest gathering a pilot group, e.g. trainees or apprentices who are receptive to online-based platforms like the SRS. We believe that this target group is most suitable, since they are mostly 'digital natives', the first generation to grow up with the internet. In this pilot project, crucial issues (like optimal award allocation) can be evaluated, and potential weaknesses of the SRS can be improved. After piloting the SRS, this project can first be implemented at one location, into administration and production. While the implementation in the administration is ensured through computer-related work, employees within the production can contribute to the SRS through mobile app solutions or provided with accessible computers. After succeeding at one Daimler location, the SRS is ready for fostering integrity on a global scale.

4. Summary

We first questioned how to ensure correct moral behaviour within a corporation. One answer is compliance bounded to norms, rules and their enforcement. We concluded that compliance is necessary but has its limits. Overemphasising compliance through command-and-control approaches crowds out the intrinsic motivation for doing the right thing and can be inefficient. We demanded a strengthening of a moral-based corporate culture, which takes into account the integrity of every employee. After defining integrity as a holistic concept related to pro-social norms such as gratitude and trustworthiness, we promoted framing these norms in an appropriate system. Subsequently, we outlined efforts of compliance and integrity by Daimler, to adapt our SRS to this corporation. Having outlined these efforts, we elaborated upon the general idea of the SRS and highlighted the importance of awards. Awards effectively trigger intrinsic motivation but have to be designed in an appropriate way. To do so, we merged Daimler's Code of Integrity with our ideas of potential awards for the purpose of implementing SRS within Daimler. Furthermore, we suggested non-monetary prices for achieving such awards, and pointed out some further steps for implementing an SRS as a complement to compliance.

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SUSTAINABILITY IN THE AUTOMOTIVE SECTOR

Materiality Specific Stakeholder Management

Materiality Specific Stakeholder Management

How to Improve Stakeholder Identification and Communication

Hannah Friedrich and Nadine Pelkmann

Keywords

Discourse Ethics, Human Rights, Stakeholder Management, Stakeholder Communication, Stakeholder Identification

R. E. Freeman's stakeholder approach is widely cited in literature and is one of the most well-known management concepts. Stakeholders are groups without whose support the organisation would cease to exist. Referring to modern concepts of Corporate Responsibility, we come forward with a new approach, placing materiality at the heart of stakeholder understanding, thus shifting attention from groups to topics. Materiality addresses the identification of specific, relevant topics that move the internal and external stakeholder landscape. Our approach is based on the theoretical framework of discourse ethics. To illustrate our idea, we will apply this philosophy to the issue of human rights, one of the most relevant materialities. To do so, we will divide the materiality of human rights into sub-materialities. To classify different stakeholders, we will further develop a scheme based on Mitchell, Agle, and Wood, using the attributes power, expertise and urgency. We will finally present different forms of adequate communication according to these attributes.

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1. Introduction

Making moral decisions is a rather complicated task. People often struggle if they have to decide upon the moral principle with which they ought to legitimate their actions. Even though moral decisions of individuals in the private realm have a rather limited scope, in small groups like families, one can easily engage in great debates on which values and principles to promote. Even harder are such decisions for moral agents whose actions are measured on a larger scale, for example, international corporations.

These corporations are engaged in a globalised world. As the European Commission states, corporations are responsible for their impact on society, and are supposed to maximise the creation of value not only for shareholders, but also for their stakeholders and society in general (cf. EU-Commission 2011: 6). Corporations need to cope with the plurality of values they face, and balance different interests. In response to these challenges, we suggest a new approach, shifting the focus from stakeholder groups to materialities. Discourse ethics provides a way to define the materialities corporations are responsible for. We will further expand upon this idea, offering an approach to materiality specific stakeholder communication, starting off with Richard E. Freeman's well-known definition of stakeholders. In this way, we will gain a more realistic view of the complexity of the stakeholder world and enhance content issues.

In order to do so, in the first two chapters we will outline the essential points of both Freeman's stakeholder approach and the theory of discourse ethics as our theoretical framework. We will then present our approach to putting materiality at the heart of the stakeholder identification process. To illustrate our idea, we will apply this philosophy to the issue of human rights, as one of the most relevant materialities. We will further develop the implications for stakeholder communication by suggesting a model for stakeholder clustering based on Mitchell, Agle and Wood. This model is focused on three main attributes: expertise, power and urgency. From this, we will deduce communication guidelines in order to make stakeholder communication more effective and efficient.

2. Traditional Stakeholder Management

The stakeholder approach was introduced by Edward R. Freeman in his book "Strategic Management: A Stakeholder Approach", published in 1984. In order to answer the question "how business works at its best" (Freeman 1984: 9), he develops an argument in favour of a stakeholder approach. Stakeholders are, according to Freeman, "any group or individual that can affect or be affected by the realization of an organization's purpose" (ibid.: 26). His argument relies on two building blocks, the *integration thesis* and the *responsibility principle*. The integration thesis states that business decisions mostly entail implicit ethical positions, and ethical decisions often entail implicit business positions (cf. ibid.: 7). Therefore "it makes no sense to talk about business without talking about ethics" (ibid.: 7), and vice versa. The responsibility principle refers to the observation that "most people, most of the time, want to, and do, accept responsibility for the effect of their actions on others" (ibid.: 8). The combination of integration thesis and the responsibility principle form, according to Freeman, the *stakeholder theory* (cf. ibid.: 9). It states that in order "to create value, one must focus on how value gets created for each and every stakeholder" (ibid.: 9). He classifies the stakeholders into groups, such as customers, employees and financiers (cf. ibid.: 24 f.). In his opinion, this approach is a solution to three current problems. It shows how business in today's globalised society can create value, provides a way to combine ethical responsibility and the common economic position of capitalism, and offers guidelines for managing a business successfully today (cf. ibid.: 29).

3. Discourse Ethics

How can we deal with issues in a globalised, pluralistic world? How can we balance the varied interests of different individuals or groups of individuals with different values? What is the best way to take normative decisions facing this *plural value, plural interests world problem*?

Kant's categorical imperative is one famous answer to the question of how to determine the morally right action. It tells us to "[a]ct from that maxim only which thou canst will law universal" (Kant 1886: 34). Following Kant, the categorical imperative is a possibility for the individual to prove whether a norm is suitable as a maxim for society overall. But Kant's approach does not seem to be helpful in solving our *plural value, plural interests world problem*. It is a monological theory, as it puts the individual at the centre of morality. However, in our modern, globalised world, moral questions often have to be answered by groups rather than by individuals. Consequently, we need an alternative theory which puts groups at the centre of morality.

This alternative can be found in discourse ethics. One of the first philosophers to suggest an approach to discourse ethics was Jürgen Habermas. In his opinion, conflicts concerning moral interactions arise due to the lack of normative agreement. The solution he offers to generate a normative agreement is intersubjective discourse (cf. Habermas 1983: 77). But what does discourse ethics say? Discourse ethics can be seen as a two-tier theory. The central idea is a proposition that we can find valid norms (first tier) in by realising an argumentative discourse under certain conditions (second tier). What is a valid norm? Answering this question, Habermas introduces the universal principle which indicates the basic requirements moral norms need to fulfil, saying that "moral norms are supposed to be unconditional, universal ought statements" (ibid.: 74, own translation). Valid norms need to be justified by good reasons which anyone, at any place and at any time, can understand (cf. Habermas 1991: 157). Furthermore, the universal principle claims that norms are valid if they earn the consensus of all those affected by them. So, in fact, there would not be any valid norms for the long run if the norms were not legitimised by the consensus of all those affected. This consensus can be achieved only when everyone involved in the discussion about norms takes an impartial point of view. A norm is valid if, first, each affected person accepts the consequences that would occur when everyone follows this norm and, second, if the actions required by this norm are preferred by each affected person (cf. Habermas 1983: 75 f.). To put it in other words: norms are unconditional, universal oughts which can be valid if they are generally consented to by everyone involved.

The second tier concerns the question of how we can find valid norms. According to Habermas, we can do so by joining a discourse under ideal conditions. First of all, the conditions of the universal principle we described before need to be satisfied. Furthermore, the discourse should not have any temporal or spatial restrictions (cf. Habermas 1991: 156). Additionally, he refers to Friedrich Kambartel's conditions for the discourse, which require "unbiased, unconstrained and unpersuasive discussions" (Kambartel 1974: 66, own translation). *Unbiased* means that all actors should be willing to raise their own opinions, and question and discuss all possible alternatives without prejudice. *Unconstrained* means that there are no penalties which would make actors agree on or refuse an action. *Unpersuasive* means that actors should not try to manipulate other actors by taking advantage of their initial preferences (cf. ibid.1994: 66 f.).

An ideal discourse is achieved when all these conditions are fulfilled. We can thus obtain a valid norm, as the strongest argument is established. Certainly, this does not illustrate real life. In reality, it is likely that not everyone can join a real discourse and, often, a consensus cannot be reached due to lack of motivation. Moreover, discourses are not free of temporal or spatial restrictions, and aspects like power and emotion often influence decisions in groups (cf. Ulrich 2008: 72). But even though it is impossible to realise an ideal discourse, it can be seen as the goal we try to approach as closely as possible (cf. Habermas 1991: 156).

On the basis of Habermas' approach, discourse ethics shows us a process of finding valid norms legitimised by the consensus of all those affected. The focus is on the *procedure* necessary to obtain valid norms, and not explicitly on the *content* of the resulting norms. None of Habermas' conditions concern the content of the norms, they simply determine the circumstances of the discourse as a foundation to find valid norms. Horst Steinmann's approach to discourse ethics adds material aspects to Habermas's procedural aspects.

Steinmann suggests the condition of competence as an addition to the conditions for an ideal discourse by Habermas. This condition requires participants of the discourse to be able to contribute knowledge relevant for the solution of a problem and present their arguments in ways that would likely find consensus in the discourse (cf. Steinmann 1994: 78 f.; Steinmann 1991: 12). The content of the norms is, in accordance to the universal principle, determined by the mutual agreement of the participants in the discourse. Discourse ethics does not give any impact on the content of norms, on what is morally right. However, Steinmann's condition of competence does in some way influence the content of norms found in discourse. It does so by ensuring that the participants of the discourse can put forward their arguments in a competent manner. This is the material aspect. Consequently, Steinmann's condition of competence is kind of a quality enhancing measure. We think that the addition of his material aspect to discourse ethics is essential, as only in the discourse can we "mobilise and apply expert knowledge on which consequences and side effects we are likely to accept, given that we follow situational norms" (Apel 1990: 220, own translation).

Similarly, to this materiality aspect in Habermas' approach of discourse ethics, we identified the lack of a materiality aspect in Freeman's stakeholder analysis. He shows us a process of stakeholder identification, as Habermas shows us a process to find valid norms. However, the materiality which the stakeholders are interested in is not represented in any way. But this is important, as the common interest in materiality is the reason for the cooperation of corporation and stakeholders. Besides this, we think that Freeman's definition of stakeholders is too narrow. Therefore, we will, in the following, suggest a modification of Freeman's stakeholder definition and use this as a foundation for our approach to stakeholder identification.

4. Materiality Specific Stakeholder Management

Freeman established stakeholder theory, and states that it is important to communicate with stakeholders. An important tool in stakeholder communication is the materiality matrix. This matrix shows the materialities, ranked by their importance to both corporations and stakeholders. We can specify the content of stakeholder communication by focusing on the materialities which appear in the materiality matrix. *Materiality* is a very abstract expression, and, for our purposes, we think it is described best as a topic or an issue. Examples of materialities are data protection, biodiversity and human rights. In our opinion, a justified basis for deciding which materialities are relevant for a corporation and its stakeholders can be found in the extended version of discourse ethics we presented in the previous chapter. The procedure of finding relevant materialities should be designed according to the conditions of an ideal discourse, following Habermas and Steinmann. Of course, this ideal cannot be reached in reality: the aim is an approximation.

After having decided upon the relevant materialities, how do we further proceed in order to identify stakeholders? The core of our idea is a change of perspective, to shift the point of view and put materiality at the heart of stakeholder identification. We therefore identify the stakeholders with the perspective of materialities. Consequently, stakeholders are no longer those groups affecting or being affected by a corporation (cf. Freeman 1984: 26), but those affecting or being affected by a materiality.

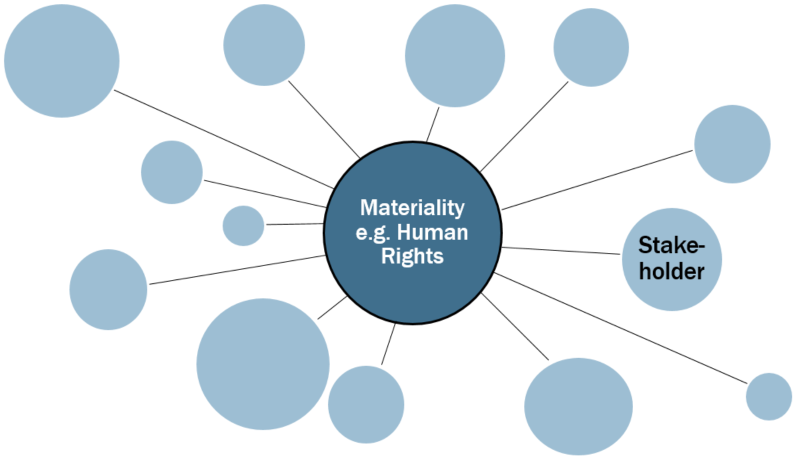

FIGURE 1: MATERIALITY AT THE HEART OF STAKEHOLDER MANAGEMENT (SOURCE: OWN ILLUSTRATION)

Let us first pick one of the materialities out of the corporation's materiality matrix, in order to identify stakeholders. To further expand our argument, we picked the materiality *human rights*. There are four defining features of human rights, according to James Nickel (cf. Nickel 2014). Obviously, human rights are *rights,* and mostly entail corresponding duties or responsibilities. Human rights are *plural*, as they address a variety of specific problems, like the provision of education or the prevention of genocide. Moreover, human rights are *universal* and of *high priority*. Due to the plurality of the term human rights, we provide *sub-materialities*. This allows us to address certain issues more precisely. Sub-materialities could be child labour, labour rights or freedom of expression. Which sub-materialities are considered by a corporation depend on the corporation's particular situation, as corporations consider the sub-materialities which they are stakeholders of. The relevant question for a corporation is thus: which sub-materiality do we affect or are we affected by? In the manufacturing sector, for example, corporations are focused on sub-materialities like labour rights or child labour. We will illustrate our approach using the following example.

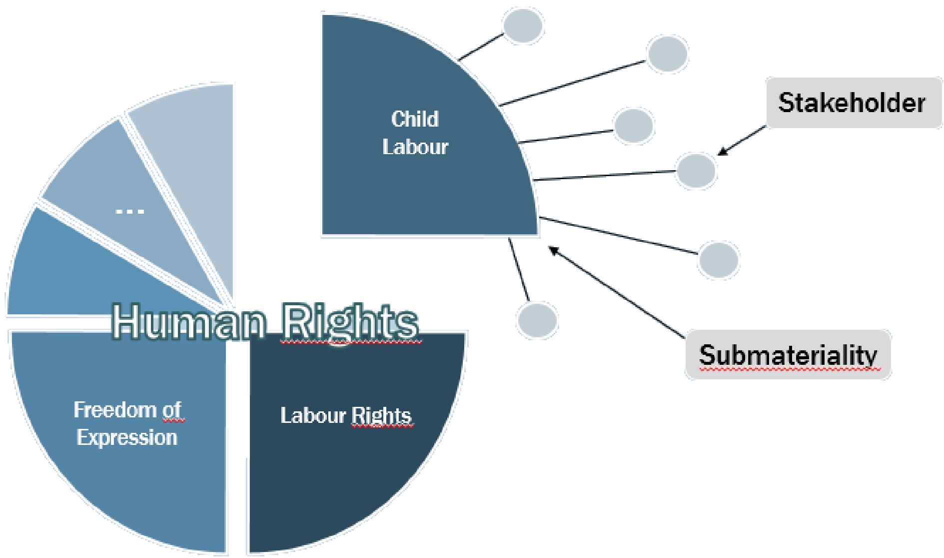

FIGURE 2: SUB-MATERIALITIES OF HUMAN RIGHTS
(SOURCE: OWN ILLUSTRATION)

Let's imagine being responsible for the stakeholder management of a corporation. This corporation is a rather large manufacturing corporation, operating on a global scale with a very good reputation. Business is running smoothly, so it was decided to expand production and open a new factory. This corporation was originally located in a country promoting western values. The new factory will be built in a country where the corporation has no factories so far. This country, ruled by a communist government, is shaped by a corrupt system and has issues with child labour. For our corporation, it is extremely important to avoid any damage to their reputation by being linked with child labour. In order to ensure this, we have to carefully check business partners along the supply chain, so that we do not become involved with anyone linked to child labour. There is no previous experience with solving this problem, therefore it is necessary to cooperate with stakeholders with experience and knowledge. The main reason for this is to get help in determining appropriate business partners.

Another aspect is minimising the risk of bad publicity provoked by a certain group of stakeholders. Firstly, we would minimise this risk by talking to the stakeholders with the expertise we need, in order to find the right business partners and therefore avoid being linked to child labour in the first place. Secondly, we need to keep in mind that despite precaution, there could possibly be child labour issues in the future, which are dangerous for our corporation. Therefore, we need to know the stakeholders who would damage us by using their influence to cause bad publicity. By knowing these stakeholders well in advance, we can cooperate with them (and so minimise risk) at an early stage. How do we know who the relevant stakeholders are? We will analyse who is affected by the materiality of child labour (cf. Freeman 1984: 26). We would thus gain a general list of child labour stakeholders. As child labour appears in our corporation's materiality matrix, the corporation is also a child labour stakeholder. Presumably, not every child labour stakeholder would be interested in the corporation. We can thus single out the stakeholders who are interested in the corporation among the group of child labour stakeholders. This provides us with a list of stakeholders of the corporation in the category of child labour. The connecting aspect here is the shared-stakeholder-relationship to the materiality. By doing this for every materiality relevant for a corporation, we would obtain a list of stakeholders classified by materialities. This procedure of stakeholder identification has the advantage that we, at first glance, see where to find which expertise. We will soon explain why this is important. Besides this, another advantage is that our approach better satisfies the complexity of the stakeholder world, as our model features a third dimension while also taking into account materialities. This allows us furthermore to link two essential management tools: stakeholder identification process and materiality matrix. This is why we think that our approach is an improvement on Freeman's stakeholder approach.

5. *Implications for Stakeholder Communication*

5.1 Cluster Models

In the previous chapter we were concerned with stakeholder analysis, dealing with the question of how to make the stakeholder identification process more efficient and effective. Now we want to turn to stakeholder communication. Hitherto, we have the stakeholders ordered according to their sub-materialities. However, for successful stakeholder communication, we need to take into account the main attributes relevant for communication. There can be found several suggestions on how to cluster stakeholders in the literature on stakeholder theory. In this chapter, we will first present two of these cluster models and then develop our own cluster. Savage et al. provide a cluster model which focuses on two attributes of stakeholders: the stakeholders' potential to threat, and their potential to cooperate. They say "the more dependent the organization, the more powerful the stakeholder" (Savage et al. 1991: 63) and "[f]requently, the more dependent the stakeholder on the organization, the higher the willingness to cooperate" (ibid.: 64). Stakeholders are classified into a matrix with four fields, so there are four possible types of stakeholders. Stakeholders have either high or low potential to threaten, and either high or low potential to cooperate. For each type of stakeholder, the authors recommend a certain communication strategy. For example, a stakeholder with low threat potential and a high potential to cooperate is a supportive stakeholder, which should be involved, whereas a stakeholder with high threat potential and a low potential to cooperate is a non-supportive stakeholder and should be defended.

Another suggestion for how to cluster stakeholders was put forward by Mitchell et al. (Mitchell et al. 1997: 874). As distinguished from Savage et al., the authors of this cluster model consider three main attributes of stakeholders: power, urgency and legitimacy. This model is schematically illustrated with three overlapping circles, each circle representing the possession of one of these three attributes. All in all, this results in seven categories: three categories containing stakeholders with only one attribute each, three categories containing stakeholders with two attributes, and one category containing the stakeholders with all three attributes. The authors also briefly define each of these attributes. By power, they understand "a relationship among social actors in which one social actor, A, can get another social actor, B, to do something that B would not have otherwise done" (Dahl quoted in Pfeffer 1981: 3). Legitimacy is defined by "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, definitions" (Suchman 1995: 574). Urgency expresses "the degree to which stakeholder claims call for immediate attention" (Mitchell et al. 1997: 869). For each of the seven categories, the authors recommend a certain strategy. In our opinion, when comparing Savage et al.'s model to Mitchell et al.'s, the cluster of Mitchell et al. is better to work with. In addition to being more differentiated, it better serves the dynamic in the stakeholder world featuring urgency. Moreover, it is broader, as it does not only focus on aspects connected to the interaction of corporation and stakeholder. However, we still see potential for improvement in this cluster. Thus, we want to introduce our suggestion for a stakeholder cluster model.

We have adopted the three overlapping circles as the schematic form of our cluster. We have also adopted two of Mitchell et al.'s attributes, *power* and *urgency,* although we will use them slightly differently. The third attribute we think necessarily has to be added to the cluster: *expertise*.

First of all, we will take a closer look at the attribute power. A stakeholder possessing power has the ability to influence the public with either positive or negative consequences for a corporation. We therefore ask: does this stakeholder have influence in shaping public opinion? How frequently does this stakeholder appear in the media? The second attribute in our cluster is urgency. We remember that Mitchell et al. refer to urgency as "the degree to which stakeholder claims call for immediate attention" (ibid.: 869). We agree with them that urgency comes in degrees; however, we think it is more feasible and precise for our cluster to ascribe a stakeholder urgency as soon as the urgency is at a level which requires immediate reaction on our part. The third attribute, expertise, is the one connecting our approach of stakeholder identification to our approach of clustering and stakeholder communication. When we say a stakeholder has expertise, we implicitly mean expertise in the certain sub-materiality we are looking at. In analysing a stakeholder's expertise, we are dealing with such questions as: can we see the potential for how transferring from the stakeholder toaffects the corporation?

Why did we take legitimacy out and added expertise instead? As already mentioned in chapter four, when talking about identifying stakeholders according to sub-materialities, we think it is extremely helpful and important to know where to find the expertise on which topic among the stakeholders. This is because we think that it simplifies and speeds up reactions to upcoming problems. We want to integrate the aspect of expertise in our cluster, as it will help us further when developing our stakeholder communication guidelines, as implied by the clustering. Expertise also makes our approach more practically relevant, as it transforms the cluster into a tool which can be used to solve specific problems. Mitchell et al.'s model only covers a classification of stakeholders in a general way, and therefore lacks this problem solving tool. We regard the attribute legitimacy as redundant in our model of stakeholder cluster. This is because both the possession of urgency and expertise imply the legitimacy of a stakeholder's claim. Whether a power stakeholder's claim is legitimate does not matter: as soon as stakeholders can damage the corporation, it is necessary to deal with them. It is important to emphasise that it is a dynamic development of stakeholders when having or not having those attributes. Urgency is an attribute that appears rather temporarily. Power and expertise are attributes which are developed over a longer period of time, but which are subjects that change. Before elaborating upon the implications for stakeholder communication (in motivation, type and form) resulting from our cluster, it is necessary to understand how power, urgency and expertise relate to each other. Urgency determines the timing of stakeholder communication. The presence or absence of power and expertise determine the type (and therefore also the form) of communication.

There are seven possible combinations of attributes our cluster allows for and, by recommending our communication guideline, we will explain the three aspects motivation for, type and form of communication for each category. In determining the motivation we ask: why are we talking to this stakeholder, what is our aim? To determine the type of communication, the question is: how do we achieve this? And in determining the form of communication, we will analyse which forms of communication correspond to the type of communication.

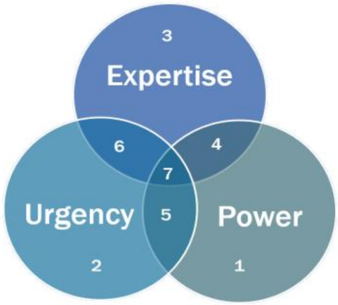

FIGURE 3: MODIFIED CLUSTER MODEL
(SOURCE: OWN ILLUSTRATION BASED ON MITCHELL ET AL. 1997: 874)

1. *power*: Stakeholders in this category feature power, but neither expertise nor urgency. In general, a power stakeholder can influence the reputation of a corporation. If stakeholders with power want to become informed about a certain matter in some way connected to the corporation, they will be heard. Therefore, communication with a power stakeholder is a potentially delicate issue. Consequently, the motivation of a corporation in communicating with power stakeholders is to minimise the risk that they will use their power in a way which has negative consequences for the corporation. To put it in other words, we want to pay attention to them, to minimise the risk of trouble. and we keep an eye on them to be able to foresee trouble as soon as possible. How do

we get there? Which type of communication is for power stakeholders? The best thing to do in order to minimise risk is to pay attention to the stakeholder. We assume that power stakeholders expect to be recognised and involved. This can be best achieved by providing a contact, keeping these stakeholders informed about materiality specific news they might be interested in, and in inviting the stakeholders to events to express appreciation of their interest. As long as power is the only attribute the stakeholder is possesses, the risk can be considered rather low, however as soon as the stakeholder also acquires either urgency or expertise, we have to increase our attention. An example for a stakeholder in this category could be a powerful influential NGO, which actually deals with issues located in another materiality like environmental issues, so an environment stakeholder.

2. *urgency*: If stakeholders are assigned to the category featuring only urgency, the recommended strategy is rather unspectacular. These stakeholders have notice of a topic relevant for us, so we need to pay as much attention as necessary to realise the topic and then react appropriately (as long as these stakeholders develop neither power nor expertise, we will not take them into account for our reaction). The motivation behind communication with these stakeholders is to become informed. Therefore, a corporation should have a contact for these stakeholders, to become informed about the urgent materiality and to satisfy the stakeholders need for attention. There is no single type of communication to recommend for these stakeholders, as urgency says nothing about the type of communication, rather about how quickly we have to act.
3. *expertise*: The motivation for communicating with a stakeholder that possesses expertise is to use this expertise to solve content-based problems. The type of communication that we would suggest is content-based exchange, which means that corporations and stakeholders talk about content issues. Therefore, in a cooperation with an expertise stakeholder, a corporation should focus on creating opportunities for exchanging with the stakeholder. Stakeholder dialogues or smaller meetings are examples of corresponding forms of communication. We can thus enhance the cooperation and engage the stakeholder in problem solving and preventing. Typical stakeholders in this category are a group of scientists doing research in fields related to our sub-materiality.
4. *expertise and power*: Stakeholders in this category possess expertise and power. So, on the one hand, we would like to benefit from their expertise and, on the other hand, we will try to monitor their activities to ensure that they do not damage our reputation. We would consequently suggest a

mixed communication guideline. We will monitor stakeholder activities and engage them in discussions on content matters, benefitting from their expertise. A stakeholder in this category could be the group of scientists we used as example in category 3, but now these scientists are famous, and their publications are read by many people (not only other scientists).

5. *power and urgency*: Stakeholders in this category are a possible threat for the corporation. These stakeholders have the power to influence the corporation's reputation and, as urgency is involved, they also have a reason to do so. Therefore, our motivation in communication to these stakeholders is to monitor their activities in order to minimise the risk that these stakeholders actually do use their power in negative ways for the corporation. This is similar to our motivation in category one. However, the addition of urgency makes rapid reaction more important. An example of this is the NGO we used as an example for category one, only now this NGO has discovered an issue actually not in their field of expertise, but in their opinion is important enough to make it public, in order to get the attention of those who can deal with it.
6. *urgency and expertise*: Into this category are placed stakeholders possessing expertise and urgency. This means that they have expertise in the sub-materiality and are currently dealing with a topic that is urgent for us. Our motivation is similar to category three, as we want to benefit from the stakeholder's expertise. Therefore, we will go for content-based exchange as a type of communication. The involvement of urgency makes this more necessary. An example is the group of scientists with expertise in the sub-materiality. In addition to expertise, they now also possess urgency, as they are currently doing research on a topic which is urgent for the corporation.
7. *expertise, power and urgency*: Stakeholders in category seven possess expertise, power and urgency. To our powerful scientists with great expertise in this submateriality, we now add urgency, so we could imagine that they are currently working on a paper dealing with a topic of high urgency for the corporation. What is the motivation for communicating with them? First, it is necessary to ensure that they do not use their power in a way which would be damaging for us. Second, it is very likely that, due to their current research, they will be helpful for the corporation. Additionally, urgency makes it necessary to communicate instantly. Therefore, the type of communication required is a mix of content-based exchange combined with monitoring the stakeholder's activities, to be warned early enough about any possible trouble they could cause.

How does this look in real life? Remember, our job is stakeholder management of the expanding corporation. We are in a position in which we want to do two things: avoid cooperation with business partners linked to child labour, and make sure that we get to know power stakeholders, involve them and monitor them, as we are in a potentially dangerous situation. We have already identified our child labour stakeholders. Let us imagine that, among these stakeholders, there is one which is very powerful, with great expertise in human rights in general and also in child labour, with great media presence. This is a very important stakeholder for us, as their expertise can be very helpful for solving supply-chain-child-labour issues, and involving this stakeholder minimises the risk of being put in a bad light. Communicating in the first place ensures that, besides gaining information on the child labour issue, this stakeholder knows that we are doing our best to avoid links to child labour, and we can also remove any possible doubts. This shows the combined motivation (use the expertise and minimise risk) and the combined type of communication (content based exchange and attention). There can also be a stakeholder which does only possess power. This could be a global NGO with a good reputation, which is actually located in another materiality, and therefore has no expertise in human rights like child labour, but in environmental issues. Why is it then a human rights stakeholder anyway? This is a good question. This stakeholder can still be (and in our example is) a human rights stakeholder, as expertise is not the indicator for being a stakeholder to a certain (sub)materiality, but interest in this (sub)materiality. This is why even an NGO that deals with environmental issues can be a stakeholder that we have to take seriously in child labour-stakeholder communication, as this NGO, due to its power, just needs to drop a few remarks linking our corporation to child labour to cause serious trouble for our reputation. Our motivation in communication with this stakeholder is risk minimisation, and we get there by paying attention (this is the type of communication). A stakeholder which does have expertise but no power could be a group of scientists doing research on child labour. This might be a group of lecturers and students of a university in the new country, who know the local background and are aware of the ethical dimensions of the problem. We want to communicate with them, as we want to use their expertise to solve our supply-chain-child-labour issue, so the type of stakeholder communication is content-based exchange. All in all, this example illustrates how the communication guidelines we suggested based on our cluster can be used as a helpful tool in stakeholder management.

6. Concluding Remarks

To conclude, we will summarise the advantages our approach offers. How does our approach differ from other approaches, and why is this an improvement? The innovative aspect of our approach is the link of stakeholder management to the materiality matrix. This link enables us to develop a broader conception of stakeholders. This stakeholder definition, in combination with the focus on materialities and the expertise within these materialities, forms a tool for a better and more specific problem-solving. By developing our thought further, we came up with stakeholder communication guidance based on power, expertise and urgency. In our opinion, this is an opportunity to better satisfy stakeholder expectations. We have thus gained an increase in efficiency and effectivity of stakeholder management. Our approach to materiality specific stakeholder communication, based on Habermas' and Steinmann's notions of discourse ethics, is meant as a contribution to solving the challenges of value pluralism introduced at the beginning.

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Connected Corporate Reporting

SUSTAINABILITY IN THE AUTOMOTIVE SECTOR

Connected Corporate Reporting

How the Connected Car Will Shape the Future of CSR Reporting

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Keywords

CSR Reporting, Connected Car, Corporate Storytelling, Daily Soap Reporting, Gamification

Corporate Social Responsibility reporting is subject to an ongoing transformation process. The innovation of the Internet of Things, and especially the revolution caused by the connected car in the automotive industry, will shape the future of CSR reporting fundamentally. This article presents the model of Connected Corporate Reporting. With a dependence on Nikolai Kondratieff's model of cycles, three CSR reporting cycles will be described, each of which has its own basic innovation which will radically affect the way companies report on CSR. Next, a framework for a content structure in Reporting 3.0, termed Connected Corporate Reporting, will be drawn. The article will introduce information and transparency, participation, and sensitisation, which are crucial for successful CSR reporting. Finally, four innovative tools for content design will be presented: corporate storytelling, daily soap reporting, massive open online course reporting, and gamification. The article closes with some final remarks on the implementation of Connected Corporate Reporting.

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1. Introduction

The way people communicate, interact, learn, work, and experience life is becoming increasingly complex. With the Internet of Things at the threshold, modern society faces a new, connected reality. The phenomenon of human beings interacting with products and services not only dramatically changes large parts of the economy, but also everyday life. While Edward Freeman has described collaboration between stakeholders and the company as a requirement for business success (cf. Freeman 1984: 190), in the future the collaboration between stakeholders and connected products might also be such a requirement. In the automotive industry, for example, the connected car is about to revolutionize traditional concepts of mobility, with large information networks handling big data about each and everything offer new possibilities for services and communication. Also, Corporate Social Responsibility (CSR) reporting is about to change, because of the transformation process described above. Recall the term 'greenwashing' to understand that marketing and CSR reporting have become hard to combine. This might change if a company's products become communicators of CSR information.

This paper presents a model of future CSR reporting, termed Connected Corporate Reporting (CCR). It makes successful reporting possible by intelligently using different communication channels that the Internet of Things creates, in combination with innovative formats and tools of reporting. The connected car enables the automotive industry to take a leading role in the implementation of CCR. It is time for reporters to leave the shop-worn, printed CSR report behind, and enter the connected world of future reporting. This article examines how such a future might look and presents the model of CCR. Firstly, inspired by Nikolai Kondratieff's model of a cyclic economy, three CSR reporting cycles are described, each of which has its own basic innovation which radically affects the way companies report on CSR. The first cycle, Reporting 1.0, is subject to the basic innovation 'obligation to report' (based on the Global Reporting Initiative (GRI) and the United Nations Global Compact (GC)). Reporting 2.0 is subject to the basic innovation 'internet'. Ultimately, the reporting of the future, Reporting 3.0, will be subject to the basic innovation 'Internet of Things', which, in the automotive industry, includes the connected car. Secondly, a framework for the content structure in the model of CCR will be drawn. In doing so, the article introduces the factors information and transparency, participation, and sensitisation, which are identified as crucial for successful CSR reporting. Thirdly, with this structure in mind, four innovative tools for content design will be presented. These are corporate storytelling, daily soap reporting, massive open online course (MOOC) reporting, and gamification. The paper concludes with some final remarks on the implementation of CCR.

2. The Development of CSR Reporting: From Reporting 1.0 to Reporting 3.0

2.1 The Reporting-Cycle Model

The market economy proceeds in cycles of ups and downs. Economic science and practice, in most cases, work with models trying to explain and predict economic developments over a specific time period. In the 1920s, the Russian economist Nikolai Kondratieff introduced a model which tried to explain long-term economic development by referring to economic patterns he claimed to have observed in the past. He argued that the economy progresses in cycles. The Kondratieff model describes an economic development in cycles which last 40 to 60 years, each triggered by a so-called basic innovation. These innovations involve immense investment. With economic development at a peak and the basic innovation fully embedded, investments decline, and the economy slips into a downturn. During this time, work on a new paradigm already takes place, ready to trigger yet another upturn (cf. Yakovets 2006: 4). Inspired by the Kondratieff model, the paper at hand describes the development of CSR reporting. For this purpose, CSR reporting is divided into three cycles, each of which has its own basic innovation (see Figure 1). The first cycle, termed Reporting 1.0, starts with the beginning of sustainability reporting, in the form of social reports. The basic innovation of this cycle is the ‘Obligation to Report’. Reporting 2.0, the second cycle, is subject to the basic innovation ‘Internet’. Ultimately, ‘Internet of Things’ (i.e. the connected car in the automotive industry) is the basic innovation of Reporting 3.0.

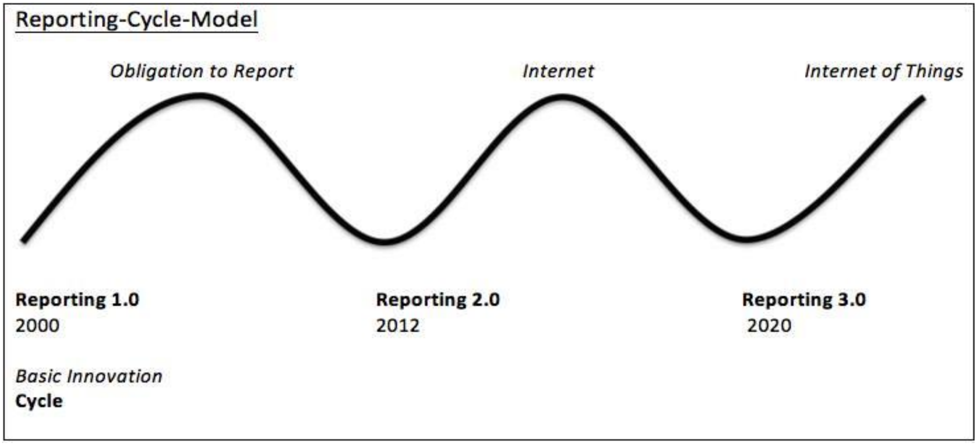

FIGURE 1: REPORTING-CYCLE MODEL
(OWN REPRESENTATION, REFERRING TO NEFIODOW, L. A., 2006)

2.2 Reporting 1.0 and the Obligation to Report

The initial reporting cycle is attributable to the rising societal need for social and environmental issues from the 1970s (cf. Brink/Habenschuss 2016: 2). The basic innovation of this cycle is identified as the 'Obligation to Report'. Proceeding from society's demand for more information about non-financial key figures, companies started to report in printed media. Over time, voluntary and annually published reports gained so much attention that politicians and non-governmental organizations appointed obligational reporting for most of the companies. In this chapter, the development of print reporting is examined. The origin of today's CSR reporting is found in the 1970s. Following an increasing interest of society in topics like live-ability and social responsibility, companies started to account for their social activities in sporadic print reports. However, some (if not most) print reports were used as instruments for public relations, making them unreliable (cf. ibid.).

In the 1980s, another form of non-financial company reports was developed. In the aftermath of ecological calamities like the Exxon Valdez oil spill, chemistry and oil companies started to report about their environmental engagement. In these annual reports, they described their objectives, measures and outcomes relating to their engagement with nature. In 1993, Deloitte and the International Institute for Sustainability Development authored the report ‘Coming Clean’ (cf. Elkington 1993). Therein, it is described how to transform an environmental report into a sustainability report, which combines the social, ecological and economic engagement of companies. The concept of the ‘Triple Bottom Line’ (cf. ibid.), first mentioned in ‘Coming Clean’, extended the non-financial environmental reports through social and financial coherence and revolutionized the sustainability coverage. It established the ‘Triple Bottom Line’ as an important part of sustainability reporting, and one which has lasted until today. The model assumes that only a confidential and equal execution of economic, ecological and social aspects can form the sustainable development of a company (cf. Brink/Habenschuss forthcoming). In 2000, the GRI published the first principles on how to create a sustainability report. The purpose of this initiative was to refine social legitimation in the global economy. GRI implements social and environmental principles that should be universal, and thereby allow for consistent reporting. In the sequel to the publication, companies worldwide started reporting on their non-financial key figures.

The next step concerned the development of the materiality matrix. It enabled companies to classify material issues by their importance. To determine these so-called materialities like employee satisfaction and climate protection, companies usually conducted an internal and external evaluation of potential topics in order to ascertain both the interest of the company and the stakeholders. “While the tool appears in many variations, they all share a basic design. One axis, typically the X-axis, arrays the importance of different sustainability issues from the company’s perspective, while the Y-axis does the same from ‘society’s’ or the ‘stakeholders’ perspective” (Eccles/Krzus 2015: 148 ff.). Depicted in a matrix, this information gives an overview of the company’s and stakeholders’ most important materialities. Based on this analysis, companies can plan their next steps in sustainability engagement and thereby account for stakeholder interests while enforcing their own goals. Since the first social report, all sustainability reporting activities were realized completely voluntarily. In 2004, the German government demanded major companies publish annual reports to inform the public of relevant developments in environmental topics and employee interests (cf. BMU 2009: 5). Companies of public interest with more than 500 employees were then required by the European Union to report about non-financial performance on the basis of GRI standards (cf. Hentze/Thies 2014: 1). The fourth version of the GRI guidelines is today’s most important standard in sustainability reporting. To expand upon this obligation to report, the EU requires an alteration of the reporting system that includes the accounting of non-financial keynotes. Since 2017, major companies have had to include a non-financial declaration in their business reports that covers facts on environmental, social and employee interests, human rights, and the prevention of corruption. Companies have to report on concepts and strategies for engaging in social responsibility (cf. DNK 2015: 1).

2.3 Reporting 2.0 and the Internet

Following the insights of the development described in the period of Reporting 1.0, there has been a constant evolution in the field of reporting. After the implementation of an annual reported frequency of sustainability facts and the standardization of these reports, taking into account the Standards of GRI and the GC, the ensuring development was mainly driven by the phenomenon of the social economy. The basic innovation of the second cycle in CSR reporting development is the internet, and the related phenomenon of social networks. Companies like Facebook and Twitter have radically changed today's online user behaviour. The starting point for the implementation of such a strong participation was the introduction of personal computers with access to internet in a large number of households. After only a few years, 'Web 2.0' updated this web experience. This second coming in web-based technological evolution brought a social component to the consumption of information. A social revolution took place. In 2012, more than 1.5 billion people were members of a social online network (cf. Jenkins 2006; Chui et al. 2012). Among the most popular networks worldwide in March 2015, ranked by number of active accounts, Facebook was still the market leader, with 1,415 billion users. It was the first social network to surpass 1 billion registered accounts (cf. Statista 2015a). The market leaders are Facebook (1.415 billion users and 500 Facebook Messenger users), QQ (829 million users), Whatsapp (700 million users), QZone (629), Skype (300 million users), Google+ (300 million users), and Twitter (288 million users). The variety of social networks is wide. Some networks provide user-generated content and others focus on a community. Platforms can offer social games, content on microblogs, social commerce or rapid communication tools (cf. Chui et al. 2012: 4). It is expected that, by 2018, the total number of social network users worldwide will increase to 2.44 billion (cf. Statista 2015b). A statistical inquiry among German commercial enterprises showed that 99% of the companies shared information via Facebook, 40% used Google+ as a channel to address customers, 37% used Twitter, 37% used Youtube, and 35% ran a corporate blog (cf. Statista 2014a). The corporate social strategies of these companies were driven by two main motives:

increasing the level of recognition (33%) and tying customers closer to the company (28%) (cf. Statista 2014b).

"Due to a constant presence in the lives of their users, social networks have a decidedly strong social impact. The blurring between offline and virtual life as well as the concept of digital identity and online social interactions are some of the aspects that have emerged in recent discussions" (cf. Statista 2015a). Common applications in social economies are the creation of wikis, discussion forums, and crowdsourcing projects. Wikis allow for increased search behaviour and the expectation of open access to stored knowledge. Moreover, the broad variety of blogs, ratings, reviews and discussion forums express the need to discuss opinions (anonymously) and exchange experience, as well as to rate and evaluate products and services. People rely on online social connections. Most social media users upload, comment on and share content, which leads to increased participation. This has an impact on the culture shaped by digital natives. Not only is the application variety very broad, but also implications for culture, following the user behaviour. As the increased exchange of opinions and the sharing of experiences show, driven by the new digital possibilities, a cultural shift has taken place. A higher sociability and connectedness between customers and companies can also be noted. The implications and possibilities for the individual and corporate usage are therefore broad. As most social platforms include social games, the possibility to use such games to connect with friends and get in touch with customers in a playful way is significant. Social technologies offer a broad variety of applications. Chui et al. detail ten ways to add value to organizational functions by using social technologies: derive customer insights, co-create products, leverage social to forecast and monitor, use social to distribute business processes, derive customer insights, use social technologies for marketing communication and interaction, generate and foster sales leads, social commerce, and provide customer care via social technologies (cf. Chui et al. 2012: 36).

2.4 Reporting 3.0 and the Internet of Things

The basic innovation of the third cycle in the Reporting-Cycle Model is the Internet of Things (IoT). The IoT is defined "as sensors and actuators connected by networks to computing systems. These systems can monitor or manage the health and actions of connected objects and machines. Connected sensors can also monitor the natural world, people, and animals" (Manyika et al. 2015: 1). Things that will be connected include machines, vehicles, building equipment and appliances, sensors of each kind. To put it simply: almost everything one can imagine (cf. Andelfinger/Hänisch 2015: 9). The IoT has the potential to transform how we live and work, e.g. via a change of office environments or the introduction of the connected car in the automotive industry. Manyika et al. estimate that the IoT "can cut 100 hours of labour per year for the typical household" (Manyika et al. 2015: 8). Concerning human health, the IoT can help monitoring a patient's health status and intake of medication. Patients can stay at home while doctors monitor their data from their workplace in the hospital. The IoT thus has the potential to improve "the quality of live for hundreds of millions of patients" (ibid.). Another field of application for the IoT is the city, specifically transportation in it. Through the management of traffic flow based on actual tracking data of public transit systems (buses and trains) and cars, there can be less traffic congestion (cf. ibid.: 9).

In the automotive industry, the IoT is the most important part of the connected car (cf. SAP 2014). For a definition of the connected car, this article follows Habeck et al. (2015: 7) and refers to "all use cases for passenger cars that build on processed information between vehicles and their environments." The connected car knows your entertainment preferences, and "tracks usage, runs diagnostics, checks repair costs; records automatically accident data" (GfK 2015: 4). It is a vehicle that makes driving as safe as possible by communicating with other cars and using integrated cameras and sensors to recognize possible obstacles, such as pedestrians. The connected car interacts with other objects that fall under the sphere of the IoT, and thereby gets as much information about the driver as possible (cf. ibid.). The most crucial infotainment feature in the connected car will be the smartphone. The absolute integration of this device requires complete audio, navigation and web-access-inclusion (cf. PRIME Research 2015). A number of features of the connected car are already integrated in today's vehicles. By 2020, it is expected that the vast majority of cars sold will be connected (cf. Habeck et al. 2015: 19). Along with the connected car goes the development of the autonomous driving car. An autonomous car is a "motor vehicle that uses artificial intelligence, sensors, and global positioning system coordinates to drive itself without the active intervention of a human operator" (State of Nevada Legislature 2011: 1). The development of the autonomous car not only promises to make driving safer by removing human judgment and errors in road traffic from the equation: proponents also speak of sinking costs concerning accident prevention, as well as accident-related healthcare. Another hope is for the reduction of emissions, because of more efficient driving. For non-drivers (like the under-aged, elderly or disabled), autonomous driving offers a new form of independent mobility. Furthermore, autonomous driving eliminates the need to steer the vehicle, and thereby turns the active 'driver' into a passive 'passenger' (cf. Habeck et al. 2015: 43). Habeck et al. (2015) estimate that people will have about an hour every day in which they no longer need to concentrate on driving from one point to another. Time spent in the car can be utilized to engage in leisure, entertainment or work-related-activities, like video conferencing or reading e-mails.

In the future, head-up displays, a virtual cockpit, touchpads, voice-control operator services, gesture recognition and a comprehensive web-access will become standard in passenger cars (cf. PRIME Research 2015). Variable seating systems will allow for a face-to-face seat configuration. Displays integrated into the cars will turn the connected car into a digital living space. In the model of CCR, passengers not only use their free time to watch movies and TV series, but also take part in a CSR communication process. The connected car's infotainment system offers a perfect channel for specific communication.

3. The Structural Framework for Connected Corporate Reporting

3.1 The Three Building Blocks of CSR Communication

The industry-disrupting features of the connected car have been sketched out above. Reporting 3.0 has to use the various channel possibilities the IoT creates in order to communicate CSR issues successfully. In CCR, CSR reporting rests on three main building blocks identified as crucial for stakeholder communication: 'information and transparency', 'participation', and 'sensitisation'. With these factors in mind, reporters ensure that their work engages as well as educates relevant stakeholders. Subsequently, it is explained that 'information and transparency' meet stakeholders' demands for comprehensive insights into a company's CSR management. This not only builds trust but also motivates stakeholders to take part in the organization's learning process. 'Participation' stresses the need to engage stakeholders by building on an interactive, individualized, long-term and stakeholder-database-built communication process. Ultimately, 'sensitisation' via stakeholder education contributes to stakeholders that actively engage in the undertakings of an extended enterprise.

3.2 Information and Transparency

According to the Cambridge Online Dictionary, 'transparency' means the exclusion of hidden agendas and conditions, accompanied by the availability of all information (cf. COD 2016). Especially in decision-making situations for collaboration, cooperation or competition transparency is an important aspect for two or more actors. There is an essential condition in transparency for providing free and open access to information. The rules for this interaction have to be fair and clear to all participants. Advantages of transparency give stakeholders confidence in the company. Transparency is an important indicator for the credibility (and therefore the authenticity) of a corporation and its reporting behaviour. The GRI was intended to bring more transparency to the sustainability communication. Transparency will mean better loyalty and productivity for employees and leaders who promote the values of the corporation.

The spirit of free and open source is common to Generation Y, as they have grown up in a digital world, with time connectedness and real-time information. Therefore, the demand for free and open access to information is public. The concepts of openness and accountability lie in the context of transparency. Phenomena like data tracking, big data and mobile open internet access via smartphones have changed understanding of transparency in stakeholder demands on companies (cf. Solis et al. 2014: 45 ff). The expectation of real-time information and access everywhere and anytime has increased. Many companies have realised this shift, which was examined in the GRI guidelines, but this data-driven culture also has also changed over the years. Big data as a buzzword gives an insight into the amount of information which is accessible to companies and stakeholders on a daily basis. Materialities touched by the cultural shift are Mobility, Social Interaction, Casual Play, Radical Interfaces and Emotional Engagement (cf. Ferrara 2012). As much as on smartphones and tablets, on which people carry as mobile devices to get in touch with people and catch up on news, touch screens are also becoming common in public places. The possibilities for connecting with various networks also have implications for new ways of reporting. Some hardware possibilities given via displays are the use of multiple devices with independent displays (which can be a role model for reporting architecture, so that linked displays can provide a reported story which takes place on several platforms and gives a more transparent picture of an issue). Although there is enormous potential for big data, there is also the need to aggregate and translate data. In communication studies, reporting is transparent when three conditions are met:

the sources of information are competing and available in a greater amount, the method of information delivery is acknowledged, and production funding and the financial origins of funding are publicly available (cf. Carey 2009).

3.3 Participation

By contributing, stakeholders form the foundation of a company's performance (cf. Helm 2007: 170). the course of the evolution of CSR reporting (i.e. from print to web-based reporting), today's stakeholders have had the opportunity to seamlessly communicate with companies, and thereby to express their opinions about the company's decisions. This development has great potential for threats if the demands of society are higher than the capacity of the companies to meet these requirements (cf. ibid.). In 1991, Shell, the world's largest petroleum company at the time, dismissed the chance to integrate stakeholder interests into its decision-making process. The company decided to take the 'Brent Spar' out of service, an aging oil storage buoy in the North Sea, and announced they would sink it in the ocean. As a reaction, activists occupied the abandoned buoy for three weeks. Followed by extensive media coverage, this occupation made consumers in Europe, especially Germany, boycott Shell's products. The company immediately turned around and abandoned their plan to sink the 'Brent Spar'. Shell took the decision to sink the buoy without integrating its stakeholders' interests into the decision-making process. Despite the immediate turn-around, Shell lost the confidence of a large part of its stakeholders, and created such a crisis of reputation (cf. Lawrence 2002: 73 ff). To minimize such risks, companies have to integrate their stakeholders into their business concepts, letting them participate with their decisions and actions. Stakeholders can thus understand specific decisions and, for example, comprehend what the company plans to do to solve specific problems. Classic CSR reporting of companies distributes information unilaterally and integrates stakeholders only sporadically. This approach makes no use of the opportunity to enter into a dialogue with stakeholders on an on-going basis. One of the most important issues in today's CSR communication is the participation of the stakeholder, which is based on the idea of a new openness to a dialogue enabling companies to create permanent and transparent communication (cf. Hoffhaus 2012).

A study has demonstrated that participating companies find themselves exposed to less criticism than non-participating companies (cf. Windolph et al. 2013). The dialogue between the company and its stakeholders is important for successful participation. Such critical decisions can be coordinated, and any questions answered (cf. Gesundheit Berlin e.V. 2015). Communication is a process of exchanging information between a sender to a recipient. Such an exchange can be between two individuals, a dialogue between several individuals, or, as is the case with television, without a connection between sender and recipient (cf. Ant et al. 2014).

Andreas Lischka describes five essential requirements that guarantee a successful stakeholder relationship: conversational communication between the company and its stakeholders is interactive, individualized, informative, long-termed and based on a stakeholder database. This is firstly done through interaction stakeholders, which are integrated permanently into the company's organization process, e.g. via response options. Secondly, individualized communication allows for an exchange of specific information, tailored to specific stakeholders. Thirdly, informative communication requires a two-sided information exchange. Companies thus need to know the information their stakeholders are interested in, and make clear the information they want to get from their stakeholders. Fourthly, long-term communication creates stakeholder loyalty through the permanent presence of the company in society. Finally, the foundation for acting upon the previous four requirements is a stakeholder database which collects data about the company's stakeholders (cf. Lischka 2000: 50). If a company meets these five requirements, stakeholders can successfully participate in the company's decision-making process. Multimedia applications, video clips and animated data make an optimal transmission of information possible and guarantee the CSR report's attractiveness (cf. Isenmann 2014: 114). Social media websites (like Facebook and Twitter, or blogs and review sites) are powerful tools for integrating stakeholders into the corporate communication process.

3.4 Sensitisation

Major disruptions force many of today's companies to undergo a radical transformation process. "The traditional concept of companies as entities with defined boundaries, limited relationships with other organizations, and an exclusive focus on internal efficiency" (Margherita/Secundo 2011: 175) is increasingly becoming obsolete. Globalisation, converging sectors, modern technologies, and the growing complexity of the global economy (cf. Maglione/Passiante 2009) have given rise to the concept of the extended enterprise. The extended enterprise "can be conceived as a coordinated and value-oriented configuration that integrates the business relationships of companies with their suppliers and partners" (Margherita/Secundo 2011: 177). Modern companies are required to rethink their learning and information exchange processes. The co-creation of products, services, and values are the aims of the networked organisation, wherein "networks of actors working together towards a shared goal" (ibid.: 179) are of great importance. Actors (i.e. stakeholders) can be investors, employees, customers, joint venture partners and alliances, regulatory authorities, unions, governments, communities, citizens, and NGOs (cf. ibid. 2011). In order to become successful extended enterprises, some companies educate their employees in Corporate Universities, which are "institutionalized forms of ongoing, structural and strategically driven knowledge transfer, exchange and creation processes within and between organizations" (Rademakers 2005: 133). Thinking the concept of the extended enterprise through makes the next step clear: not just employees, but all the stakeholders need to be integrated in the Corporate University model. This envisions a corporate university which "promotes and develops innovative learning and capability-building processes among globally distributed and integrated networks of employees, customers, suppliers, partners, as well as academics, professionals, independent learners and other institutions" (Margherita/Secundo 2011: 181).

The previous examination demonstrates how educating stakeholders can be a driver of success. Stakeholder education via CSR reporting benefits the whole learning network. The sensitisation of stakeholders to critical issues in the realm of CSR must be a top priority of today's reporters. Educating stakeholders can increase a company's impact on CSR in several ways. Firstly, by educating stakeholders about responsible behaviour, companies can (indirectly) decrease their impact on the environment. Take the example of an automotive company. By teaching its customers how to drive energy-efficiently, a car company lets its stakeholders contribute to the goal of reducing CO2-emissions. Secondly, by educating stakeholders about relevant CSR issues, companies can position themselves and their CSR strategies. Often, there is an apparent deficit of stakeholder knowledge about the relevant CSR issues in a company. Again, taking the example of an automotive company, stakeholders may know little about the guidelines of the EU for CO2-emissions in passenger cars. In 2015, every car that is newly registered must not emit more than an average of 130 grams of CO2 per kilometre. Explaining to stakeholders what these guidelines mean for the company helps them to understand the company's strategy of reducing emissions of future cars. Elaborate stakeholder sensitisation also contributes to the way stakeholders perceive CSR reporting itself. Stakeholders who, for example, know what differentiates different driving technologies, might be able to better understand and value an automotive company's efforts to develop sustainable technologies. Thirdly, by educating stakeholders, companies demonstrate their willingness to communicate with and include stakeholders in CSR activities. By making the aim of educating stakeholders explicit, a company shows that stakeholders are understood as being part of its learning organisation, and an important factor in its CSR vision.

What might be the most important factor in having educated and therefore sensible stakeholders is the different perspectives they take. Note that in the concept of the extended enterprise, one cannot call this an outside perspective. Stakeholders are part of the learning network. However, while they contribute to knowledge transfer like every employee, stakeholders do so from another perspective. They represent different positions and prioritise CSR issues other than the company's employees. Companies that take CSR seriously should be interested in being challenged by stakeholders that approach topics like CO_2-emissions, human rights and compliance differently.

4. The Content Design in Connected Corporate Reporting

4.1 Tools for Content Design

The connected car, as part of the IoT, enables the automotive industry to experiment with innovative tools of content design in CSR reporting. Enhancing participation, sensitisation, information and transparency requires strong reporting tools. Having in mind the impulses of the IoT and connected cars as a basic innovation for a new cycle of reporting, this article will next examine how companies in the automotive industry can design their CSR content. In the following part, four tools for content design in the CCR-model are presented: Corporate Storytelling, Daily Soap Reporting, Massive Open Online Courses, and Gamification. Their strength of being recipient-sensitive means that all of these concepts concentrate on the needs of stakeholders. They also take into account physical prerequisites, and build new concepts for providing platforms and media instruments. All four tools concern education, entertainment and engagement as important aims for strong content design. Corporate Storytelling addresses the finesse of purposeful and clear writing, and combines educating, entertaining and engaging characteristics. Daily Soap Reporting refines the idea of integrated reporting, as it combines entertainment and engagement.

Massive Open Online Courses cultivate open access and transparency, while joining educational and entertaining elements. Gamification makes use of game mechanics and elements, to transmit information and engage stakeholders.

4.2 Corporate Storytelling

Tales are part of the nature of human beings. It is natural to use stories to transport information. In all human communities, transmitted stories can be found. Orally transmitted stories have existed since Greek and Roman mythology and philosophy. Stories translate a moral experience or lived wisdom. Even the oldest deliverance of stories can be identified as such, no matter whether orally transmitted, painted or written down. The first tool for content design presented in this article is called "Corporate Storytelling".

Storytelling, as a tool of corporate communication, is a more recent phenomenon. Although it can be a useful part of every company's corporate culture, many do not act upon it. However, some examples can be found in service-driven companies, and in small and medium sized companies. In the business environment, information was originally communicated via data, charts and neutral language – only the hard facts and 'necessary' information. This is a very efficient way of communicating information. However, it is not a very effective one if one wants addressees to emphasise a message or start a dialogue (cf. McLellan 2006). Especially in CSR, communicating important information is crucial. This is because CSR issues touch our values and world-view, as do stories. Schulz von Thun describes the anatomy of a message as having a factual level, a self-revelation, a relationship and an appeal (cf. Schulz von Thun 1981). Stories are a good way to address these four aspects of a message equally. Different surveys have shown that issues explained via stories have a better chance of being remembered. Another positive effect of storytelling is that readers can identify with the storyteller and the transported information. Corporate storytelling thus works as a tool for engaging stakeholders. Storytelling provides a toolbox for powerful communication (cf. McLellan 2006: 20).

Successful corporate storytelling depends on three main aspects. Firstly, 'painting' a picture requires that one builds it around something people can visualise (cf. Forman 2007). Companies ought to use common phrases and describe situations people can connect with. A good story has a clear sense of progression and tension, which is built logically and stretches from the first to the last minute of the narrative (cf. Watson 2011). Secondly, 'decoding' requires a progress of learning to translate the company's strategy into a story (cf. Forman 2007). When not having a core message for companies to connect with, there is the alternative of describing recent strategies, core issues of the company's development, or its goals to an outsider. Information and technical terms need to be decoded, so that addressees can easily follow the storyline. Thirdly, 'focusing' requires storytellers to be aware of their addressees. If companies know who they address their stories to, they can specify their content, setting and language accordingly. This is especially important for the relationship companies want to build via stories (cf. Confalone 2015). The composition of an effective corporate story is similar to that of every good story: there is a need for a vivid setting and character development, a compelling plot and dramatic tension, and good pacing (cf. Marzec 2007: 26 ff.). Additionally, a differentiation in the direction of the storytelling can be examined. There is the classical format of one-way storytelling and the dynamic form of storytelling. While the first describes a story with a pre-defined ending, the second is based on incremental elements of a standard story but systematically includes upcoming news and has no pre-defined ending. Addressees are invited to contribute to the story and, together with the company, decide on its ending.

4.3 Daily Soap Reporting

Examining the question "Sustainability reports: who is reading these things?", Solitaire Townsend, co-founder of Futerra Sustainability Communications, claims that "reporting needs to climb out of the pages of reports, and diffuse the fascinating data across social media, advertising, debates and new technologies" (Townsend 2011). The second tool for concept design presented in this article takes into account that reporting is becoming more social, more interactive and more personal. It is called 'Daily Soap Reporting'. A further examination of the two components 'daily' and 'soap' will make the concept clear.

The connected car and the platforms it is connected to enables reporters to deliver CSR information on a frequent basis, perhaps daily. In 2013, the collapse of the Rena Plaza garment factory in Dhaka, Bangladesh drew attention to the issue of human rights. In the aftermath of the collapse, retailers in the garment industry faced intense pressure from governments, NGOs and customers. This led to the signing of a safety plan for Bangladeshi factories by companies like H&M, C&A and Primark (cf. Greenhouse 2013). This example shows that unexpected events drawing public's attention to a specific CSR issue often require a fast response and flexible communication. Annual reports and static websites cannot meet this demand. The same holds true for positive events. The shipping, oil and gas conglomerate A.P. Moller - Maersk Group has identified safety as one of their core values. In their annual CSR reports, the group dedicates several pages to this core value. Besides information about the prevention of accidents, it names exact numbers and details of fatalities. Through more frequent reporting, Maersk stresses the importance of safety even more. After a month free of accidents, the group could publish an article and describe actions it took to prevent fatalities from happening. The group's CSR report 2013 mentions that an independent auditing company produced 100 recommendations concerning safety improvements in Maersk's container factories in China (cf. The A.P. Moller - Maersk Group 2013: 18). The group could have published these recommendations as soon as they received them and whenever they implemented some of them. This being said, the 'daily' in Daily Soap Reporting should be clear. More frequent reporting copes with rapid and unexpected changes of CSR issues and provides content for the media channels in our modern, connected world.

Now onto the 'soap' in Daily Soap Reporting. Not only should reporters provide content more frequently, but also consider the specific style they use. In the 1930s, soaps (short for soap operas) were serials broadcast on radio and television. An open-ended narrative and concentration on everyday family life were common characteristics of these soaps. Like today's TV series, soaps usually had a loyal fan-basis. What can CSR reporting learn from soaps? Content that is delivered on a daily basis needs to be presented differently than in an annual report. Why not create a loyal fan-base for CSR reports? Picture the fan of a TV series during the day, looking forward to in the evening sitting on their couch in front of the TV, watching a new episode of their favorite show. Watching their favorite soap in the evening is part of many people's daily routine. To follow a soap's plot and the design of the characters is usually not too demanding. It doesn't require the audience to be wide-awake and ready to follow complex storylines. While CSR data is important for benchmarking purposes, not every stakeholder can interpret it adequately, or even has time to do so. Data should therefore be integrated in various formats, like interviews with experts, articles on (at first) CSR-distant topics, videos, podcasts, and others. The "Daimler 360 Magazine" was an attempt to report in such a manner. The 2009 issue, among other things, featured an interview with Dr. Dieter Zetsche, vivid graphics that presented CSR data in an unconventional way, an extensive article on the electric revolution, and a report on Daimler's 'Day of Caring'. It is true that such a magazine-format is not appropriate for a company's annual and comprehensive CSR report. However, for social media platforms and the connected car, it might be the perfect thing.

That being said, Daily Soap Reporting provides passengers of the connected car with different content throughout the day. Passengers can consume these expert interviews, videos, podcasts and other formats on their screens or via the audio systems in their cars. The idea is that stakeholders always have a variety of articles in a timeline at hand to choose from. Companies' communication experts have to learn to work more like a news magazine editorial department. Consuming articles on a company's social responsibility values and actions might become routine for tomorrow's connected car drivers.

4.4 Massive Open Online Course Reporting

In 2014, Deutsche Telekom ran its first corporate Massive Open Online Course, in collaboration with Leuphana University, labeled 'Magenta MOOC: Share your entrepreneurial spirit'. With 'Magenta MOOC', Deutsche Telekom expanded on a corporate scale what providers such as edX, Coursera, Udacity and the German Iversity had demonstrated for several years in higher education. The non-profit online learning platform edX, for example, promises "great online courses from the world's best universities" (edX 2015). Besides being entirely online and digital, as well as free or affordable on a low budget, a MOOC generally "requires no previous qualifications to study" and sets "no limitation on age or geographical location of students" (Sadera 2014: 9). Most notably, the latter is why proponents of MOOCs claim that "online learning [might] be the most important innovation in education in the last 200 years" (Regalado 2012: 62). While online learning per se is not entirely new, MOOCs are different in their scope. What is revolutionary is the combination of different tools that are used for teaching, such as "videos, audios, lecture recordings, online quizzes and activities, forums and readings" (Sadera 2014: 9). MOOCs are not designed to be consumed one-directionally. Peer-to-peer communication via email and discussion forums is an important component of the teaching concept. There is also the possibility to engage with an MOOC's content asynchronously. Students do not have to be at certain places at specific times to hear a lecture. Instead, one can fit sections of the course into one's daily schedule. This "is particularly appropriate for students who work full-time and for returning learners with care or other responsibilities" (ibid.: 11).

Connected Reporting can benefit from MOOCs. The content needs to be focused on three target groups: employees, suppliers, and customers. Imagine a MOOC designed around the corporate responsibility guidelines of a company. On its website, for example, Daimler AG names seven responsibility dimensions: management responsibility, product responsibility, production responsibility, employee responsibility, ethical responsibility, social responsibility, and responsible business partners (cf. Daimler 2015: 4). Each of these comprises several subfields. For Daimler, subfields of the production responsibility dimension are "[e]nergy efficiency and CO_2-free production, water conservation, waste and resources management, [and] air purification" (ibid.). Ultimately, it is Daimler's employees who are responsible for implementing these guidelines. A MOOC offers the chance to not only inform about and make a large number of employees aware of the production responsibility dimension, but to create a shared vision concerning Daimler's production responsibility. "In resonant companies, a shared vision trumps individual needs, and the atmosphere is ripe with enthusiasm, passion for learning, and hope […], people learn together, pull together, win together" (McKee 2015: 40). The ultimate goal is that a shared production responsibility vision translates into enhanced employee engagement and innovation. At the end of Magenta MOOC, 100 teams uploaded their innovative solutions to a couple of tasks. Ideas, for example, included the transformation of old phone boxes into charging stations for eBikes, eCars, and smart devices, along with an app and cloud-translation service for the hearing and visually impaired (cf. Bouzidi 2015: 95).

As subfields of their responsible business partners responsibility dimension, Daimler has identified "business partner integrity management" and "compliance with standards in the supply chain" (Daimler 2015: 4). Multinational firms work together with multiple partners from all around the globe. With contracts and elaborate inspections, these firms aim at getting a grip on the principal-agent problem. Imagine a MOOC designed to align supplier and ecosystem partner understanding of responsibility with Daimler's understanding of it.

One challenge to tackle when implementing a MOOC is how to motivate people to engage with it. Stanford University struggles with completion rates "as low as five to ten percent" (Walsh 2015: 27). However, completion rates are not the best approach to reassessing engagement. Paul Sebastien, vice president and general manager for MOOC provider Udemy for Business, assures that "[c]ompletion rates are definitely a lot higher in the business setting than in the academic world. Integrating MOOC completion into a reward system as well as offering badges, certifications and material incentives for completed course sections might motivate participants to proceed with the course contents" (ibid.: 28).

The third target group of MOOCs for reporting purposes is customers. Imagine a MOOC designed for customers to engage with while driving their car. EdX, Coursera and other providers offer students the possibility to profit from academia experts in higher education. Companies could offer customers the possibility to profit from their expertise on sustainability and social responsibility-related topics. The German software corporation SAP SE, in cooperation with the Hasso Plattner Institute, has set up the online learning platform openSAP. It offers MOOCs in English and Chinese on information technology, and "win[s] trust through broad-scale customer education" (Herring 2014: 48). Note that "SAP's completion rates are trending at five to seven times higher than the completion rates of academic MOOCs" (ibid.).

4.5 Gamification

Gamification is a tool for encouraging and engaging stakeholders. It is a method that includes gaming aspects and elements into non-gaming processes, products and services. The aim is to make stakeholders undertake and adopt actions or behaviour (cf. McGonigal 2011; Deterding et al. 2011). Gamification uses multiple aspects of standard games, like awarding points and badges and including levels, leader boards, avatars, gifting, real-time feedback, virtual currencies and challenges (cf. Sicart 2008; Kumar/Heger 2013: 27). Gamification promises to break open traditional forms of communication in the business environment through a gaming perspective. Take feedback as an example. Though feedback is important for successful communication, in the business environment, stakeholders often get little and time-delayed feedback for certain aspects. In games, feedback usually is given directly and in real-time. Games often make certain goals clear to reach from the start, encouraging the player. The business environment can learn from this. Ultimately, rules at work often seem to be non-transparent and dogmatic, while rules in games are mostly formulated clearly and transparently (cf. Kumar/Heger 2013: 27). These game-specific aspects fulfill certain functions for both the developers and the players. For CSR communication, two functions seem to be important: motivation and education. Gamification catches stakeholder attention by offering short introductions. These should be easy to understand, and easily playable. Success and personal development should be present soon. Nike's Application 'Zombies, Run!'

is a good example of the successful use of gamification to encourage stakeholders (in this case, customers) to run and use the company's 'Nike+' Application, and other sports products. The user has to install the app on their smartphone and run away from a horde of zombies. It includes story-elements, individualized music playlists and standard running data, like pace and GPS.

In a CCR model, gamification might be a content-design tool to engage and encourage passengers of the connected car. Stories and information about a company's social responsibility can be transported via a game, which passengers can play using the car's infotainment system. Corporate blogs and the standard online CSR report can include aspects of games. Passengers might be awarded with points or badges for reading certain articles. Rewards could come in the form of vouchers or, in the case of an automotive company, invitations to guided tours through factories.

5. Conclusion

Connected Corporate Reporting uses Big Data as well as newly-connected reporting channels to inform stakeholders transparently, let them participate in decision-making processes and sensitise them to specific CSR issues. Companies refer to a stakeholder database to customize the content provided for each individual stakeholder. Databases are constantly filled with data, because stakeholders use and communicate via objects from the Internet of Things. The presented model of Connected Corporate Reporting, with its several implications for CSR reporting, might at first seem difficult to implement. Undoubtedly, it requires some bravery to make the first step towards the future of CSR reporting. However, a company that wants to cope with the huge transformations that are changing our society has to stay open-minded about unconventional methods. During the cycles of Reporting 1.0 and 2.0, companies have tested various formats of CSR reporting, of which some were doomed to failure, while others contributed to a more sustainable and responsible economy. If companies learn to use their connected products for communicating crucial CSR issues, new forms of interactivity and participation will come into existence, leading to real discourse. While the model of Connected Corporate Reporting introduced is implementable for any industry, the connected car enables the automotive industry to take a leading role in the future of CSR reporting. Be brave: leave the printed CSR report behind and enter the connected world of future reporting.

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SUSTAINABILITY IN THE AUTOMOTIVE SECTOR

Moral Cars

Moral Cars

Ethical Decision Making of Autonomous Cars in Crash Situations

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Keywords

Autonomous Cars, Ethical Decision Making, Dilemma Situations

This paper addresses ethical decision-making routines of well-informed autonomous cars in collision scenarios. Here two cases of how autonomous cars should act, based on available information, will be analyzed. First, if there is little information and little predictability, we argue that the best option is to brake. Secondly, it is shown, if autonomous cars can process and exchange information quickly, decision making becomes a complex ethical issue, in need of a basic concept for different conflicts: individual vs. collective interests, and individual vs. collective decision-making power. To provide solutions, the positions of Anders Sandberg and Noah Goodall, who try to overcome the main weaknesses of utilitarian and deontological approaches, are introduced. We conclude that a full-fledged solution with universal moral validity is not feasible. The challenge is finding a well-balanced compromise between individual and collective decisive power, as well as the right positioning between the conflicting theories of utilitarianism and deontological ethics.

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1. Introduction

Autonomous driving is in its infancy, yet there is no doubt that cars being able to drive independently of humans will transform not only the automotive industry but the lives of people as a whole.

Autonomous driving has gained a lot of public interest over the past few years, but the matter is not as new as one might think. Daimler was a pioneer in this regard. It was back in 1986 when Daimler's engineers started a project, in cooperation with the German Federal Armed Forces, to research and build autonomous cars. The result of this cooperation was the "Versuchsfahrzeug für autonome Mobilität und Rechnersehen" (VaMoRs), a completely altered Mercedes 500 SEL that was able react to real-time image evaluation, and whose steering and brakes were controlled by a computer.

Twenty years later, most of the world's leading automotive companies are preoccupied with this topic. Technology has made huge steps forward, and for the past three years Daimler (along with other big players like Nissan, Audi and the technology giant Google), has been taking various measures to push its development. In August 2013, the Mercedes S500 INTELLIGENT DRIVE drove 100km from Heidelberg to Pforzheim without a single human intervention. In January 2015, Daimler's CEO Dr. Martin Zetsche presented the "F015", a sophisticated conception of an autonomous car, and Daimler engineers recently announced that newly developed autonomous vehicles might be ready to go into mass production in 2020.

Nevertheless, one must be aware that even though we will reach a new level of mobility, new technologies are also prone to bringing about hazards and insecurities. In this paper, we will discuss an issue that is deeply entrenched in moral philosophy and must be addressed from an ethical point of view when we talk of autonomous cars. The question is: what happens if autonomous cars face a situation of inevitable collision and need to make a decision about what to do next?

In Chapter 2, we will give a brief overview of the benefits of autonomous driving, show why the question is a moral one, and see why it is legitimate to ask such a question at all. We will then begin to provide possible answers to the question. We will split the investigation into two scenarios. In Chapter 3, we will introduce the first scenario. Here, the car will face an inevitable collision, provided with only little information about the circumstances shortly before the crash. We will then consider the first response to the question, that of slamming the brakes on. We will show that, although the solution of braking is an obvious one, it is more complicated than it first appears. In addition to the physical reason of reducing kinetic energy, we will provide a moral justification for braking, through the application of the Doctrine of Double Effect. Eventually, we will show the limits of this solution if more information becomes available. This leads to our second scenario. We will argue that if the autonomous car gets more information, we face a complex ethical decision, with various factors involved. While searching for a basic decision-making concept, it all comes down to the question of whose interests to prioritise – those of the car holder, or those of society as a whole, and to whom we should grant the power to decide. In Chapter 4, we will assess scenario 2, with the classical positions of utilitarianism and deontology. Both of them entail several shortcomings that make the application of recently published frameworks necessary. The positions of Goodall and Bradshaw-Martin/Sandberg will therefore be introduced and assessed. We will conclude in Chapter 5 that providing a full-fledged solution with universal moral validity is not feasible, the challenge will instead be to find a well-balanced compromise between individual and collective decisive power, as well as a position between the conflicting theories of utilitarianism and deontological ethics.[1]

2. Advantages and Challenges of Autonomous Driving

2.1 Benefits of Autonomous Driving

Currently, autonomous driving is regarded with a great deal of distrust. A recent survey in Germany conducted by Puls Marktforschung found that the preferred way of driving is still the conventional one: every second participant of the survey chose the option of driving with complete

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1 As the term "autonomous cars" will be used frequently in the next sections, a defining remark is advisable. The National Highway Traffic Safety Administration (NHTSA) has issued a classification scheme that clusters cars into different levels (Level 0 – Level 4) according to their degree of autonomy. In this paper, we assume that cars have already reached the highest level of automation, which is the level of full self-driving automation (Level 4). NHTSA defines these vehicles as "designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any time during the trip. This includes both occupied and unoccupied vehicles." (http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases +Policy+on+Automated+Vehicle+Development) (Accessed 22.07.2015).

human control. By contrast, only 5.2% stated that they would prefer a fully autonomous car for transportation. However, a compromise between technology and human control, i. e. the solution of partly autonomous operated driving, seems to be more attractive to the respondents. 42.5% would prefer to sit in a vehicle that is conducted partly autonomously (cf. Puls Marktforschung 2015). One of the reasons for the observed lack of trust, aside from a somewhat intuitional fear of novelty, might be the missing vision of the benefits that come with autonomous driving. In order to steer clear of a biased perception and a unilateral discussion, we will provide a collection of benefits in the following section. The findings are clustered around the four keywords 'Mobility', 'Security', 'Traffic' and 'Efficiency'.

Mobility

Autonomous cars can improve the mobility of a wide range of people. Their support could range from cases of mere tiredness to situations where those under the influence of medication need to move around (cf. Maurer et al. 2015: 4). People with impaired vision, epilepsy or severe Asperger's syndrome, who are currently excluded from having driving licenses, could eventually profit from the benefits of auto-mobility. The same benefit would apply to the elderly, who suffer from increasing forgetfulness or disorientation. In general, individuals that do not possess the required abilities to drive could still have independent use of mobility, where today they are dependent on the help of others, or cannot move at all (cf. Bradshaw-Martin/Sandberg 2013: 5).

Security

The vision of accident-free driving has a huge impact on modern car engineering. Vision Zero is a philosophy of road safety which deems deaths and injuries caused within the road transport system to be unacceptable (cf. Tingvall/Haworth 1999). A policy reflecting this vision was first brought into practice by the Swedish government in 1997, and in 2010 the United Nations adopted some of the policy's principles and hence made vision zero a global goal (cf. Belin et al. 2012). Existing driver aids (like 'adaptive cruise control' or 'lane departure warning') have already improved the security of passengers and other road users. Still, more than 3,000 road deaths occur annually just in Germany (Statistisches Bundesamt 2015). With autonomous driving, vision zero could almost become reality. The main contribution would be the continuing eradication of human failure through its replacement with nearly infallible computer systems. Autonomous cars could diminish the number of killed or severely injured individuals. This would be excellent for society's well-being (cf. Bradshaw-Martin/Sandberg 2013: 4).

Traffic

Traffic jams will be a rare phenomenon once autonomous cars have entered the streets in a sufficiently high number, and when they are connected. Through intelligent communication, cars need less space between them, which means more cars can be put on the same road and traffic will still flow. Being able to keep to shorter distances is of use in city traffic because more cars can get through the traffic lights at the same time. Another aspect of traffic improvement comes with the fact that autonomous cars could also be shared, in order to minimise the number of cars on the streets in total. If the technology works safely enough, autonomous cars could even go beyond sharing. Completely unmanned vehicles could enter traffic and fulfil several tasks, like picking up passengers or transferring goods independently of direct human supervision (cf. ibid.: 5).

Efficiency

The last key feature is the gain of efficiency in economic, environmental and individual aspects. Car-2-car communication, enhancement of traffic flow and the sharing of autonomous cars will serve the fuel-efficient driving and cost-efficient use of the cars. This will keep costs of car maintenance down and help preserve the environment in a global society that is becoming more motorised. Moreover, there is another great benefit that affects each individual driver. If the car operates without the need for the passenger to be alert, individuals can do other tasks. In this scenario, people are not forced to spend their time driving anymore if they are not willing to. Instead, they can work, socialise or enjoy their leisure time. Commuter productivity could increase hugely, and individuals would be able to manage their issues more time efficiently (cf. ibid.).

Having an idea of the changes that autonomous driving will bring about will certainly reduce the discomfort that people feel about it. Still, it is important to note that the aforementioned lack of trust will not be eliminated completely through the clarification of affairs. There are serious questions that must be tackled by academics and practitioners. One of these questions is linked to the fact that once a person sits inside a fully autonomous vehicle, they must rely on independent decisions which are made by technology. The passenger's fate, as well as the fate of the other individuals involved, is at the hands of a machine, and the experience of a complete loss of control is unavoidable.

In order to restore trust, one of the greatest challenges to arise will be providing a convincing foundation for the cars' decision-making processes, as well as a transparent account of it. This is of great importance, especially with regard to decisions made by an autonomous car that directly affect the passenger or another physical entity: decisions made in crash situations. What should an autonomous car do in the face of inevitable collision, and what should be the foundation of its decisions?

A New Challenge Arises

Unprecedented Events Lead to Crashes

Accidents will occur, no matter which passive or active measures are taken, since unexpected events will always happen (cf. Benenson et al. 2008: 519). As Goodall argues, crashes can occur independently of the capabilities of automated vehicles and of their environment (cf. Goodall 2014a: 2). There are two reasons for this.

First, it is very probable that system failures will occur. Every human-made system ever conceived has occasionally failed. There is no reason why the systems designed for autonomous vehicles should be an exception. These system failures can eventually lead to an accident.

Second, even if we have perfect technology, crashes will still occur. Two different assumptions can be made about the car's environment: either the autonomous vehicle drives in mixed traffic with human drivers, or the traffic consists of autonomous vehicles only. Let us begin with the first assumption. An autonomous car with perfect technology and therefore complete awareness of its surroundings would be able to safely avoid static objects. Dynamic objects with unpredictable behaviour, such as human-driven cars, could still cause an accident in some situations. As Benenson, Fraichard and Parent acknowledge, there is no way to completely avoid crash situations for an autonomous car when dynamic objects with unpredictable behaviour are involved (cf. Benenson et al. 2008: 519).

Now let's consider the second possibility: traffic without human-driven cars, consisting of autonomous vehicles with infallible systems only. Even then, crashes will occur. Since autonomous cars would in this case be able to predict each other's behaviour correctly and coordinate their actions through communication, driving would be very safe. But autonomous vehicles would still face crash situations involving wildlife, pedestrians, cyclists or natural catastrophes. Furthermore, it is to be added that neither the assumption of perfect systems nor that of traffic consisting of autonomous vehicles only is realistic in the near future. It can be concluded, therefore, that autonomous cars will encounter inevitable collision states, which Fraichard and Asama define as follows:

> "An inevitable collision state for a given robotic system can be defined as a state for which, no matter what the future trajectory followed by the system is, a collision eventually occurs with an obstacle of the environment" (Asama/Fraichard 2004: 1).

The Ethical Aspect

In such inevitable collisions, any action taken by the autonomous vehicle will lead to a crash situation. Nevertheless, different actions might lead to different outcomes, differing in how much harm will be caused and to whom harm will be inflicted. In an inevitable collision state, the decision of the autonomous car is always an ethical one. Decisions taken by an autonomous car in unavoidable crash situations differ from those taken by human drivers. When faced with a crash situation, a human driver does not have much time to think; their reactions must be very quick and will therefore be instinctive rather than carefully thought through. This does not hold true for decisions taken by an autonomous car. The autonomous car only has the same time to assess the situation, but the grounds its decisions are based on were conceived far in advance and programmed into its system. We now have all the time we need to think about these grounds for decision-making, and we can think about ethically ideal behaviour, and program future autonomous vehicles so that they will act according to it. However, these possibilities come with great responsibility. Careful consideration about the foundations for such ethical decisions are needed.

Problems of Reliance on Human Drivers

Handing over control in dangerous situations so that the ethical decision is still taken by a human driver is not a valid solution to the problem of unprecedented crash situations. There are two ways a human could be involved in the process of driving: either the driver is monitoring the car's behaviour continuously, with the possibility to intervene at any time, or the car gives a signal some time before the crash occurs so that the driver can assess the situation and take over. In the following, we will demonstrate that both have significant shortcomings.

To expect humans to remain alert while monitoring the car's behaviour over a long period of time seems unrealistic. A necessary condition for autonomous cars being allowed on the market will probably be to drive significantly more safely than the average human driver. This means that an accident would occur on average much less than every 1.46 million kilometres (cf. Vorndran 2010). To stay attentive over such a long period of time (without having to interfere in any other way) seems to be a very demanding task. Although the effects of automation on a human driver are still unclear, Goodall points out that a human driver would not be able to take control of the vehicle immediately, because of a loss of attention (cf. Goodall 2014a: 5). In addition, accidents or other dangerous situations may occur because of people intervening, although there might be no necessity for it. Interventions through human drivers could even generate more accidents (cf. Hevelke/Nida-Rümelin 2015: 624).

Furthermore, if the driver is expected to pay attention to the road and traffic, autonomous cars would lose much of their utility. Many of the things that make autonomous driving so attractive would have to be given up, such as making use of autonomous driving for one's leisure or work time, car sharing and giving disabled people access to mobility, to mention but a few.

Another possibility is that the autonomous car tries to predict crash situations and alert the drivers some time before the crash occurs, so that the driver can take over. As Goodall points out, the main problem that arises is that humans would need substantial warning time (cf. Goodall 2014b: 1). Simulation experiments suggest that drivers would need up to 40 seconds to regain awareness of the situation, depending on the activity they were pursuing. It is probable that the movements of other vehicles, pedestrians, cyclists or other moving objects cannot even be predicted six seconds into the future (cf. ibid.). The warning time will therefore be insufficient. In addition, the driver's reaction in such situations would be a spontaneous one, as the time would be insufficient for longer thinking. Nothing guarantees or even indicates that spontaneous decisions taken under pressure tend to be rational or even ethical. In contrast, the autonomous car would be able to quickly assess the situation and approximately calculate probable outcomes. It would then be able to choose a certain action, the decision depending on how it was programmed.

In dangerous situations, the autonomous car will stay in control and have to make ethical decisions without waiting for the approval of the human. Therefore, the question remains: what should an autonomous car do in the face of inevitable collision?

3. Decision Making Dependent on Technological Constraints

Scenario 1

In scenario one, we take a well-functioning, fully-autonomous car, with limited technological performance. The car's ability to distinguish between objects and to calculate the trajectory of moving objects has reached a stage which makes autonomous driving at least as safe as human driving. However, it is still subject to constraints. The field of view is still relatively small, and many features of the surroundings cannot be registered by sensors. The car cannot distinguish between different types of vehicles, is not able to discern how many people occupy other vehicles, and the car cannot make out the specific characteristics of people. The car reacts reasonably well to the actions of other road users in ordinary traffic situations. In crash situations, however, the car is not able to accurately predict the behaviour of other road users.

Imagine now that an autonomous car happens to be in an unavoidable collision. As mentioned before, in such a collision, any possible action taken by the autonomous vehicle will lead to a crash. Nevertheless, different courses of action might lead to different outcomes. In scenario 1, we assume that the sensing constraints are such that the autonomous car recognises that it is in an unavoidable collision state, but that it cannot assess the outcome that would follow from a specific action. More precisely, it is neither able to estimate the kind nor the gravity of the damage that would be caused by a specific action.

Let us look at an example of such a situation. Imagine the autonomous car from scenario 1 is driving on a narrow mountain road. A crowded bus is driving in the opposite direction. Shortly before passing the car, the bus unexpectedly cuts into the car's lane. The autonomous car is now facing an unavoidable collision. No matter how the car reacts, the speed is too high and the distance to the bus too narrow to avoid a collision. The autonomous car can now react in many different ways but cannot predict the exact consequences of its action – the only sure thing is that a crash is unavoidable. How is the autonomous car supposed to react? We argue that in such a situation, the best action is simply to break. We will justify this solution in two ways: a physical and a moral one.

The first justification involves a pragmatic approach to the scenario. As it is impossible to differentiate between the different collision states, braking is the option with the highest probability of bringing about an acceptable outcome. Reducing kinetic energy is more likely to result in less damage in the majority of inevitable crash situations. This bears on the uncontroversial physical fact that the higher the velocity of a body, the higher its impact energy in a collision. Higher impact energy in turn causes higher deformation in the colliding bodies, which means that it causes more damage.

Still, the solution of braking is suboptimal. There are a set of cases where it might change things for the worse, e.g. cause severe or even deadly injuries that would not have occurred otherwise. While the pure physics of braking might not justify such outcomes, the second reason we will provide can account for such cases. We argue that braking can be morally justified by applying the Doctrine of Double Effect (DDE). "Double effect" refers to the two effects that an action may produce: the one aimed for, and the one foreseen but in no way desired (cf. Foot 1967: 1). The DDE is defined in various ways, but the following account from the "New Catholic Encyclopedia" comprises the most important features:[2]

1. The act itself must be morally good or at least indifferent.
2. The agent may not positively will the bad effect but may permit it. If he could attain the good effect without the bad effect he should do so. The bad effect is sometimes said to be indirectly voluntary.
3. The good effect must flow from the action at least as immediately (in the order of causality, though not necessarily in the order of time) as the bad effect. In other words the good effect must be produced directly by the action, not by the bad effect. Otherwise the agent would be using a bad means to a good end, which is never allowed.
4. The good effect must be sufficiently desirable to compensate for the allowing of the bad effect.

Now, what implications does the DDE have with regard to inevitable crash situations for autonomous cars and the justification for braking? To give a clearer understanding, we will return to our example and give it a slight modification, such that the example now represents the set of cases where braking makes things worse.

Suppose that there is a third vehicle involved. This vehicle is driving at full speed behind the autonomous car. Since there is a turn between the third vehicle and the autonomous car, the third vehicle is not able to anticipate the crash. The autonomous car decides to brake as hard as possible, to minimise the damage produced by the collision with the bus. As a result of slamming on the

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[2] http://plato.stanford.edu/entries/double-effect/ (Accessed 22.07.2015).

brakes, the tailgating vehicle crashes into the autonomous car and the passengers die.

The physical explanation will not suffice to justify the death of a third party (the occupants of the tailgating car) in order to try to reduce the damage of the two parties involved in the crash in the first place (the bus and the autonomous car). It is a matter of differentiating whether the autonomous car, and respectively its programming, intentionally aimed for the death of those passengers, or merely foresaw that consequence in order to produce a greater good.

As it is not the purpose of this section to enter into discussion about whether automatically operated products like autonomous cars can have intentions or not, we must rephrase the question. In this scenario, the car does not have access to essential information about its environment. We thus take it to be a "dumb" object, completely dependent on the intentions of the software developers and other involved people that programmed the car to brake in the described situation. We will assess our example in detail through the application of the four conditions provided above.

1. The mechanical exercise of braking does not, in itself, represent any values that we consider morally good. However, neither does it in itself involve any evil, although it may of course be used for evil purposes. Considering it as an act itself, it can well be argued that at least it is indifferent.
2. Foot holds the view that the clue of DDE lies "in the distinction it makes between what we *do* (equated with direct intention) and what we allow (thought of as obliquely intended)." (Foot 1967: 3) In accordance with this, we argue that the people who program the autonomous car do not aim to direct attention to the death of the passengers in the third vehicle. Instead, they foresee the impairment of the tailgater as an oblique consequence to produce a greater good, i.e. the autonomous car not crashing into the bus with unmitigated velocity.
3. By means of braking, the mitigation of damage sets in immediately and is not caused through the crash of the tailgating vehicle. The crash of the tailgating vehicle is not a means to an end, that of reducing damage for both the autonomous car and the bus.
4. The question of whether it is permissible to weigh lives against each other is controversial. In the face of existing uncertainty, braking might produce a case where things are worse or not. In combination with the claim to distinguish between allowing and doing, we hold the position that the act of braking to attain the positive effect of rescuing the lives of the passengers of both the bus

and the autonomous car does sufficiently compensate for the allowing of the deaths of the tailgating passengers.

As we have mentioned, future outcomes of actions are uncertain. We must thus consider another case: the positive effect, which would justify worse outcomes as side-effects, does not occur at all. Such a case would arise when, by braking, one does not invoke a good effect and only brings about a bad outcome. Referring to our example, this could be the deaths of the passengers in the tailgating vehicle, together with the death of all the passengers in the bus and the autonomous car.

However, we argue that braking can still be justified, due to the considerations made under reason one. In the face of the unpredictable outcomes of the other possible manoeuvres, it is rational to assume that, for the vast majority of cases, braking mitigates damage. Braking is therefore still the most acceptable option, even though the worst cases can be unexpected. In this regard, the characteristic of any unexpected occurrences is important to stress. If such situations can be anticipated, and it is possible to avoid them through a combination of swerving and braking, for example, then this should be done. This is to say, we do not categorically exclude swerving as a solution. If the predictability of outcomes gradually increases, swerving could become an appropriate measure to reduce damage too. Still, in an extreme scenario, when the outcomes of collision states are all equally unknown, braking is the first solution.

As a final remark, we are not suggesting that it is possible to generally defend the solution of braking in each and every inevitable crash. It is highly dependent on circumstances. As is stated under the second condition of DDE: "If he could attain the good effect without the bad effect he should do so." Our example is constructed in a way that does not allow for the positive effect without the negative. For every other case, a deliberate evaluation is required when applying the DDE.

3.2 Scenario 2

In scenario two, we use a well-functioning full-autonomous car equipped with highly advanced technology. It is subject to only marginal sensing constraints, and has a very wide and dependable sensory coverage of the surroundings. Many details for the surroundings are now accessible: the car can distinguish very precisely between different road users, and even between different types of vehicles. It is able to discern how many people occupy a vehicle and can make out specific characteristics of people. The car reacts very well to the actions of other road users in ordinary traffic situations. In crash situations, the autonomous car is now able to approximately calculate the outcomes of different actions.

What should an autonomous car do in scenario two if a crash is unavoidable, with different actions being possible? We argue that braking is no overall solution anymore. The reason for this is that the car is now able to assess the outcome that would follow a specific action. In scenario 1, if a car happens to be in an unavoidable collision, almost nothing is known about the following attainable states, other than that they all are collision states. In scenario 2, an autonomous car in an unavoidable collision state knows much more. It knows that no matter which action is chosen, every state following the current state is a collision state, but it can also approximate the outcome of every collision state.

Assume that the autonomous car assesses three actions as available, leading either to collision state A, B or C. Now, the autonomous car also knows approximately the damage that will occur in A, B and C. Choosing an action is therefore equivalent to choosing a specific outcome. This means that the decision has become a complex and highly ethical one: we have to choose an allocation of harm. Of course, we want the amount of harm to be as low as possible. Even with this in mind, it is still unclear how the car ought to react in many of the situations.

Let's take a second look at the example from scenario one to illustrate this point. The autonomous car is driving on a narrow street, and its lane is cut by a manually operated bus coming from the other direction. The only modification of our example consists of repealing nearly all technological constraints the autonomous car faced in scenario 1. To reduce complexity, we assume that the autonomous car can choose between three different actions (A, B or C), with each of them leading to a different outcome.

A. The autonomous car swerves heavily to the right, inflicting damage only to its own passengers while the bus is undamaged. The car hits the crash barrier or goes off the road, clearing the way for the bus.

B. The autonomous car tries to minimise its own damage and squeezes through the space between the bus and the road's boundary, resulting in the bus hitting the crash barrier or going off the road.

C. The autonomous car stays in the lane, brakes and crashes into the bus head-on. Both parties are severely damaged.

Actions A, B and C allocate damage between the parties involved in the crash situation differently. In A, the main damage is inflicted to the autonomous car, whereas in B the main damage is inflicted to the bus. In C, both parties suffer severe damage. It should be remembered that as we are in an unavoidable collision state, with no action that would spare both parties.

One difficulty is that the action minimising the damage must not be an action that allocates damage equally to the parties. It could be that, in order to minimise damage, one action must be chosen that distributes damage unequally. Distributing damage equally is thus not necessarily the preferable solution.

Having to choose between options A, B and C, we must ask: how should the autonomous car decide? Being required to make a choice between A, B and C implies that there has to be a basic concept on which the car decides. Hence, we come back to our basic question: on which foundation should the decisions of autonomous cars be based? The answer to this question is not clear. Instead, the question itself serves as a starting point for examining the core points of the matter. Independent of what this foundation looks like, it has to take into account a conflict that lies at the heart of the example we have introduced: the conflict between the interests of the car-user and the interests of the group of traffic participants as a whole (including the user of the autonomous car). We summarise this underlying problem as the Question of Priority.

- The Question of Priority: To which of the parties should we give priority?

If this is a core question that has to be considered when trying to find a foundation for the decision-making processes of autonomous vehicles, then this question does not stand alone. As it is not clear who has to give the answer to the Question of Priority, another question follows on from it.

- The Question of Decisive Power: Who gets to decide which ethical principles are to be employed, and to whom do we give priority?

In the following section, we will look at possible answers to the basic question of what a decision-making foundation could look like. We will assess the opportunities and shortcomings of several ethical frameworks as possible answers. In Section 5, we will then evaluate how the introduced positions relate to the Question of Priority and the Question of Decisive Power.

4. An Ethical Foundation for the Autonomous Car's Decisions

Consequentialism

For consequentialists, the classification of actions as morally right or wrong depends on their consequences and how much "good" they produce (as opposed to the circumstances or the intrinsic nature of the act, or anything that happens before the act).3 There are several subdivisions of consequentialist theories, assigning importance to different aspects of consequences. The dependence of normative properties on consequences constitutes the common core of all of them, no matter what one refers to as being good, e.g. utility, happiness or wealth.

The paradigm case of consequentialist theories is utilitarianism, its proponents being famous philosophers of the 18th and 19th century like Jeremy Bentham and John Stuart Mill. In their view, the moral correctness of an act depends only on its future effects. They hold the position that an action is morally right if and only if it causes the greatest happiness for the greatest number.[4]

Considering this theoretical background, we can draw an implication with regard to the way autonomous cars in crash situations similar to those of scenario 2 should make their decisions. Being able to differentiate between possible outcomes of collision states and their relative probabilities to actually occur, autonomous cars should – according to a consequentialist approach – strive to choose the crash trajectory that causes the greatest happiness for the greatest number of individuals. Or, if happy lives are not what matters, it should maximise what matters instead (cf. Lin 2015: 8). Conversely, autonomous cars should choose the action which is most likely to minimise global harm and damage (cf. Goodall 2014c: 5).

The consequentialist approach to ethical decision making in autonomous cars might initially appeal to our intuitions. It seems reasonable to treat unavoidable situations in this manner to ensure the well-being of the majority, when outright inviolacy is not an option anymore. Still, there are several shortcomings, and they might relativise the initial positive appeal.

Consequentialism is criticised for the fact that, by looking only at the consequences, it can justify any kind of act. It demands that, in certain circumstances, innocent people can be killed,

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[3] Cf. http://plato.stanford.edu/entries/consequentialism/ (Accessed 22.07.2015).

[4] cf. http://plato.stanford.edu/entries/consequentialism/ (Accessed 22.07.2015).

beaten, lied to, or deprived of material goods to produce greater benefits for others.[5] No course of action is absolutely prohibited, and no privileges for people in certain relationships are granted. Consequentialism takes all individuals into account equally, regardless of context. It does not matter whether harm must be inflicted to people close to us (friends, family, compatriots) in order to bring about the greater good. Similarly, it does not matter how harmful an action is to some, as long as it brings about more global benefits. Every person must be aware that they can be taken into a consequentialist calculation and may be required to sustain some damage, even though they may not have been directly committed to the issue.

With regard to our example, one extreme case of consequentialist reasoning might be that of self-sacrifice. As we have seen in the previous chapter, one possible course of action for the autonomous car in scenario 2 is to swerve heavily and get out of the lane. The bus could steer clear of any damage, but at the same time the autonomous car would expose its passengers to extreme risk as an act of self-sacrifice. A consequentialist expected-utility calculation could justify this decision, given that this action would increase the total amount of saved lives. An autonomous car with a consequentialist decision-making framework would always choose the act of self-sacrifice, as long as the expected-utility calculations of alternative manoeuvres deliver a higher than expected number of deaths or injuries (cf. Lin 2015: 8 ff.).

Deontological Ethics

In contrast to consequentialist theories, deontological theories do not judge the morality of choices in regard to how much good the consequences of these choices bring about ("good" can be interpreted as utility, happiness, wealth or similar values, depending on the theory). In a deontological approach, "what makes a choice right is its conformity with a moral norm."[6] Moral agents ought to obey these norms; the maximisation of such norm-keeping is not required. Since choices are not justified by their effects but by their conformity to a moral norm, a deontological theory can hold that an action is morally wrong even if it maximises the good. This theory promotes or minimises the overall number of wrong choices.

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5 http://plato.stanford.edu/entries/ethics-deontological/ (Accessed 22.07.2015).

6 http://plato.stanford.edu/entries/ethics-deontological/ (Accessed 22.07.2015).

When applied to machines, "deontological ethics consist of limits that are placed on a machine's behavior, or a set of rules it cannot violate" (Goodall 2014a: 7). This has the clear advantage of rights or duties we acknowledge as very important being upheld by the machine (in our case, the autonomous car) in every situation – we only have to make these rights or duties part of the system of rules it cannot violate. The car will then never act in a way which infringes this right or duty, independently of other positive effects which might be also brought about.

Although deontological ethics can provide guidance in many situations, it has great shortcomings when used as a foundation for the decision-making process of autonomous cars. First, developing such a set of rules "would require that someone articulates human morals" (ibid.). This would be a very difficult task, since there is no general agreement in the field of ethics about what is right and wrong. Second, rules generally need to be interpreted, whereas an autonomous car would only be capable of literal interpretation. This would lead to unexpected and, in some cases, unwanted behaviour. It might be inferred that the rules only need further specification until no misinterpretation is possible, but it is highly questionable whether the rules could be specified in such a way that literal interpretation would truly be sufficient. Third, no matter how specific the rules are, since it is improbable that a human-made set of rules could ever encompass every situation, the autonomous car could still encounter an unthought of situation. The right action would then not be defined by the rules.

4.1. Sandberg and Bradshaw-Martin: Autonomous Cars As Moral Proxies

In their paper "What do cars think of trolley problems? Ethics for autonomous cars", Sandberg and Bradshaw-Martin argue that autonomous cars are likely to get into ethical dilemmas, and at the same time neither represent moral agents nor moral patients.

According to the authors, only subjects that have control over their actions can be held morally responsible (cf. Bradshaw-Martin/Sandberg 2013: 13). This requires two essential preconditions. The first is the capacity of free will. It is controversial whether humans do really have free will. However, in the case of autonomous cars, it can be argued that they are subject to determinism and hence do not have free will. This is due to the fact that they are programmed in advance and are supposed to follow the program (cf. ibid.). This argumentation holds as long as neural networks and artificial intelligence are not employed in the programming process.

The second precondition for moral responsibility is constituted by a subject's amenability for the social practices of praise and blame. These social institutions allow society to address a lack of moral responsibility (cf. ibid.: 12). In the view of Bradshaw-Martin/Sandberg, our existing institutions are ineffective when it comes to praising and blaming autonomous cars. They therefore cannot be made morally responsible for any of their actions. Against this backdrop, the authors claim that the best solution is to keep moral responsibility as close to the human passenger/owner as possible. This would be in line with the current situation. At the moment, it is the human driver who is held morally responsible whenever disagreements about the right moral actions in a particular situation occur.

As a support to ease the burden of dealing with moral responsibility and to evade complete moral arbitrariness, this paper proposes the design of different ethical decision profiles, of whom the human individual can choose the one closest to his own moral convictions. The authors conceive of five possible ethical decision profiles. The car's decision could be based on a contractualist, an empirical, a probabilistic, a deontological or a consequentialist decision-making framework. They operate within legal and conventional limits, but it is the individual person that must weigh the advantages and disadvantages of each profile and eventually decide. The individual user is thus recognised as morally responsible for the use of an artificial technology.

4.2. Goodall's Three-Phase Approach

In his paper "Ethical Decision Making During Automated Vehicle Crashes", Noah Goodall (2014c) presents a three-phase approach to developing ethical crashing algorithms for solving the question of how an autonomous car should behave when a crash is unavoidable.

In the first phase, which is feasible with current technology, a "rational system" (ibid.: 63) for automated vehicle ethics should be used. This system should be shaped so that it minimises global damage (for example, on the basis of an algorithm which optimises a damage function so that the lowest overall damage is achieved). It should follow standards agreed on by representatives of selected interest groups; Goodall mentions the developers of automated vehicles, lawyers, transportation engineers and ethicists. These standards should be open and transparent to the public. Rules that shape this system should be based on widely agreed-upon concepts, such as the conviction that injuries are preferable to death, or that property damage is preferable to injury. For situations in which these higher-level rules do not clearly recommend specific behaviour, a safety metric should be developed. Goodall recognises, though, that a human-made set of rules is unlikely to cover all possible scenarios. According to Goodall, in cases not covered by the rules, or in which the rules conflict, the car should brake and evade (cf. ibid.).

The second phase presented by Goodall requires sophisticated software that does not yet exist. In this phase, an autonomous car can use machine-learning techniques to understand correct ethical decisions but would still be bound to the rule-based system from phase one. Goodall suggests using a neural network for this approach. Such a car would have the potential to learn human ethics through observation of human behaviour, or through rewards for its own ethical behaviour. There would be no need for a human to articulate precisely why an action is ethical or not. A car equipped with a neural network could identify the components of ethical behaviour on its own by analysing what characterises actions that humans rate as morally right. Goodall suggests the neural network be trained "on a combination of simulation and recordings of crashes and near crashes, with human feedback on the ethical response" (ibid.). Humans would therefore rate outcomes as more or less ethical, without the time constraint of a real crash.

In phase three, another major shortcoming of neural networks is expected to be solved: the inability of a neural network to explain its decisions. It can be of great importance to understand a car's behaviour in a crash situation, especially if the car did not behave as expected. Only that knowledge would enable engineers to make sure that if an autonomous car shows unwanted behaviour, it can be fixed so that it does not happen again (cf. ibid.).

These three phases constitute Goodall's incremental approach to automated vehicle ethics. As soon as the required technologies are feasible, we should move from one phase to the next, which erases the shortcomings of the former.

We have now introduced different philosophical positions which could constitute answers to our basic question, namely what the foundation of an autonomous vehicle's decisions should be when faced with an inevitable collision. We have demonstrated that pure forms of consequentialist or deontolodic approaches have major shortcomings. But what about the other two positions? In the next section, we will have a closer look at the positions of Goodall and of Sandberg and Bradshaw-Martin, with respect to the Question of Priority and the Question of Decisive Power introduced in Section 3. Independently of what an ethical foundation for the decisions of autonomous cars looks like, it has to take into account both of these questions: which should we give priority to, the interests of the car user or the interests of all traffic participants taken together? And who gets to decide which ethical principles are to be employed, and whom we thereby give priority to? In the following, we will analyse how Goodall, Sandberg and Bradshaw-Martin answer these questions, and what the general challenges in answering these questions are.

5. Individuals vs. Social Collective – Prioritising Interests and Decisive Power

5.1. The Conflict of Interests

We shall first look at the Question of Priority: which should we give priority to, the interests of the car user or the interests of all traffic participants taken together? Neither Goodall nor Bradshaw-Martin and Sandberg provide a clear-cut answer. This is not due to shortcomings of the authors, but to the insolubility of the conflict at heart. It is that of the interests of an individual human being (the passenger of the autonomous car) versus the interest of society as a whole, which includes all relevant stakeholders (with the individual passenger belonging to that group as well). The conflict between the interests of an individual human being and those of a collective relates to the ingrained disagreement whether it is morally right to maximise overall utility or to respect individual interests as absolute boundaries of permitted actions.

As we have seen in Section 3, the utilitarian approach clearly favours the interests of society as a whole by maximising the number of happy lives. By contrast, the deontological framework opts for norms that we must adhere to in any case, and that set limits that cannot be overridden. However, philosophers have been arguing for and against those positions ever since they were established, and disagreement about the criteria for rightful moral actions persists. This is especially the case when it comes to weighing lives against each other, which can well be required in situations similar to that mentioned in scenario two. It is not clear whether utilitarianism or deontological ethics are right with their propositions, but what can be said is that a decision for a particular decision-making foundation also means a position in this conflict.

During the evaluation of the two classical positions, applying just one or the other does not yield appropriate results, and entails major shortcomings. A feasible way of positioning could be a compromise between the two. Still, as there is no universal “right or wrong”, there is no obvious way to weigh these positions against one another.

Goodall, Sandberg and Bradshaw-Marting consider that there is no single rightful moral solution. As it is not possible to find a universal and uncontroversial solution, Goodall proposes negotiations between relevant interest groups, to find a rational rule-system based on widely agreed-upon concepts. This system is then employed, in order to minimise global damage. However, he does not prescribe any particular decision outcome in favour of one of the collision parties ex ante. Sandberg and Bradshaw-Martin go one step further and propose different ethical decision profiles. The user of an autonomous car can choose between them according to their moral preferences. The authors evade the problem of prioritising one party while at the same time acknowledging the disagreement about how a moral solution might look.

Who Gets to Decide?

If it has to be decided whose interests should be given priority, then we also have to to think about who gets to decide on this. We have identified two possibilities for this question:

A. We should decide about it collectively.

The members of the concerned society should be involved in the decision-making process in some way; in which way in particular is of no importance here. What matters is that it is some kind of collective decision between members of society or its representatives.

B. Each person should decide for themselves.

This decision should not be taken away by a certain group which then decides for all the other members of society. This decision should stay with the individual.

Let's first take a look at how recent positions try to answer this question. Goodall speaks in favour of a certain version of possibility A. He suggests representatives of selected interest groups should decide on a framework of rules to which the autonomous car would be bound. This means that they implicitly have to decide on the Question of Priority, since the rules would also regulate who is to be given priority. Goodall stresses that these rules and standards should be open and transparent to the public but does not give any decisive power to the individual.

Bradshaw-Martin and Sandberg clearly support possibility B: the decision should stay with the individual. They conceive an autonomous car as the moral proxy of the car user. To ease the burden of moral responsibility and evade complete moral arbitrariness, Bradshaw-Martin and Sandberg suggest that the car user should be able to choose between different ethical decision profiles. Since these different profiles would also vary in respect to whose interests would be given priority, the decisive power remains (within limits) with the car user.

When trying to answer the Question of Decisive Power, what we actually have to ask ourselves is whether this is a decision that can justifiably be made by a group of people and then enforced on others, or if the matter at stake is such that it should remain a personal decision. Of course, one could argue that whether a group of people may decide on such a question and then enforce the decision on others is a question of legitimisation. The group could consist of representatives elected by members of society. The group could also consist of all the members of society, deciding collectively which option to take. But even then, the question would remain: is this not a decision that should remain with the individual? Is a decision about personal safety in a private car one that can be made by someone other than the car user?

Choosing some form of possibility A may seem attractive at first, but turns out to be problematic in some respects. If a certain group of people decided to put the interests of the individual in the background, this could have major negative effects for the car user, which might be hard to justify if the decision was not directly consented to by that car-user. The most problematic case would be one of self-sacrifice for the common interest. Unavoidable crash situations can come up in which overall harm would be reduced dramatically if the autonomous car risks the lives of its occupants.

Recall our example in which a bus cuts into the lane of an autonomous car. Harm could be minimised if the car drove off the road, leaving the bus unharmed but subjecting the passengers of the autonomous car to great risk, probably leading to their deaths. Such a decision taken by an autonomous car would result in a most severe infringement of the right to physical integrity of the passengers. It is highly questionable if such an infringement can be justified by the decision of a group (however legitimate this group might be), or if the only way to justify it is that the car users have to consent to it individually – and thereby must also be given the possibility to reject it. Of course, such cases will be very rare. But this example shows that the autonomous car might be confronted with certain choices which should remain individual decisions and cannot be decided upon once and for all by a certain group of people.

On the other hand, choosing a pure form of possibility B and thereby leaving the decision of who gets priority entirely to the individual can also be problematic. If the individual driver can choose freely to always be given first priority when the car has to choose between several actions, this might lead to a very aggressive way of driving and endanger other road users more often than necessary. It thereby seems reasonable to limit the decisive power of the individual car user in some way.

In summary, it seems that giving full decisive power (possibility B) to the individual is not a valid option. Some limits should be agreed on collectively. At the same time, extreme cases show that some of the car's actions might only be justifiable through direct consent from the car user. We might have to provide some room for the private decisions of the car user.

6. Conclusion

Autonomous driving will come with great advantages, and also give us many new questions to think about. We have demonstrated how autonomous driving will lead to improvements in mobility, traffic, security and efficiency. We have also argued that one of the main reasons customers might lack trust in autonomous driving is that the occupant of such a vehicle will have to rely on independent decisions made by technology in situations of great risk, namely in crashes. We deduced that one of the most important questions that still has to be answered concerns what an autonomous car should do when faced with an unavoidable crash situation? Or more precisely: on which basis should it decide?

We first tackled this question within two different frameworks. In the first scenario, we discussed the question assuming that not much information was available to the autonomous car, the technology being at a rather rudimentary stage. We argued that since the autonomous car would not be able to estimate the kind nor the gravity of the damages that would be caused by a specific action, the best reaction possible would be simply to brake. We justified this solution on the grounds of a physical approach and by the doctrine of double effect. In scenario two, we assumed that more information is available, the technology being very well-developed. Since the car is now able to assess the outcome that would follow a specific action, choosing an action is equivalent to choosing a specific outcome. That means that in scenario two, the decision has become a complex and highly ethical one: we have to choose an allocation of harm. How the autonomous car should now decide is not clear.

Instead, we identified two main issues that have to be considered when trying to find a foundation on which the decisions of autonomous cars should be based. No matter how this foundation looks, it has to take into account the conflict of interests between the passenger of the autonomous car and the group of traffic participants as a whole. The two main issues that are to be tackled can therefore be summed up with the following questions:

- The Question of Priority: To which of the both parties should we give priority?
- The Question of Decisive Power: Who gets to decide which ethical principles are to be employed, and to whom should we thereby give priority?

In the second half of the article, we looked at possible answers to the basic question of what a decision-making foundation could look like. We assessed the opportunities and shortcomings of different ethical frameworks, such as utilitarianism and deontological ethics, and introduced the positions of Goodall and of Bradshaw-Martin and Sandberg.

In the last section, we analysed how these two more recent positions can give us answers to the Question of Priority and the Question of Decisive Power. We concluded that no definitive answer to the Question of Priority can be found, since the conflict between the interests of an individual human being and those of a collective relate to the disagreement about whether it is morally right to maximise utility or to respect some individual rights as absolute boundaries of permitted actions. Philosophers have been arguing for and against those positions forever. A feasible way of positioning this could be a compromise between the two. Still, as there is no universal "right and wrong", there is no obvious way how to weigh these positions against each other. What can be said is that any decision for a particular decision-making foundation also means a position in this conflict.

In respect to the Question of Decisive Power, we concluded that giving full decisive power to the individual is not a valid option. Some limits should be agreed on collectively. At the same time, extreme cases show that some of the car's actions might only be justifiable through direct consent from the car user. We therefore might have to provide some space for private decisions by the car user.

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SUSTAINABILITY IN THE AUTOMOTIVE SECTOR

Autonomous Cars

Automated Cars Save Lives

How Swarm Intelligent Cars Increase Traffic Safety

Andreas Gilson and Florian Holz

Keywords

Automated Cars, Swarm Intelligence, Road Safety, Traffic Efficiency, Automation

This paper deals with the impact of automated cars will have on traffic safety, along with their multilateral connection by becoming an intelligent network. It is only a matter of time before automated cars will become reality, and their numerous advantages will soon outweigh potential problems. Most importantly, automated cars have a higher chance of preventing crashes than human drivers. We argue that once cars are automated and strongly connected with each other, the benefits will be even greater. Traffic will no longer be a chaotic mix of individual vehicles but a swarm of intelligent machines, working together to increase efficiency and safety. We will first give a distinction between automation levels and the terms used in this paper. By pointing out the technical superiority of self-driving cars, we will show how taking humans out of traffic eradicates a large portion of today's fatalities. When it comes to communication, the identification of swarm governance mechanisms and their parallels to traffic have great potential: applying swarm intelligence frameworks to future traffic will lead to advanced reaction methods and efficiency advantages. After weighing up potential risks, we conclude that automation combined with swarm intelligence will significantly improve the safety of traffic.

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1. Introduction

The next big revolution in technology will be automation – and it has already started. Like the invention of steam engines or electricity, automation will have a huge impact on both the economy and society. The first sector to be radically revamped will be transportation, and its flagship is the automated car. Passenger cars convert from objects of utility to private spaces, where you can while away the time doing everything but driving. This space can be used as a private office on the way to the next meeting, or to have breakfast while being driven to work. It will also change the way of travelling, with the opportunity to bridge vast distances while sleeping in one's own bed. The comfort advantages are immense. Even the environment will benefit, with a clear reduction in fuel consumption through eco-friendly driving styles and smarter traffic coordination. However, the greatest benefit of automated cars will be their impact on safety. The WHO reports 1.24 million road traffic deaths worldwide every year (cf. WHO 2013). Taking the human risk factor out of the equation will eliminate the majority of accidents. Furthermore, integrating advanced communication technologies will make it possible to coordinate traffic more efficiently, and thus increase its safety.

Today's traffic is anything but perfect. Especially in emerging economies, traffic jams are the rule rather than the exception. The unsteady styles of human drivers keep the amount of accidents and interruptions high. A look at nature reveals a world in which traffic jams do not exist. We all know about the smooth motion of fish swarms, which move apparently flawlessly around obstacles or predators. Would it not be nice to have such movement in our everyday traffic? Maybe our future traffic won't look like a shimmering swarm but applying the patterns these animals follow is not as unrealistic as one might think. Many scientists engaged in collective intelligence research are seeing the parallels between traffic and swarms. Flocking behaviour and swarm intelligence normally work on the basis of a few simple rules, which result in common movement appearing quite complex. Applying this to the world of traffic would increase the steadiness of traffic flow, as well as overall efficiency. A further increase in safety could be attained, as unsteadiness is a factor in uncertainty and crashes.

Two major questions arise: how can the introduction of automated cars lead to an increase in safety? And how can swarm intelligence research help us to attain this goal?

To answer these questions, we will first analyse the automation levels and trends of automated cars. After explaining which changes await us, we argue that taking steering out of human hands will eliminate most existing accidents. We then will have a closer look at the extent of the parallels between traffic and swarms. This will help us to examine how communication between cars can save lives in sudden crashes. Subsequently, we will explain why improving the efficiency of traffic also leads to more safety and use mechanisms, and the techniques of animal swarms can achieve this goal. The organisation of bee swarms and ant colonies will deliver answers for how to improve traffic flow conditions and distribute traffic more efficiently. In the end, after having stated the vast range of advantages that automation and networking will bring, a critical appraisal, discussing new potential risks of automation, will follow.

2. Trends and automation levels

How advanced is the development of car automation? In the following, we want to explore the levels of automation that exist, and when other levels will become reality. It is first necessary to point out the difference between autonomous and automated. While "autonomous" is the most commonly used term in public discussion on this topic, it implies an agent acts alone or independently. Cars, whose potential we want to demonstrate in this paper, instead depend on communication with their passengers and other vehicles, clouds and the surrounding infrastructure. As long as somebody else makes decisions about factors like destinations, preferred routes or the time of transportation, the vehicle itself is not autonomous, in a strict sense. The more accurate term is "automated", which "connotes control or operation by a machine" (Wood 2012: 1428). In the following text, we will therefore limit ourselves to the use of "automated", its synonym "self-driving" and its accompanying noun "automation".

The International On-Road Automated Vehicle Standards Committee of the Society of Automotive Engineers (SAE) has defined six levels of automation (cf. SAE 2014) that are widely used in today's research. These span from 'no automation' to 'full automation'. Crucial to the understanding of the differences is the definition of the 'dynamic driving task':

> It "includes the operational (steering, braking, accelerating, monitoring the vehicle and roadway) and tactical (responding to events, determining when to

change lanes, turn, use signals, etc.) aspects of the driving task, but not the strategic (determining destinations and waypoints) aspect of the driving task" (SAE 2014).

The suggested levels are the following:

1.	no automation	The driver performs all aspects of the dynamic driving task. Warning or intervention systems can be included.
2.	driver assistance	In some specific driving modes, such as high speed cruising, the assistance system executes steering or acceleration and deceleration.
3.	partial automation	Steering and acceleration/deceleration mostly performed by the car. The rest of the dynamic driving task, especially the tactical ones (like responding to suddenly emerging events), remain in the hands of the driver.
4.	conditional automation	From this level on, the system performs the entire dynamic driving task in specific driving modes (e.g. on highways) for the first time. The driver still needs to be ready to intervene promptly as soon as the car reports a critical situation.
5.	high automation	The automation still does not cover all driving modes, but in the covered ones, the driver does not need to intervene anymore.
6.	full automation	The automated driving system performs all aspects of the dynamic driving task in all driving modes. Cars at this level are further described as automated.

At what level of automation are cars now, and when will the other levels become reality? Some assistance systems already exist, like emergency braking features, where the car intervenes when the driver does not react quickly enough. When the sensors register hazardous obstacles on the road and the driver does not react in time, the assistance system initiates braking so that a collision is prevented (cf. Wirtschaftswoche 2015). Congestion Assistance, letting the car take over acceleration and deceleration while the driver has to keep their hands on the steering wheel, is predicted to come by 2016. Tesla Motors carried out first tests of highway pilots in October 2015. This is an important step towards conditional automation, allowing free-hands driving on highways, warning the driver if something unpredictable happens and giving them seconds to react. Until now (January 2016), the feature has been "restricted on residential roads or roads without a center divider" (Reuters 2016). Elon Musk, CEO of Tesla Motors, even thinks that in 2018, drivers will technically be able to fall asleep while driving, but that it might take several years more before it is legally approved (cf. CBC 2015). This implies that, at least in some driving modes, there will be no human intervention needed at all. Technical standards would be catapulted from simple driver assistance to high automation in only three years.

Distinguished members of Electrical and Electronics Engineers, the world's largest professional organisation dedicated to advancing technology for humanity, even assume that by 2040, up to 75% of all vehicles will be automated (cf. IEEE 2012). Other forecasts are less optimistic. Raj Rajkumar, director of autonomous driving research at Carnegie-Mellon University – the institute with the longest history of research in self-sufficient cars, having begun in 1984 – does not believe in the appearance of such cars "anytime soon", which means neither during the current nor the next decade. The lack of any "situational awareness" – meaning the ability to react reflexively to unforeseen situations – makes cars not needing human monitoring, in his opinion, "pure science fiction" (Slate 2014). However, most experts agree that full automation will come from 2025 on. Mercedes, for example, presented the automated concept car F015 Luxury in Motion at the CES in Las Vegas as part of Daimler's "City of the Future 2030+" vision (cf. Mercedes-Benz 2015). Automated cars will become reality the next 20 years, and we run the risk of being overstrained by this development if we aren't prepared in time.

3. *Erasing human failure*

History

In the last few decades, the constraint of human influence on traffic has led to a drastic increase in safety. In Germany in 1970, 21,332 people died in traffic, while in 2014 this figure was only

3,368 (cf. Beiker 2015; DESTATIS 2015a). This remarkable reduction also took place while the amount of registered vehicles rose from under 20 million to more than 50 million. How was this possible? Since 1970, the German government has introduced many regulations, such as the requirement to use seatbelts (1976), the prohibition of driving with an alcohol level of more than 50 millilitres (2001) or using a phone in the car without a hands-free kit (also 2001). Technical innovations have changed traffic safety as well: different sorts of airbags and the introduction of the ABS lock braking system had a huge impact on fatality reduction in the 80s and 90s (cf. Beiker 2015). In the last 20 years, a wide range of assistance systems have been added. 'Autonomous Cruise Control', which automatically adjusts the speed to keep a safe distance to vehicles ahead, 'adaptive highbeam', that changes the headlight range continuously so that a maximum range can be guaranteed without disturbing other drivers, parking aids, emergency braking systems and others have put modern cars on the level called driver assistance. Even medical and infrastructural measures have had an impact. In Sweden, "2+1" roads, where each lane of traffic takes turns to use a middle lane for overtaking and safer crossings, are reckoned to have had a significant contribution to the world's best fatality statistics (cf. The Economist 2014). All this has led to a constant reduction in fatalities. The safety effects of all these changes and developments superimpose each other. It cannot exactly be stated which one has had how much of an influence, but the bottom line is that the higher the regulation and technological progress, the better the traffic safety.

Statistics

Even though a lot has been done to take the human risk factor out of traffic, today's statistics tell the same story as numbers from preceding centuries: humans are the main factor in casualties. In 2014, 90.1% of all accidents were linked to the misconduct of human drivers (cf. DESTATIS 2014). There were 388,750 causes for 291,105 accidents with personal injuries (cf. DESTATIS 2015b, 2015c) Leading mistakes occurred while turning, moving backward, entering or starting (14.3% amongst human-caused accidents), or were priority violation (13.1%), speeding (12.5%) and insufficient safety distance (11.8%) (cf. DESTATIS 2015c). Meanwhile, the causes for accidents without human failure are characterised by very small percentages. Slippery lanes were responsible for 2.7%, and only 0.9% of all accident causes were related to technical defects (cf. DESTATIS 2015b).

Just by introducing cars without drivers, we have the opportunity to eliminate a majority of these fatalities. In 2013, 69.1% of all accidents with personal injuries were caused by passenger cars (cf. DESTATIS 2014). Daimler forecasts that automated cars will be able to prevent almost all of these accidents by 2070. Until then, traffic will be in a mixed state, with automated cars and human-driven cars, while the proportion of automated cars is reckoned to rise continuously. Daimler expects accidents caused by cars (and not other road users, such as motorbikes or pedestrians) to be reduced by 10% by 2020, 19% by 2030, 23% by 2040, 50% by 2050 and 71% by 2060 (cf. Beiker 2015).

Human vs. machine

Vision Zero, which has the aim of cutting all traffic related fatalities to zero, has been discussed for more than two decades. Sweden established it as an objective in the 90s, and the EU invests millions into research projects like 'Highly automated vehicles for intelligent transport' (HAVEit) to achieve this. Automated cars do not drink or exceed speed limits. They can have a huge impact on traffic safety and have the opportunity to push us a major step in the direction of Vision Zero. To get a deeper insight, we now want to focus more precisely on ways in which robotic cars are better than humans. To compare their potential, we need to analyse their strengths and weaknesses. Psychological data analysis classifies sources of human errors into five categories:

- Information Access (Was the relevant information available? Was there a free field of vision?)
- Information Reception (Did the driver carefully observe the situation? Was the relevant information recognised?)
- Data Processing (Did the driver interpret the situation appropriately, based on the available information?)
- Objective (Did the driver make the appropriate decision?)
- Operation (Was the decision implemented in the correct way?)

41% of human errors lie in information reception, 23% in information access. Humans therefore are relatively good at processing the given information (16%), making the right decision (14%) and translating it into action (6%) (cf. Beiker 2015). According to Klaus Dietmayer, Prof. at the Institute of Measurement, Control, and Microtechnology in Ulm, Germany (cf. ibd.: 425f.), the performance of automated cars depends on three uncertainties, that comply with human information access and information reception:

- Uncertainty of conditions (direct consequence to unavoidable measurement errors; uncertainty of values like size, position and speed),
- Uncertainty of existence (consequence to inadequate processing or measurement errors, e.g. the reflection of a headlight in a puddle can be identified as an object; some real objects can't be identified).
- Uncertainty of classification (consequence to inadequacy of classification procedures or insufficient measurements, e.g. is the object ahead an empty cardboard box or a solid, hazardous object?).

On the basis of statistical methods, these uncertainties can be assessed relatively accurate. When the uncertainties attain an unspecified upper limit, a car with conditional automation would need to hand over the dynamic driving task (all tasks belonging to driving a car, cf. chapter "Trends and automation levels") to the driver, while a highly or fully automated car (where the driver isn't expected to be able to intervene all the time) would need to achieve a safe status, such as stopping in the emergency lane.

There are several scenarios where the uncertainties exceed this limit: sensors and classification tools can degenerate slowly or even fail, and bad weather can affect the function of sensors. This can cause accidents which threaten lives and make the introduction of automated cars questionable.

One reason for possible accidents is the lack of time: overtaking by a driver is believed to take between five and ten seconds. Attaining a safe status could take a highly or fully automated car even more time. So far, a prediction of the traffic situation can only be made two or three seconds in the future, since calculating all the scenarios that might occur becomes technically impossible. That is why an automated car needs to acquire sensor data all the time. For a high level of uncertainty, the car cannot be aware enough of its surroundings to achieve a safe status (respective to handing over the driving task, as long it is not highly or fully automated). Dietmayer proposes further research into making situation prediction methods more forward-looking and increasing their precision. Using contextual information and hypothesises about the behaviour of other road users, a data bank could be created in which all possible developments of specific situations could be stored. Having access to this data could help in improving the predictions of automated cars in the scenarios covered. While this seems theoretically possible, it would be necessary to assume consistent behaviour of the road users, which doesn't include all possible dangers. On the other hand, human drivers make assumptions based on experience as well. They too will be in trouble if a driver comes up the road the wrong way. Such a prediction method could thus be a solution.

Aside from such methods, it is also possible to prevent the uncertainty limit in the first place. Bad weather conditions can be predicted through different channels, which could lead the car to stop or to hand over the dynamic driving task. Dietmayer also argues that for failing sensors, the combination of different sensor technologies (radar, lidar, infrared, ultrasound and cameras) would allow the car not to lose its ability to drive safely until the driver takes over, with the car attaining a safe status.

Nonetheless, some challenges remain concerning information reception, access and processing. If an automated car stops every time there is heavy rainfall or a snowstorm, it is necessary to keep the possibility of a passenger taking over the dynamic driving task. This would throw the automation level back to conditional. A sudden fail of important processing tools or several sensors at once would be even more of a threat to the introduction of automated cars, since it would put passengers in life-threatening situations. A hypothesis-based prediction, as proposed by Dietmayer, might be a partial solution. He believes that there won't be any significant progress on this field in the next ten years or more (cf. Beiker 2015). On the other hand, it is very likely that in ten or twenty years, cars will be much more reliable in information reception, access and processing than humans, who are the main errors leading to road accidents (80%). Furthermore, by introducing partially and conditionally automated cars, the level of usage will rise, making it possible to continuously develop sensors and processing tools. Bad weather and technical problems shouldn't be an insuperable danger in the long run.

The remaining 20% of human error sources are to be found in the categories 'Objective' and 'Operation'. Here, machines have a definite advantage. A computer will not panic but stay objective when recording a deer that passes the road. Most deaths in such situations occur because drivers turn and hit a nearby tree instead of just braking in front of the animal. Every decision can be programmed before the situation occurs. Operations can be performed much more accurately and faster by an automated car than any human. It can determine precisely how great a turn has to be made to prevent damage. As everybody learns in driving school, human reaction time is only up to one second. In machines, it is almost zero. Current robots manage the recording and processing of data plus taking decisions and figuring out the way they need to move in only 0.05 seconds (cf. ExtremeTech 2014). If the brakes are triggered 0.9 seconds earlier, with a speed of 80 km/h, the stopping distance can be shortened by 21.6 meters. This can prevent accidents or lower damage strongly. In Chapter Five, a case study will show the difference this can make.

Every automated car will have these advantages over a human-driven one. They are faster, more accurate and almost never act poorly. Of course, the risk of technical defects or software errors will always persist, as there is no such thing as a perfect machine. Nevertheless, the failing of automated systems in other means of transport (like planes or trains) are relatively rare, and emergency backup systems can prevent them from causing actual damage. We conclude that in the coming decades, automated cars will surpass human drivers in safety terms, and that the higher the proportion of automated cars in traffic, the greater the level of safety will be.

4. Automated Cars and Collective Intelligence

The new technologies implemented in automated cars will make them fully connected individuals in a single network. Sharing information and communication can put them in the stage of collective intelligence. Even today, we can see similarities between the conduct of drivers in traffic and animal's behaviour. If you look at the time-lapses of intersections and highways of big metropolises like New Delhi, Shanghai or Rome, it somehow seems miraculous that everyone finds their way through this chaos. The actions of the individual drivers become one faceless traffic-mass, which seems to follow its own rules. The same occurs if you watch a flock of starlings moving through the air. Both consist of decentralised individuals that group and move in the same direction.

A classic example of flocking behaviour is locusts. Of the approximately 13,000 species of grasshoppers that exist in the world, about 20 are called locusts. Most of the time they are harmless but, occasionally, they produce massive migrating aggregations. As long as they are still young, this results in marching bands that may extend for kilometres. Once they are winged adults they form massive flocks, sometimes extending over hundreds of square kilometres in the air and traveling enormous distances each day (cf. Beekman et al. 2008: 22). The biologist Iain Couzin was one of the first researchers to examine the behaviour of individual locusts in swarms. He found out that all it takes to form a functioning swarm without collisions is that every individual follows three simple rules (cf. Fisher 2009: 26):

1. avoidance (avoid bumping into other individuals)
2. lignment (move in the average direction that those closest to you are heading)
3. attraction (move toward the average position of those closest to you)

These rules can be applied almost exactly to driving a car. In his book "The Wisdom of Crowds", the American journalist James Surowiecki modifies the rules for the more specific case of cars on a crowded highway (cf. Surowiecki 2004: 150):

1. don't hit the car ahead
2. shift lanes when you can
3. drive as fast as you safely can

We know that animals in swarms and cars in traffic follow similar patterns, but how can we use this knowledge to make traffic safer? To answer this question, we have to understand the concept of swarm intelligence or collective intelligence (which we will use as synonyms), and which go beyond mere swarm behaviour. Locusts may fulfil all the necessary conditions for forming a functioning swarm, but this does not make their actions intelligent. They lack the ability to determine their flight direction consciously as a collective. The movements of a locust swarm are thus totally dependent on the direction from which the wind is blowing. If the wind comes from the wrong direction, the whole swarm gets blown into the sea and all the locusts perish (cf. Hill 1997: 149). Sometimes, following a few simple rules is just not enough for a swarm to reach its target. Another good example of this are ant mills. Occasionally, a group of army ants, which are almost completely blind, loses track of the leading group and begins complying with the one rule of following the ants in front of them. This can result in a continuously rotating circle, where all the ants continue to walk around until they die of exhaustion (cf. Surowiecki 2004: 40f). Swarm intelligence requires something more than just following: the ability to learn. To achieve this, we need additional communication within the group. An excellent example of an animal species which successfully implements such communication in its swarm behaviour, is the honeybee. Unlike locusts, honeybees have the skills to navigate directly to a chosen target and to communicate the position of new food sources or nest sites to other individuals. Furthermore, a few knowledgeable bees is enough to guide the whole uninformed swarm to a desired target, which makes them, from a collective intelligence perspective, vastly superior to locusts.

It might be out of the question for human drivers to be smarter than locusts, but it is also clear that today's traffic is still far from a collective, intelligent solution. We argue that automated and connected cars can do the same to traffic that communication does to swarm behaviour – make it intelligent. Their market introduction will put a key piece of the traffic puzzle in place, becoming one decisive step closer to Vision Zero. They will not only increase safety. In the second and third of Surowiecki's rules, one major problem of today's traffic is reflected. Everybody wants to arrive at their destination as quickly as possible, without considering the intentions of the road users around them. This can make traffic nerve-wracking, dysfunctional and dangerous. Intelligent swarms work well because they pursue one common goal. Humans sitting in the back of a self-driving car will no longer try to save every single second by switching lanes as soon as it seems to accelerate things. Like a train, they will concentrate on other things and be satisfied with the arrival time that the car proposes. Automated cars can therefore concentrate more on the common goal: that everyone arrives safely at their destination.

5. Reacting in Critical Situations

Now, we want to concentrate on the opportunities that come from turning traffic into a collective network. Imagine a sunny afternoon on a highway, where quite a lot of cars are around but the traffic is still flowing. Suddenly, the tyres of the car in front of you burst, the car abruptly turns, and ends up overturning in the middle of the highway. Stop. What would normally happen now? Maybe you are lucky, and you and all the other drivers around you react instantly and make the right decision to brake early enough, or to drive around the car. More likely, another car will hit the overturned one, another will hit that one, and so on. As a result of this chain reaction, a pile-up can occur, with you right in the middle.

This could be avoided in a world with connected and highly or fully automated cars. Let's assume that the cars drove at a speed of 120 km/h. A normal braking distance at this speed is 144 metres, an instant full braking 72 metres. The average braking distance in such a situation likely lies somewhere in between. In addition, humans need a reaction time of up to one second, which is 36 meters in this case. An average driver therefore needs about 130 metres before their car stops. Automated cars will have a significantly shorter reaction time and push the brake pedal without hesitating. Assuming a reaction time of 0.05 seconds (cf. Chapter 3), they can reach 74 metres or even less: the braking distance is almost halved. And this is not the only advantage:

humans are startled and accidentally steer in the wrong direction, which can cause more accidents and thus lead to a pile-up. That will not happen to rationally programmed cars.

When the cars start communicating with each other, a major advantage occurs. The communication can take place in a split second, and thus every car around or behind the accident can immediately be informed. Most casualties happen because drivers behind the accident don't realise that there is one. If every car more than a hundred meters behind the accident starts braking at the same time, none of them will crash. Pile-ups of more than six cars can thus already be avoided, because in the imagined scenario, up to six cars could be in a 100 metre range behind the accident, supposing there are three lanes. Above this number, we would exceed the optimum 30 cars per mile per lane, and reach unstable flow conditions (for more information, cf. Chapter 6.1). Outside of this approximate 100 metre range the 74 metre stopping distance should suffice to avoid an accident. It would be necessary to find a way not to be forced to stop the whole highway as the 'brake wave' goes back along the road. The problem should be solved by coordinating the strength of the brakes. If every hundred meters the brakes are triggered a little slower, the cars would come closer to each other, but some kilometres further back, there is no need to brake at all.

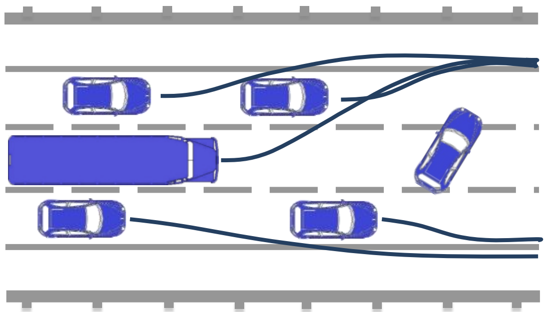

FIGURE 1: REACTION ON BASIS OF SWARM RULES (SOURCE: OWN ILLISTRATION)

Of course, some cars in a hundred metre range of the accident are still in danger of crashing into the overturned vehicle and the surrounding ones. A swarm-like movement around the obstacle is not unrealistic. In 1986, the programmer Craig Reynolds astonished spectators by showing that small triangular objects called 'boids' act exactly as swarms, by letting them follow the three swarm rules: avoidance, alignment and attraction. In his animation, the objects moved smoothly around any obstacle, giving the impression of artificial life (cf. Fisher 2009: 25f.). Why shouldn't the same be true in real-life traffic? In the burst-tyre scenario, the automated cars could instantly switch to 'swarm mode', where their action strategy is reduced to following these three rules and ignoring other objectives like destination, speed limit or avoiding crossing lanes. Their sensors would deliver all the information required, such as the position of the other cars (including the overturned one) and the limitation by the crash barriers on the sides. The first rule would prevent hitting the cars and the barriers, the second would lead them around the obstacle, and the third would assure that their velocity is adapted to each other. By reducing the objectives to such simplicity, it appears to be possible to execute all this coordination in only few seconds. The main advantage is that the cars do not need to communicate with each other, or for a centralised server to steer them. The only thing required is the instant reaction to the situation and the simple programming of the swarm rules – nothing utopian in a time of highly or fully automated cars. Even cars with partial or conditional automation can easily be prepared for such situations, without needing the driver to intervene.

These considerations can easily be transferred to many other critical situations. Braking and coordinated evasion can be applied to truck accidents, loss of cargo or natural obstacles on the road. Wrong-way drivers would also no longer be dangerous, as long as we are still in traffic with vehicles that are not highly or fully automated (afterwards, they will probably not exist anymore). The reactions of automated cars can therefore deliver many advantages in sudden critical situations. This safety potential should be scrutinised in greater depth and deliver material for further research.

6. Efficiency

6.1 Traffic Flow and Safety

The Relationship Between Efficiency and Safety

Swarm intelligence research reveals simple mechanisms that can be adapted to specific traffic situations and lead us to interesting and unconventional concepts. As we have just examined in the previous chapter, this can help us in finding new ways to deal with unexpected hazards and other critical situations. This will certainly have a big impact on traffic safety, but if we really want to get close to Vision Zero, we also have to invest in the prevention of such critical situations.

How can accidents and other dangers be averted in the first place? The solution is both in the interests of everybody and simple: by making traffic more efficient.

Efficiency is usually defined as an input-output relationship, comparing the actual result to what can be achieved with the same resource investment (cf. BusinessDictionary 2015). In our considerations, the input factors (time, vehicle density, technologies used, share of automated cars, etc.) are difficult to measure, and the impact on future output can only be estimated. Therefore, we will use a slightly different conception of efficiency in this paper. When we talk about increasing the efficiency of traffic, we mean stabilising traffic: in other words, making it more coherent. The effect is a reduction of traffic jams, better use of road capacity, and the general acceleration of traffic. Before we explain how this can be achieved, we first have to understand some important transport research basics and examine why improving the efficiency of traffic also means improving its safety.

Traffic-Flow Theory

Speaking of efficiency in this context, there is no way to get around the traffic-flow theory. This describes the study of individual drivers, vehicles and the interactions they make with infrastructure and one another (cf. Wikibooks 2015). The aim is to understand and develop efficient movement and minimise traffic congestion problems. Although human driver behaviour is difficult to assume and can never be predicted exactly, humans tend to behave in a reasonably consistent range. This makes traffic streams somehow predictable, allowing them to be roughly represented mathematically. Here, the distinction is made between different flow conditions. When there are less than 12 vehicles per mile on a lane, we speak of free-flow. At this rate, each car can travel as quickly as it wants while keeping a safe distance from the others. Around 12-30 vehicles per mile per lane is considered a stable flow. 30 cars seems to be the maximum: any density exceeding this value makes traffic flow unstable. At this state, even minor incidents can cause persistent stop-and-go traffic. One unexpected lane change forces a few drivers to hit their brakes, generating a wave of braking that passes through all the cars behind them. This braking wave moves more quickly in faster lanes, because drivers have to react more suddenly to keep their distance. The fastest lane slows down the most, encouraging its drivers to change lane, and the chain reaction starts all over again. Traffic exceeding 67 vehicles on one lane per mile, the so-called breakdown condition, often leads to a complete halt in traffic flow. The result is a jam, with a density in the range of 185-250 vehicles per lane, per mile (cf. Rijn 2004: 9).

Whereas a jam seems to be the worst-case scenario from an efficiency perspective, full congestion has an interesting side effect. Studies by the Dutch researchers Golob, Recker and Pavlis suggest that once traffic is congested, crash severity is greatly reduced (cf. Marchesini/Weijemars 2010: 3). As soon as all lanes present similar flow conditions, driving becomes noticeably safer. In fact, reports have shown that high-density variability and large speed differences between lanes are major factors for the likelihood of crashes. Rear-end crashes are more likely to occur with less consistent flow (cf. ibid.: 3f). Efficiency improves safety not because of the reduction of jams, but rather stabilises traffic flow in terms of velocity and density. This gives rise to the question of whether it is possible to transfer the positive effects which appear in jams to a smoothly running traffic state at high speed.

Coherent Flow

The results of a study by the German physicist Dirk Helbing and Bernardo Huberman, a Hewlett Packard scientist, answered this question with a clear yes. They identified a traffic state called coherent flow. In this state, all the vehicles move at the same velocity in one solid block. Even though this means that some cars move more slowly than they would under normal circumstances, traffic as a whole moves at an optimal pace. Furthermore, they argue that this coherent state of motion remarkably improves safety by eliminating lane-changes and speed differences (cf. Helbing 1998: 738f). Helbing conducted further studies with the traffic researcher Martin Treiber, in which they equipped cars with special sensors to group them in solid blocks and create coherent flow conditions. They found out that even if only 10 to 20% of the cars on the road are modified this way (the equipment used in today's automated prototypes is far more advanced than the sensors used in the studies, which makes better results more likely), they would be able to eliminate much stop-and-go traffic (cf. Surowiecki 2004: 156). We know that coherent flow conditions stabilise traffic and therefore lead to an increase in safety. Properly implemented, a more coherent flow gives further positive effects: for the environment by saving on carbon emissions, for personal comfort by saving time, and for economic aspects by reducing the cost of fuel consumption and the opportunity costs of the total time spent traveling.

It might be important to add here that the concept of coherent flow works best once the vehicle density of 30 vehicles per lane per mile is passed. In stable or free-flow conditions a coherent state is difficult to achieve, especially when human drivers are the majority of traffic participants. If vehicle density is low enough, there is no efficiency problem and thus we can focus on states with a higher density and therefore more room for improvement. Traffic flow researcher Ron Dembo points out the vast potential here:

> "There is a physical limitation to what a road can handle, but we're not even close to that point. Doing away with the human driver would have a huge impact" (Cheney 2013).

6.1 Highways

The Difference Communication Can Make

Highways are designed for high-speed traffic and characterised by controlled access. They provide an unhindered flow of traffic, on multiple lanes without intersections or traffic lights. Anyone who regularly drives on a highway knows that the idea of unhindered flow is often a mere theoretical concept. In Germany alone, 475,000 traffic jams were registered in 2014. Together they lasted 285,000 hours, longer than 32 years (cf. ADAC 2015). No one actually wants to cause a jam or congestion, but thousands of people are stuck in traffic every day. The introduction of self-driving cars provides new opportunities for getting closer to the ideal of a coherent and smoothly running traffic flow. It will probably take a while for our highways to be crowded by self-driving vehicles, but once we get there, traffic will have changed completely.

We can assume that by this time vehicle networking technologies, such as vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, will be standard, built-in features of automated cars. Even if there is still a small percentage of non-networking cars driven by humans, this technological progress will lead to an enormous increase in efficiency. Communication technologies make it easy to synchronise velocity and keep an optimal distance from other vehicles. Automated cars can thus easily group and move together in solid blocks at high speed. The result is a stable and coherent flow, which forces the remaining human drivers to adjust their driving behaviour accordingly. Any important data about unexpected braking or lane changing actions will be collected by surrounding cars. They can inform all the affected cars behind them through V2V communication to adjust their speed simultaneously, and a chain reaction like a wave of braking can be prevented successfully. That this theory can really work out in practice was proven in August 1997. Several researchers form California's PATH program equipped eight Buick LeSabres with features worth a couple of hundred thousand dollars. Motion sensors, gas pedal and steering wheel controls, radio communication systems and radar allowed the cars to drive on their own and synchronise their speeds. The convoy of LeSabres went off in one block, keeping a 21 foot distance from each other. Their movements were completely synchronised, without any delay caused by human reaction time. In four days they travelled hundreds of miles, carrying real passengers with no accidents at all (cf. Surowiecki 2004: 154).

Other researchers have shown that connected, automated vehicles can also help to significantly increase the capacity of highways. A study by Dr. Shaldover, a pioneer in transportation systems and one of the founders of the PATH program, analysed the capacity benefits of cooperative adaptive cruise control systems (CACC). Human drivers are not very good at maintaining an optimal distance to surrounding cars. Vehicles equipped with CACC technology use V2V communication to calculate their optimal position and special sensors combined with cruise control to keep the perfect distance. Using CACC at 50% market penetration, Dr. Shaldover estimates a maximum capacity of 2,685 vehicles per lane per hour. That increases today's typical value (of 2,200) by 22%. When all the cars on a highway are equipped with this system, he expects the capacity to doubled (cf. Augustin/Pinjari 2013: 1f).

V2V communication and CACC systems are only two examples of technologies that make it quite easy to achieve a coherent state of flow. Automated cars will probably use these two and more technologies, with a huge impact on the efficiency of highway traffics. When a certain vehicle density is reached, and free-flow conditions are no longer fulfilled, the cars form solid blocks. They drive in all available lanes at an optimal distance and velocity. Through a permanent exchange of data, these values are constantly recalculated and adjusted. This makes it difficult for the few remaining human drivers to break out of the stream, because most of the time they are surrounded by automated cars. These cars are already driven in the best possible way, which makes it reasonable for the remaining humans to fit into their blocks. There are still a few decades to go until a scenario like this becomes reality. Even if coherence is the key to the efficient use of highways, it is much more difficult to achieve this in a world where human drivers are the majority.

Mixed Traffic and Bees

In Chapter 4, we talked about the swarm intelligence of honeybees. While individual bees follow the basic rules of avoidance, alignment, and attraction, the swarm as a whole has the ability to fly directly to a chosen target. Irrespective of whether they are searching for a new source of food or a suitable location for new home sites, a similar mechanism applies. 5-25% of the workers in the hive are scouts, who permanently scan their surroundings. When scouts discover a new nest site, they return to their hive and perform the well-researched waggle dance. Through dancing, the scouts communicate the location of the target to the other workers. While the dance points in the direction of the target destination, the speed and kind of waggling tell the distance. The remarkable thing about this technique is that the dance is performed in a dark and quite chaotic hive. Very few bees (about 5%) are actually able to see it. Nevertheless, more come out of the hive and find their destination, as if everybody was informed. About 95% of the swarm start flying in complete ignorance. Amazingly, the ones who know the way are not flying ahead to lead, but right in the middle of the swarm. How do they do this? Martin Lindauer, a famous behavioural scientist, found the answer by watching honeybees from below. He discovered that a few bees fly much more straightforwardly and a little more quickly than the others. His observation has already been substantiated by many other studies and we know for sure that the faster bees lead the whole swarm. Interestingly, computer simulations have revealed that there is no need for the informed bees to identify themselves as such. They somehow act as hidden leaders, as all the other bees align their directions with those of their neighbours, and the swarm as whole reaches their target. What honeybees teach us about leadership is perfectly summarised by Len Fisher in his book The Perfect Swarm:

> "In other words, it needs only a few anonymous individuals who have a definite goal in mind, and definite knowledge of how to reach it, for the rest of the group to follow them to that goal, unaware that they are following. The only requirements are that the other individuals have a conscious or unconscious desire to stay with the group and that they do not have conflicting goals" (Fisher 2009: 30f.).

How can we use this to improve the efficiency of highways? We argue that self-driving cars are capable of taking over the role of the leading bees in mixed traffic. As soon as free-flow conditions do no longer exist all the necessary requirements are fulfilled. Unless you plan on leaving the highway, you are more or less stuck with the group, with no real chance of breaking out. More importantly, all the drivers share one common goal: move forward as fast as you can safely drive. Even the presence of a few leading automated cars in traffic can make a world of difference to its performance. The main disparity of this analogy is that, unlike the swarm of bees, all the cars on a highway are already heading in the same direction, so the guidance has to take place on another level. What could this look like?

The major factor for inefficiency on highways is traffic jams. Intelligent leadership by automated cars makes it possible to prevent or dissolve them when they do occur. This can be achieved by creating a coherent state of flow. As dissolving jams requires the same action as preventing them, plus some additional ones, we will concentrate on this case. Once jams are created, it takes hours (in extreme cases, even several days) until they disappear. Cars entering the back of a traffic jam move much more quickly than those leaving it at the front. This also explains why jams seem to move backwards up the highway if you watch them from above. All we have to do to get rid of traffic jams is to make sure that there are fewer cars entering than leaving. At this point, the automated car comes into play. Just as a few knowledgeable bees can lead a whole swarm to a target, a few automated cars can be enough to control the whole traffic behind a jam. Since they gather a lot of data by constantly checking their environment and recalculating the optimal route, automated cars have a good overview of the number and density of cars around them. Traffic acquisition and distribution algorithms like the one we will discuss in Chapter 6.3 allow us to locate and analyse the number of cars in traffic jams accurately.

By considering the density of traffic and the length of the jam, automated cars can compute the velocity at which everyone is required to drive to make sure that there are more cars leaving the jam than entering it. The last and most important step is to get all the human drivers to adjust their speed accordingly. One way of achieving this is to block all the available lanes. On a three-lane highway, three automated cars could occupy all the lanes miles before they reach the jam and reduce their speed significantly. In theory, this could create a convoy with coherent flow, which ensures the jam has enough time to dissolve and, even though everyone in the convoy drives more slowly than usual, everyone would benefit. In practical terms, this approach might lead to some unwanted consequences. Apart from the fact that it might be difficult for the automated cars to get so close together (since they cannot just stop for a while and wait for each other), a method like this in traffic, where most of the drivers are human, could actually cause frustration or a new jam itself. What we need here is a bottom-up solution. Just like the uninformed bees in the swarm who simply align their directions with those of their neighbours, human drivers tend to copy the behaviour of others. We switch on our lights when all the other cars drive with them, and when everybody else is driving a bit more quickly than is allowed, we often do it too. To imitate others is a typical human strategy and often a successful one, especially for solving problems in everyday life. Automated cars can use this behaviour to slow down traffic before a jam. All they have to do is to communicate the relevant information to the surrounding cars, just like the scout bees with their waggle dance. While dancing is not really an option for a car on a crowded highway, this could be through simple visual signals displayed on the rear window. Every driver that is close behind the automated car, even if only for a very short period of time, receives the information that there is a jam ahead and what is the optimal speed is to avoid it. By slowing down, the self-driving car can cause others to do the same. This would work out best if it positions itself in the fastest lane, as it is forbidden to overtake cars that are in faster lanes. Attention would simultaneously be drawn to the message on the rear window, which could keep people from feeling frustrated.

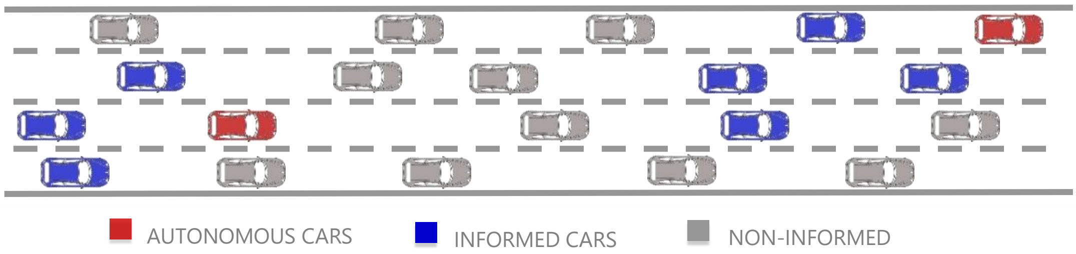

FIGURE 2: AUTONOMOUS CARS AS LEADERS IN MIXED TRAFFIC
(SOURCE: OWN ILLUSTRATION)

It is up to the informed drivers to guide the uninformed swarm. If the number of people who adjust their speed is great enough, this will have self-reinforcing effects on the other drivers, which then leads to almost everyone slowing down. Of course, this works better when more automated cars and thus informed humans are actually driving on the highway, but even a very small share might be enough. Iain D. Couzin, professor at the Princeton University, has done a lot of research focusing on the leadership of swarms in motion. His studies reveal two interesting facts. First, he discovered that as soon as 5% of the individuals are informed, the group will find its target of 95%. Even though further studies are required to clarify whether the 5% rule can be transferred to cars on a highway, it gives us a good guideline. It's not hard to imagine that it will have a significant impact on traffic if 10% of the drivers adjust their speed to an optimal level. It won't take long until almost every driver on the highway is informed when one out of ten cars communicates the optimal velocity. Secondly, he found out that the larger the group, the smaller the proportion of informed individuals required to guide the group is (cf. Couzin et al. 2005: 513f). This is something that can be applied to our scenario very well. A larger group is equivalent to a higher vehicle density, and therefore more congestion. This does not only mean that a greater number of human drivers receive the information displayed by one automated car, but also that the impact of their adjustments on the remaining uninformed cars increases. When one car slows down, the cars behind are forced to do the same, and thus the higher the density, the fewer automated cars are required to achieve the desired effect. This is just one example of how we can use the mechanisms of animal swarms to improve driving on highways. By copying the behaviour of bees, self-driving cars can become role models for future traffic. In the next section, we will deal with whether or not it is possible to achieve similar results on streets in urban areas.

6.2 Urban Areas

Advantages of Communication

Driving on a highway is not really comparable to driving through the more complex environment of a city. Countless intersections, zebra crossings and traffic lights mean almost permanently interrupted traffic. Pedestrians, cyclists and public transportation increase the diversity of traffic participants immensely. To coordinate all these individuals in an efficient way is really a difficult task, and often enough, not a successful one. In many big cities, traffic jams are the rule rather than the exception. It often takes hours to drive very short distances, and everyday there are numerous accidents. In the following, we will focus on how automated and connected cars can help to improve this situation.

Just like in the bee analogy, communication is key. The bigger the market share of connected cars, the greater the benefits are. V2V communication makes it possible to shorten the space between vehicles and synchronise their movements. When vehicle density is high, the cars can group in blocks and move at the same speed. These blocks have synchronised start-up times, which will increase the number of cars crossing the road at one green signal drastically. The available space will be utilised in a better way. To really minimise efficiency loss at intersections, we have to combine this idea with the possibilities that arise through V2I communication. Connected traffic lights, for example, could communicate the green and red light times so that the cars can adjust their speed accordingly, and thus the blocks would be perfectly timed and pass several crossings at once. This could also work the other way round. When approaching cars send their position, speed and planned route to traffic lights, the light phases can be adapted, so that an optimal pace gets put into practice. Concepts like this function best when all the cars on the road participate and create one big network, though they can also have significant impact on mixed traffic. Automated cars can again become communication leaders and role models for human drivers. They could not only display how many seconds are left until the traffic light switches to green, so that the driver reaction delay is shorter, but also communicate important data like the required velocity to cross all intersections in one 'green wave', or warning-signs at places with a particularly high risk. All these ideas fight the symptoms of congestion. Nevertheless, fighting the symptoms will never be as effective as eliminating the origin. What is the cause, and how can we cope with it?

Cities provide a large network of streets in a very small area. Every destination can be reached by many different routes, and often only locals know the best ones. Studies suggest that in a typical city, more than 80% of the traffic runs on 10% of the streets (cf. Vanderbilt 2009). This does not seem to be an efficient solution. Isn't there a way to distribute the traffic more efficiently, and to utilise the other 90% of the streets? A view on an ant's foraging method gives us the answer.

Ants and Traffic Distribution

Ants use pheromones, chemical messengers, to mark their routes. The ants that come back first from searching for food have obviously found the shortest route. The ants that were not supposed to do the scouting follow these marked routes and their pheromone traces got bigger and bigger. When the other ants come back from scouting, they followed these traces as they were already bigger than the ones they had left. After a very short time, most of the ants will follow the shortest way to food. The ant trail is complete. This, however, is not even the smartest part about the pheromones: after a while, the food that the trail leads to will thin out. Ants that come back from this place will search for a new source of food, and the ant trail will be less frequented. As the pheromones dissolve constantly and vanish after a certain period, the scent will lose its strength and fewer ants will use it. In a short time, new ant trails will be built, and new food sources will be explored.

What can we learn from this ant trail system? Through computer simulations, it has found wide application. The so-called Ant Colony Optimisation has been used to minimise transportation time between the production sites of Unilever in England, to find bus routes or for routing telecommunication. All these optimisations are based on the Travelling Salesman Problem, the question of how to find the shortest route when visiting a list of cities and returning to the original city. However, the ant method is actually not very accurate in solving special problems. There is no guarantee of finding the shortest way possible (although the one you find will be quite short). The strength of the ant method is the continuous self-adaption; the dissolving feature of the pheromones and the constantly changing scents.

We can use this to distribute traffic in a better way. If every car sends virtual pheromones to a central server, we would always know which roads are frequented strongly. If the scent of a street becomes too strong a signal it can be sent to the cars' navigation systems, which could instantly search for a new route. The more cars react to these signals, the more alternate routes would be used and the better the distribution. As the virtual pheromones would dissolve after a while, the original heavily-frequented route would not be put into disuse. The information for finding the least traffic would always be in real-time, and this advantage delivers data which does not yet exist in this form. Combined with existing navigation systems, the method could dissolve jams faster and even prevent them in a way that is not currently possible. No further infrastructure, such as satellites or fixed sensors on the roadside, would be needed. The cars would move like a self-organised swarm.

The information and its spread would have several effects. First, as the vehicles are better distributed to the existing infrastructure, less congestion would occur, especially in cities, a lot of places with a lot of different ways to arrive at one's destination. Consequently, the average traffic flow would be more stable. This would result in more comfort for drivers who arrive, on average, a lot more quickly at their destinations, as well as for residents living besides busy roads. Even pedestrians, restaurants and nature (if you think about traffic jams in a city near a forest) would benefit. One could object that the system would lead to more traffic in areas where this isn't desirable, but non-traffic zones could be protected by marking them ex ante in the centralised map system.

Secondly, the collected data could be used to improve infrastructure projects and city planning. By analysing the frequency and intensity of the roads use, you can easily figure out which streets are overloaded and where new roads would be unnecessary. This knowledge could also improve the timing of the traffic lights, if they are not yet equipped with V2I communication features.

Thirdly, a real-time traffic density map could also help with facing additional problems. Emergency vehicles can shorten the time they need to get to their destination by avoiding more frequented areas. For natural disasters or terroristic attacks, which usually lead to chaos on streets, it would be easier to maintain an overview. It is even conceivable that spatial and temporal patterns of congestion could be predicted and addressed in a timely manner. Last but not least, this system would have a strong positive impact on safety again. In-time distribution implies less density variability, and therefore more stable traffic. As we have learned, instability is one of the main factors in high crash rates. U.S. statistics show that half of all fatalities happen at impact speeds of less than 35 mph (= 56.33 km/h). (cf. Vanderbilt 2009). Such low speed conditions normally exist in areas with many alternatives for arriving at one's destination. Here, the advantages of the ant trail system could take effect perfectly.

One objection to the system is that it would only work if all the vehicles in traffic (or at least a major part of them) were able to send and receive the information needed. We think it would already be possible in mixed traffic with a small percentage of automated cars using this ant trail system. These cars could record and list the cars around them, sending virtual equivalents to pheromones on their behalf. That means if there are four cars around the automated car which don't have the required equipment to send the information themselves, the automated car sends five portions of virtual pheromones, one for itself and one for each perceived vehicle. Technically, this should be easy to implement, since automated cars need to be aware of the cars around them anyway. Such a system could be more precise than existing navigation systems. TomTom, for example, only uses data from a small portion of traffic participants. Combined with the benefits of V2V and V2I communication, the ant trail system will give us the opportunity to use existing infrastructure more efficiently, and to find out where it should be extended.

7. *Critical Appraisal & Outlook*

Having seen all these safety advantages, it would be wrong not to spend some time on emerging risks. There will always be some situations where damage cannot be prevented. As there might be no driver to decide to whom or what extent the damage will be caused, it is up to the car to decide. This gives rise to a whole new set of ethical questions, that our colleagues Anna Erbacher and Matthias Walter deal within their paper "Moral Cars" (cf. Erbacher/Walter 2024). While automated cars will eliminate accidents-caused by drivers and improve traffic as a whole through intelligent communication, the process of automation will also give rise to other new problems. Besides the discussed dangers of failing sensors or the difficulty of accurate predictions, digitalised cars also face new threats, like the risk of hacking or data abuse.

Hacking

One of the major threats that comes with digitalisation is hacking. Modern cars are already like computers on wheels. Their systems require huge amounts of code and software to work properly. A comparison with conventional software systems shows the complexity of a car's digital interface. While complex computer operating systems like Microsoft Windows consist of little more than 50 million lines of code, some experts estimate the number of code lines in a modern upper-class passenger car to be almost 100 million. According to a study by the consulting firm Frost & Sullivan, this number will triple in a few years (cf. Die Welt 2012a). For every new driving task that the car takes over, and for every newly-implemented networking feature, the amount of software and the car's vulnerability to hacking will rise. The idea of someone being able to hack other people's car systems and having access to its brakes, steering and transmission is alarming. Scenarios range from bank robbers who stop the engines of police cars to gangs who manipulate the navigation of cars with valuable cargo (cf. Die Welt 2012b). A look at recent cases, where researchers managed to hack into car systems, reveals that these scenarios are not as unrealistic as one might think, but only under special circumstances. Most of the successful hacks were only possible when the researchers had physical access to the car's operating system. These hacks are considered relatively harmless, since it takes a lot of time and a laptop in the passenger seat to manipulate the software and interfere with critical driving tasks.

However, this changed in July 2015 when the two security experts Charlie Miller and Chris Valasek managed to take over the critical driving tasks of a Jeep Cherokee driven on a highway by Wired journalist Andy Greenberg. All they needed to hack the internet connected entertainment system of the Jeep and then modify the whole operating system was the car's IP address (cf. Wired 2015). As a consequence of this hack, Chrysler had to recall and update 1.4 million cars. Nevertheless, it has to be said that it took two of the world's best experts with years of experience in this field more than one year to develop this hack for one specific model (cf. Zeit Online 2015). For now, criminals taking over other people's cars is rather fictional. Nonetheless, it is clear that new connectivity and communication systems in future cars will also come with new vulnerabilities. Andrew Martin, Professor of Systems Security at Oxford University, established a basic security rule: "Nothing is hack-proof – everything is a trade-off between how much you want to invest in protecting it, and how much your adversary wants to invest in breaking it" (The Guardian 2015).

There are a few things car manufacturers can do to minimise the risks. The most obvious might be separating systems that require internet connections, like the entertainment system, from those that are responsible for critical driving tasks. Unfortunately, keeping the latter systems unconnected is more difficult with every step of automation, since they are dependent on a lot of external data for navigation purposes that is at risk of manipulation. Furthermore, car manufacturers have to invest in computer security and intensify their cooperation within the IT sector. Intel security (former known as McAfee) is already working together with BMW, Toyota and Ford Motors, and has published "Best Practices" for automotive security (cf. Fortune 2015).

One way or another, there is no such thing as absolute security, and it is likely that the future of digital automotive security will be similar to today's computer security: a dynamic process of permanently searching for new security gaps and closing them with updates.

Data Protection

Another issue is data collection and its usage. This might not be a direct concern for traffic safety, but the increasing digitalisation of cars goes hand in hand with a whole new level of data collection, including new privacy concerns. The collected data can be divided into private data about the car's driver and passengers, and data about its surroundings. The amount and kind of information that is gathered and stored differs with every stage of automation. The higher the stage of automation of the car, the more data about the car's environment is needed. A fully automated car needs to be fully aware of its surroundings, and therefore collects a lot of data from third parties. This theoretically includes the license plates, locations, velocity and direction of other cars, as well as the faces of other passengers and pedestrians, and videos of everything that happens around it (cf. Beiker 2015). Fully automated cars collect relatively little data about their passengers, like routes or the time spent at several destinations. The situation is reversed whenever a human is driving. For every driving task that the driver is in control of, the car needs to acquire less data about its surrounding and is able to collect more information about the driving styles and preferences of the driver. Cars that offer both possibilities, like partially, conditionally or highly automated cars, thus collect large amounts of critical data that can be used in proper ways or abused by third parties.

The list of third parties that might have an interest in accessing the data stored on a car's hard drive is long. It includes car manufactures that want to develop and improve their services and systems, insurance companies that want to calculate the risk for individual customers or clarify liability questions after traffic accidents, the police and secret services for finding suspects or punishing traffic violations, traffic control centres, advertisement agencies, fleet operators and, basically, every other company that deals with car or traffic-related issues. (cf. ibid.)

There are certainly new regulations and data protection mechanisms required to prevent extensive supervision and data abuse. What is needed is a way to ensure that transmitting data is only legal, when it contains no critical elements that can be used for privacy invasions. One solution approach for this could be anonymisation. Most of the required information can be gathered and processed in a way that does not contain private data about a specific person or elements like faces or license plates. This would work for traffic and congestion analyses as well as for the data car manufacturer's need to improve products and services. Even V2V and V2I communication doesn't necessarily require a specific identification (cf. ibid.) since it is not important here to know whose car is coming, but simply to know that a car is coming. The problem is that in some cases, even with anonymised data, the drawing of conclusions regarding a specific person's identity is possible. This can be done by analysing regular patterns, like driving the same way from home to work every morning at the same time. One way to avoid this could be to anonymise factors like the location or the time, but this could also restrict data usability for congestion analyses or city planning.

Another important tool for ensuring an adequate level of privacy protection is the deletion or temporary storage of data. The information car sensors and cameras acquire while driving can be deleted after only a few minutes. The car then would still have all the information about the circumstances of an accident, without revealing all of its driving history. This data, such as speeding directly before an accident, could be relevant for judicial questions. It would even be conceivable that the driver or the passengers of the car can simply delete all their stored data by pushing a button. This scenario raises an important question that has not been clarified yet: who holds the rights to the data that partially or fully automated cars gather and store? It seems that there are many different parties with conflicting interests surrounding the data of automated cars. In most cases, there is a trade-off between data protection and the usability of the data. For the driver or the passenger, this generally means a trade-off between data protection and safety. A promising approach seems to be the car's owner choosing their preferred program from different options, with an individual trade-off ratio. This could even work without them being the holder of the rights to the car's data.

We conclude that the data protection issue remains a challenge for the car industry. It would be desirable for the legislators to enact concrete laws, especially regarding the ownership of rights, and that the leading car manufactures also agree to set high data protection standards.

8. Conclusion and Outlook

The safety advantages brought about by self-driving cars seem to overweigh the risks listed above by far. As we have shown, more than 90% of accidents occur because of human failure. Just by replacing human drivers, the 70% of traffic accidents caused by passenger cars can be almost totally averted. In critical situations, instant braking signals to other cars and swarm-like movements around obstacles could prevent pile-ups and reduce damage significantly. Automated and connected cars will make traffic much more efficient. Plus, in their role as communicating leaders (comparable to scouts in a bee swarm), they will help by steadying the traffic flow. Ant foraging methods serve as an analogy for better traffic distribution, and therefore less congestion problems.

Both will prevent hazardous situations and other uncertainties that might lead to accidents and jams, reducing the amount of fatalities to a fraction of today's numbers.

Overall, combining the introduction of automated cars with approaches of collective intelligence could pave the way for a future traffic revolution. Without human failure and egoism, traffic would better serve the common goal of everybody arriving more quickly and safely at their destination than today. Lessons on swarm intelligence research and the technology of connected and automated cars can lead us to a new era of real-time and dynamic traffic management, where Vision Zero actually becomes reality.

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