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Table of Contents

ToTS Volume 9, Issue 2: pg3–pg4
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Editorial Special Issue

Dr. Don M. DeVol

In our modern world, mobility is one of the most important cornerstones. Working and leisure time often are closely connected to getting from A to B, e.g. to get to work, to transport goods, to go on vacation, to visit different places all over the world.

Traffic is essential, important and useful, but it can be dangerous too. Each year, many thousand people die or get injured in traffic accidents. When it comes to drivers, several different laws and norms exist to make traffic as safe as possible, e.g. one has to stop at a red light and is not allowed to drive with a certain amount of alcohol in one's blood. Although everyone wants to get to their destination as quickly and safely as possible, traffic offenses such as speeding or drunk driving are still widespread traffic safety issues. In this special issue of the ToTS Journal, seven papers will be presented, that deal with different traffic safety aspects.

Many statistics identify especially young, inexperienced drivers as producing outstanding safety risks. The first paper deals with the development of our traffic competences as children. The next four papers, then, focus on young drivers' attitudes and behaviors, with the second paper centering novice drivers with autism spectrum disorder. The sixth paper describes how speeding offenders need to change their attitudes in order to pass the Medical-Psychological Assessment and to regain their driver's license. Finally, the seventh paper deals with the influence of greenery on traffic behaviour.

Infrastructure planning also plays an important role to increase traffic safety in children. Schützhofer and colleagues performed a literature analysis to find out how traffic competences, e.g. visual competences, are developed in children. They found that children need more time to perceive and interpret different traffic situations and conclude that existing infrastructures often do not meet children's safety needs. Therefore, the authors give advice what should be done to support children's safe traffic participation such as education, active school way planning or rebuilding infrastructures. Schützhofer et al. conclude that child-adapted infrastructure also increases traffic safety for other road users, e.g. wheelchair users.

Žardeckaitė-Matulaitienė and colleagues took a closer look at the learning history of novice drivers. They compared driving test performances and subsequent police records. The results show that bad theoretical tests correlate with entries in the police record, while young drivers passing their tests on their first attempt are less likely to be fined. The authors conclude that knowing the traffic rules (better) prevents from traffic violations. Interestingly, the results also show a correlation between time of driving experience and entries in the police records. According to the authors, this is reasonable for the more time one drives (and breaks traffic rules) the higher the chance to get caught by the police. Žardeckaitė-Matulaitienė et al. (as all traffic psychologists) conclude that it is problematic that novice drivers are not caught by police frequently enough when infringing traffic rules: Bad behaviors can become habits if not being sanctioned, e.g. by fines.

Ross and colleagues considered novice drivers with autism spectrum disorder (ASD). Therefore they questioned the novice drivers themselves, their parents and their driving instructors. Their results show that novice drivers have more difficulties in learning how to drive, e.g. due to their perfectionism or higher need for structure. In spite of these problems, basically it is possible for those people to gain a driver's license as well. According to the estimations of the driving instructors the authors advice to adapt the process of learning to drive for people with ASD so they have more but shorter lessons to better meet their needs.

As already mentioned above, drunk driving seems to be quite a common traffic offense all over the world although differences between countries can be found. Assailly and Cestac examined young drivers from three countries in order to find reasons for these differences. They asked the drivers to report their drunk driving intentions as well as the social norms of their families and friends regarding drunk driving. The results show that social norms have influence on drunk

driving intentions but their influence vary across countries as the norms themselves vary, as well. The results also show that gender differences can be explained with cultural factors, such as sex stereotypes. The authors conclude with several possible countermeasures to avoid drunk driving.

Pereira da Silva et al. also targeted substance use in young people but focusing on drug consumption. In line with other European studies drug use was reported by many youngsters, with cannabis being the most frequent drug. The results show that nearly half of the subjects admitted driving under the influence of drugs, the majority of them several times, although most of the young people knew that drug consumption was illegal and impairing their driving abilities.

When a driver's license is withdrawn due to several or severe traffic offenses in some countries a driver needs to pass a Medical-Psychological Assessment (MPA) before regaining their license. Wagner et al. examined assessments of speeding offenders. Their results show that not the traffic offenses themselves but rather the offender's change of attitudes influenced the outcome of the MPA. To question false habits and achieve new attitudes such as problem awareness and self-criticism it was helpful for the offenders to participate a professional psychological driver improvement program. As a result, the fitness to drive could be increased leading to a positive assessment, restoring the driver's license and better avoiding future offenses. The authors conclude that the MPA and driver improvement programs are useful tools to improving traffic safety.

In the last paper, Ausserer and Risser analyzed how greenery can change traffic behavior. They interviewed residents and observed their behavior. As previous studies show that greenery can increase the rate of walking and cycling, the current results show that more greenery should be implemented in cities. People enjoy greenery when they walk but most people are not willing to make detours to see more greenery. In addition, greenery increases the attraction of places, yet not the feeling of safety. Thus, the authors advise to achieve a better cooperation between traffic planning and greenery planning in order to create routes that are both safe *and* attractive.

The results of the papers in this issue stress that especially young and novice drivers are a high-risk group because they are inexperienced and, maybe due to cultural or peer influence, more likely to show risky behavior such as drunk driving, speeding or breaking other traffic rules. Thus, young drivers should be addressed more intensely to avoid these traffic offenses so that undesired behaviour will be reduced or avoided right from the beginning. Therefore, it is important to further understand why young/novice drivers do what they do so that concrete countermeasures could be developed and implemented in order to increase traffic safety. The same is true for pedestrians and cyclists who have the same right of traffic safety. Therefore, future city and road planning should consider these growing groups of road users more. A stronger focus should be put on children's special needs in traffic. One way to achieve that is the strategic use of safety measures combined with greenery in order to increase the attractiveness of the public space. In the end, it cannot be excluded that making traffic generally more lenient and less dynamic will also have a possible influence on children's traffic safety and on which behavior young drivers will develop.

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The development of traffic competences – do children need special infrastructure to be safe in traffic?

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ABSTRACT: *A lot of (visual, auditory, social, emotional, psycho-motoric, intellectual and cognitive) competences are needed for safe traffic participation. Traffic competences develop during childhood and youth and there is a close relationship to brain maturity. Based on extensive literature analysis a comprehensive tabulation of empirically based developmental milestones was developed by gathering knowledge from different disciplines (Schützhofer, Rauch, Knessl & Uhr, 2015, Schützhofer, 2017).*

These milestones of traffic competences, forming the core of this paper, are now extended and updated to answer the question of how children can be aware of the traffic environment at a certain age and what this implies for their safe traffic participation. This article forms the framework for the tabulation and focuses on the development of visual competences and hazard perception. Based on the results of the literature review, it will be discussed if there are implications for infrastructure planning as well as for traffic education. Main objective of this research is the development of recommendations for age dependent safe traffic participation that do not under- or overstrain children and give them the chance to have their own active traffic experiences within adequate and safe borders.

This traffic psychological and developmental psychological knowledge is essential in various fields. The results address policymakers, traffic managers, transport planners and technicians and help them to appreciate that children are not small adults and adaptions of the existing traffic environment are needed. They can also be a starting point for the development of traffic safety workshops for pedagogues, parents and police officers as in Austria.

KEYWORDS: *Development of traffic competences; traffic education; traffic infrastructure for children; hexagon of traffic safety work; traffic sense*

1. INTRODUCTION

Children are not small adults. Their necessary competences to be safe in traffic are still in development. Empirical findings show, that the perception of the traffic environment strongly depends on the developmental stage of the child (cf table 1). An important target of traffic and mobility education is to train children age-adequate and to help them take the first steps in traffic within safe borders that do not lead to over- or understraining. High-quality programs on traffic and mobility education therefore have to be theory-based and need continuous evaluation. Furthermore, good programs are well structured and build on each other considering that traffic and mobility education are lifelong processes. Thus, they need to begin early in kindergarten and last as long as possible. In the sense of *mobility* education, programs should continually include aspects promoting children's active and independent mobility by reflecting on the consequences of travel behavior on health and environment; this is not elaborated in this paper. According to the development of the cognitive ability of abstract thinking, good programs start with simple and concrete tasks that become slowly more complex and abstract. Also, according to this mentioned development of abstract thinking the first steps have to be made in the playroom, followed by the protective space. The last important step is the training in a real-life environment. Therefore, besides education and training, infrastructure plays an essential role for safe traffic participation of children.

2. THEORETICAL BACKGROUND

As argued in section 2.1, traffic safety work is more successful when it follows an interdisciplinary ap-

proach, a holistic understanding of traffic behavior and use of infrastructure. Safe traffic participation not only needs a lot of developed single competences, these single competences also must interplay fast and correctly (Schützhofer, 2017, Schützhofer, Rauch, Knessl & Uhr, 2015). Table 1 shows all necessary competences for safe traffic behavior of children in their development from age 3 to age 14 (cf section 2.2). Due to space constraints in this article the examples focus on visual competences and hazard perception.

2.1. Interdisciplinary traffic safety work

Traffic safety and mobility work often focuses on children and pedagogues in kindergarten or school. Sometimes parents are also involved. Because traffic participation takes place in the traffic system, it is necessary to take the whole traffic system into account, including infrastructure, traffic laws etc. and to think in a holistic and interdisciplinary way (Schützhofer et al., 2015).

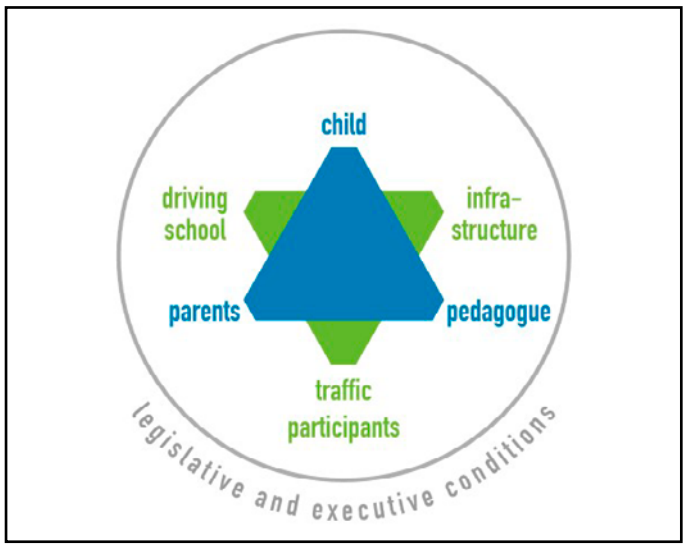

Figure 1: Hexagon of traffic safety work

As shown in figure 1, the pedagogic triangle (child – parents – pedagogue) was extended by another triangle consisting of infrastructure, other traffic participants (e.g. as role models for correct traffic behavior) and driving schools (e.g. as institutions for traffic education for adults). The two triangles are embedded in the actual legislative and executive legal framework. The more child adequate the single dimensions of the hexagon of traffic-safety-work are implemented in the traffic system the more active traffic participation of children can be observed. The safer the given infrastructure is evaluated by the parents the more children are allowed to participate actively and to walk unaccompanied in traffic (Frauendienst & Redecker, 2011, Ausserer, Röhsner & Risser, 2010). Schützhofer et al. (2016) therefore recommend checking if guidelines and regulations for traffic planners are child adequate. Traffic psychologists can here contribute with the necessary knowledge and background information and help with further education.

In Austria, for example, there are RVS guidelines for a safe school environment (RVS 03.04.14, 2003) and for child-friendly mobility (RVS 03.04.13, 2015). RVS guidelines are activity regulations with a recommended character representing the current technical standard for a defined field of action. They are based on legal, normative and further technical rules. The school environment in the RVS guidelines is defined as a radius of 250 m around the school entrance. For the broader environment the implementation of school way plans is recommended. The aim of these guidelines is the adaption of the traffic environment around schools to the needs of children. They contain a list of ratings of specific traffic-organizational and constructional measures. Besides an improvement of traffic safety, the creation of an attractive residential area is considered. Essential for technicians is also the improvement of the visibility conditions. General recommendations for measurements are pedestrian zones in front of schools, enough space in front of the school entrance or bus stops to avoid crowding, speed limits near schools, bicycle lanes, pedestrian crossings that reflect the special needs of children (cf Leden, Johansson, Rosander, Gitelman, & Gårder, 2018), kiss and go areas, and barrier free design. School way safety and traffic safety of children in general are also an important issue in the traffic safety program of the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit) (bmvit, 2016).

An evaluated good practice example for an interdisciplinary approach for improving traffic safety of children is the so-called school way plans in Austria (Knowles, Schneider & Robatsch, 2016). They are developed involving children, parents, school directors, police officers, a representative of the road maintenance department and traffic safety experts. The school way plan helps parents to find the safest way to school and to detect any possible dangerous situations. The plans support the local authorities in a further step to decrease or eliminate hazards on the way to school. The school way plans are a good basis for the school way training.

Children focus on different aspects of the traffic and built environment than adults do

(Limbourg, 2008). For example, in an Austrian study, children's perceptions on the environment were collected with a smartphone application (Stark et al., 2018b). Children locate aspects in their environment that they like or dislike. More than 450 evaluations were collected and visualized in a digital map containing photos and descriptions. A categorization of their observations reveals that children focus not so much on traffic safety issues but rather on functionality aspects like (not) enough space, places to sit, waiting times or damaged local infrastructure as well as on aesthetics like for example cleanliness and roadside greenery (Figure 2). They also take notice of environmental related aspects like air quality and noise emissions in their areas of activity in the city of Vienna. They often take the traffic environment as granted and do not dare to express their wishes. Traffic infrastructure should therefore be planned and build carefully, in a way that attracts the child's attention.

2.2. Development of traffic competences – developmental milestones by means of visual competences and hazard perception

As outlined before, traffic competences develop during childhood and adolescence. In Table 1, developmental milestones of average children and their implications for safe traffic behavior are described. This takes into account that some children develop at a slower or faster rate. To use the developed competences effectively in traffic, children need age-specific traffic education and training. Without such education, the necessary traffic understanding is missing. Figure 3 demonstrates, as an example, why this is essential by means of visual competences of a 6-year-old pupil. The first photo on the left-hand side shows a typical traffic situation: A father wants to cross the street together with his six-year-old daughter. The second and third photos demonstrate that both have a completely different perspective of the situation: The adult can get a good overview resulting in a reliable information basis for safe traffic behavior. However, the child can only get an overview of parts of the situation and cannot get all relevant details for a safe crossing decision.

Adults need to be aware of these facts when doing traffic education with children. In addition, transport planners have to take the smaller size and the lower eye position into account. Due to their smaller size children don´t see the same as adults. When adults are not aware of this fact, they explain traffic relevant details that the children cannot understand because they don´t see them. The child in figure 3 would have to move closer to the street or even walk onto the street to have the possibility of a full overview.

In addition to the handicap due to smaller size, depth perception and near and far accommodation are not fully developed until the age of nine. Depth perception and near and far accommodation are necessary requirements for speed and distance perception. Children up to the age of nine are therefore not able to estimate speed and distances in a satisfactory way. They compensate for this lack by interpreting light intensity for distance perception. In their speed rating bright colored cars are both faster and nearer then dark colored cars. This misinterpretation can lead to dangerous situations in traffic and must be considered. Additionally, peripheral vision must be developed during childhood and adolescence. There are different empirical findings concerning this ability, but what is

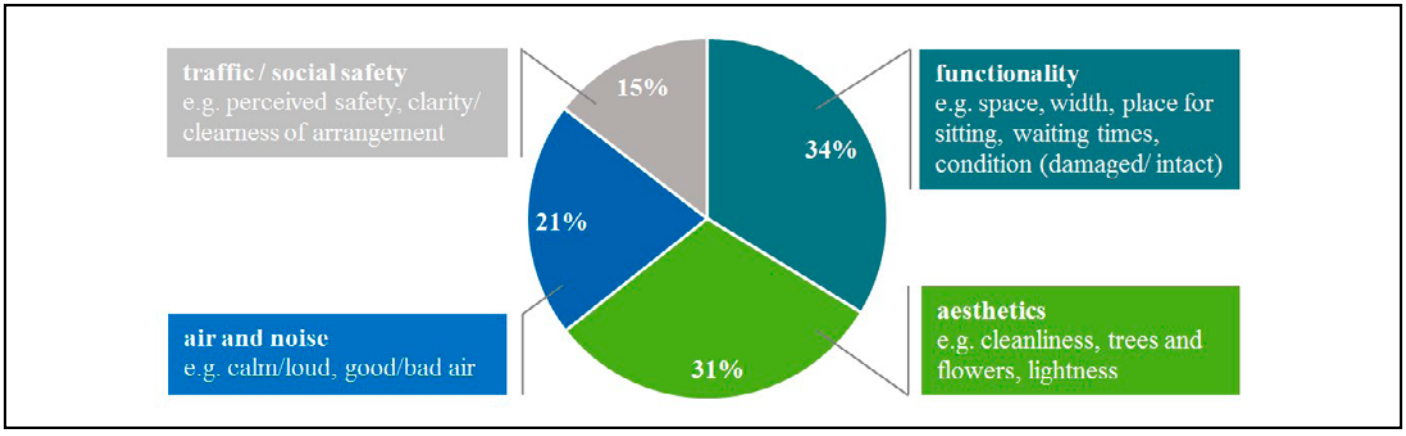

Figure 2: Categorization of aspects of traffic and built environment children evaluated with the help of a smartphone application (N=466)

Figure 3: An example of a typical traffic situation (left), adult perspective (middle), child perspective (right) (picture credits: AUVA)

known for sure is that even teenagers cannot use their peripheral vision efficiently (cf table 1).

Hazard perception is one of the most important abilities for safe traffic behavior. It is strongly connected with the development of cognitive abilities. Children up to the age of 6 have a preoperational thinking structure. Children from 6 to 12 have a concrete-operational thinking structure (Piaget, 1983). This means that they are not capable of abstract and anticipatory thinking processes. These processes are still in development. In this context it is very important that *knowledge* should not to be equated with *understanding*. Many studies have shown that children in kindergarten and in primary school had good results when they were shown pictures of traffic situations and were asked to identify what was dangerous. But when they showed them the same pictures and asked them what they could see, they mentioned numerous traffic irrelevant details before they talked about the traffic relevant ones (Limbourg & Günther, 1977 citied after Limbourg, 2008, Hill, Lewis & Dunbar, 2000). When children were asked if something can become dangerous in the situations shown here, especially the younger children failed completely but even the older ones didn´t get good results. That´s because the cognitive processes necessary for anticipating are not developed in these age groups. This means that hazard perception and hazard awareness are not fully developed until the age of ten.

Compared with adults, children have slower perception, thinking and decision processes. An awareness of hazard perception develops in three developmental stages (Limbourg, 2008, cf figure 4). Pre-school children do not have a realistic sense of hazards in traffic. They have an egocentric view of the world and magic thinking which means that they confuse reality and fantasy. Three, four or five-year-old children feed their dolls or teddys and want to put big Lego figures into a small toy car. They have the same thinking structure in traffic. For example, they believe they are super(wo)man and cars cannot harm them – that´s the logical conclusion from a child's perspective. At the age of six, children switch from the pre-operational thinking structure to the con-

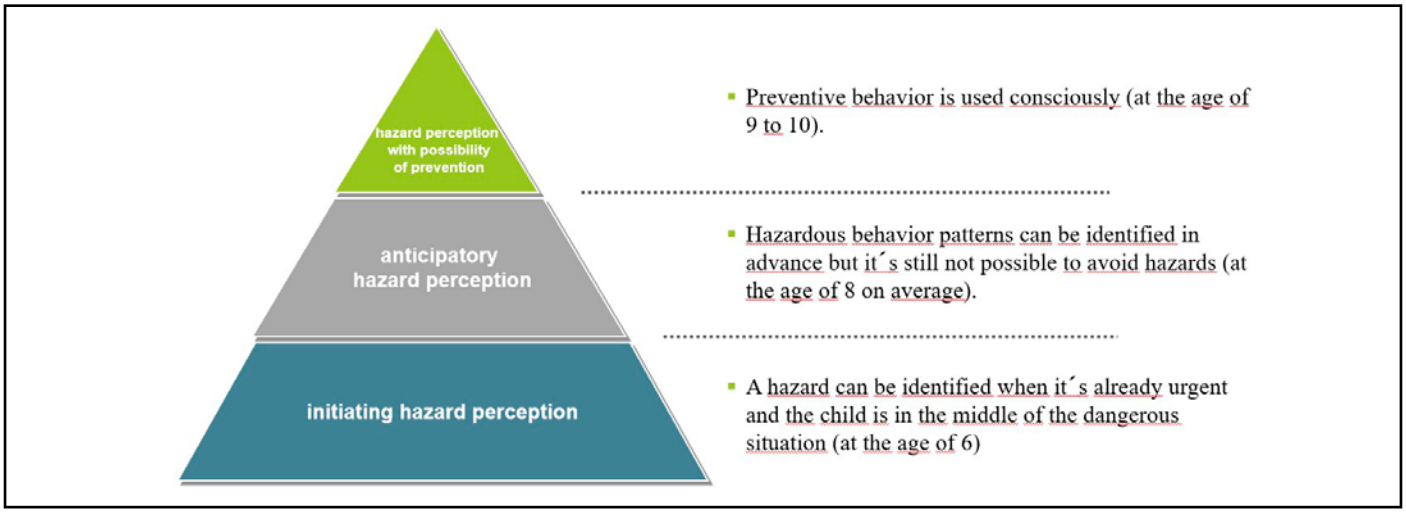

Figure 4: Development of hazard perception and safety awareness (Limbourg, 2008 translated and adapted)

crete-operational one. They can now already identify a hazard but only when they are confronted with it and are in the middle of a dangerous situation. This means that a child at the age of six realizes the danger when it´s already too late to cope with the situation. The child cycles, for example, downhill and identifies the hazard when it´s already too late for braking. It cannot realize that cycling downhill could lead to dangerous speeding. At the age of 8 on average, children can realize this in advance, but preventative behavior is not used consciously until the age of 9 to 10. Then the child can choose an alternative route and doesn´t cycle downhill, for example.

3. IMPLICATIONS FOR CITY AND TRANSPORT PLANNERS

From a child's perspective, the public space is not only a space in which to move, but is also a space to live, to meet and to play. It should be pointed out that children want to explore their environment actively. They clearly rate walking as well as the use of a bicycle or scooter as their favorite travel modes (Stark et al., 2018a). Knowledge of children's different perception of the traffic environment should not lead to restrictions to their active and independent mobility. Moreover, the idiosyncrasies of children due to developmental processes should be considered in infrastructure planning. In particular, the design and dimensions of traffic areas must be adapted to children's requirements and abilities. Thus, ideally, public space should be designed in such a way that persons with not fully developed traffic competences can fulfill their mobility needs at the best possible rate. In this respect, it could be unreliable to relate recommendations to specific age classes. It may be better to strive for child-friendly traffic environments using a low as possible stage of development as a yardstick. The following recommendations are based on what is actually seen or perceived through the eyes of a child. No claim is made that this is a complete list, but it should provide examples of implications for city and transport planners.

Generously sized sidewalks extended into the road in special areas help to give an improved overview. A better overview is also given when vision is not obstructed by (large) cars, advertising hoardings, large plants, etc. at junctions, (zebra) crossings or near schools (cf figure 3). In this regard, a careful revision of existing guidelines is recommended, for example regarding adequate clearance gauge requirements. Due to the longer time demands of children e.g. for gap choices, large-scale speed reduction measurements like speed limits or speed bumps for motorized transport and pedestrian islands are as helpful for children as longer green signal phases on traffic lights. As mentioned before, speed reductions should be accompanied by measures on road alignment such as roadway swiveling.

Other organizational measures such as pedestrian zones or temporary car-free zones around schools at the beginning and end of lessons are recommended. Parents escorting their child to school by car should not be allowed to drive close to the school building (kiss and go). This should also refer to teaching staff except for disabled persons. In this regard, as one example, the City of Bregenz (province Vorarlberg, Austria) can be mentioned. In the vicinity of a school strict restrictions have been implemented for safe and active travel for children. Traffic bans for motorized transport (except for residents and suppliers) apply from 07:15 a.m. to 5 p.m. on working days. Bus and tram stops as well as spacious bicycle stands are sited close to the school; parking spaces are limited. In addition, job tickets for public transport and incentives for active mobility are offered for the teachers. There are also other individual examples that have already been implemented in some Austrian provinces (Salzburg, Styria). As a pilot test, also Vienna is going to implement a temporary driving ban starting in September 2018 at one school between 07:45 to 08:15 a.m.

Another very important issue is the logical structure of infrastructure. For the child´s better understanding bicycle lanes, for example, must not only be clearly marked but also continuously. When they are interrupted by a junction the child doesn´t know how to go on. Children need a logical (at best self-explaining) structure for safe orientation in the traffic system.

It should be pointed out, that residents and parents should be involved when implementing measures in the school environment to enhance the acceptance of regulations.

4. CONCLUSION AND DISCUSSION

Depending on age, children don´t have the full set of necessary traffic competences or it is not fully developed (cf table 1). Due to these facts they need more time in traffic situations for perception, getting an

overview, information processing, making decisions (e.g. gap-choices) and starting actions (e.g. crossing the street or starting to cycle). Especially due to children´s longer time demand and their smaller size infrastructure that is ideal for adults isn't always the optimum for children. Interdisciplinary traffic safety work can help to find the optimum traffic environment for all users. As described before, the development of school way plans in Austria is a good practice example. School way plans need regular reworking and should be accompanied by effective and determined awareness programs for parents. However, if hazard zones are identified, every effort must be made to improve the built environment in terms of traffic safety.

As outlined before, existing guidelines for a safe school environment and for child-friendly mobility in Austria (RVS) are good practice examples for inclusive urban planning and are a first step in raising awareness regarding children's requirements. These guidelines should also be considered for the immediate catchment area of kindergartens. It should be noted that practical implementations based on such regulations need to be evaluated carefully. In a next step such regulations should be transformed into more binding legal instruments.

It can also be concluded that it is necessary to make adults aware of the child's age dependent traffic competences. This would help to sensitize road users to this vulnerable group so that they are able to understand and appreciate exactly how children may react and the reasons why. In this context, Table 1 can serve as a basis because it gives a comprehensive overview especially concerning single competences. For safe traffic behavior a fast and correct interplay between the numerous single competences is essential. However, single competences develop at different speeds. As such, it is necessary to have a holistic and systemic approach and to investigate how theory based and age specific traffic education as well as child adequate infrastructure can help to compensate for the missing single competences. A lot of research is already done, but further research is still needed - especially with an interdisciplinary approach. This research could also be fruitful for a better understanding of self-explaining infrastructure, the redundancy of existing traffic signs or the need for new helpful signs or signals.

To sum up, depending on the local structural conditions special infrastructure for children may be necessary. Child adapted infrastructure helps to improve traffic safety of children and enables them, for example, to perceive all the relevant details to make a safe crossing decision. As a positive side effect, a child adapted infrastructure often tends to make traffic conditions also safer for people with special needs such as the disabled, wheelchair users and the elderly.

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Table 1: TRAFFIC SKILLS AND THEIR FOUNDATIONS

	MOTOR SKILLS			VISUAL PERCEPTION				
Age	Gross motor skills	Hand motor control / finger dexterity	Effects in traffic	Perception of colour / light and dark	Visual acuity and accommodation	Peripheral vision	Depth perception and spatial perception	Effects in traffic
up to 3 years:	**3 years:** hopping off a step with both feet, with reliable balance control (Michaelis & Niemann, 1999) **3 years:** running with swinging arms (Michaelis & Niemann, 1999) **3 years:** moving around obstacles (Michaelis & Niemann, 1999) **3 years:** clear acceleration when running, greater agility and dexterity; walking backwards, walking on tiptoe, dancing to music, balancing on narrow beams (Schneider & Lindenberger, 2012) **3-4 years:** climbing stairs with alternating legs and descending stairs with one leading leg; jumps and hops with flexible upper body; throws and catches ball with slight involvement of the upper body; ball is still clamped against chest; steers tricycle; pedals (Berk, 2011) **3 years:** walking backwards, standing on tiptoe (Schneider & Lindenberger, 2012)	**3 years:** child can turn individual pages of a book (Michaelis & Niemann, 1999) **3 years:** child can use precise three-finger pinch grip (thumb-index finger-middle finger) to manipulate small objects (Michaelis & Niemann, 1999) **3-4 years:** undoing and doing up buttons; eating without help; using scissors; copying circles and vertical lines; drawings of people consisting of a circle for the head and lines for the limbs (Berk, 2011)	**3 years:** considered purely from the perspective of motor skills development processes, the child can perform simple riding manoeuvres on a bicycle (getting on and off, braking, riding in a straight line, riding around corners) (Pfafferott, 1994) **from approx. 3 years:** child can complete simple manoeuvres in terms of motor skills on a bicycle (Basner & De Marees, 1993)	**4 months:** child sees colours like an adult (Kellmann & Arterberry, 2006) **3 years:** colour perception (50-85%) (Van der Molen, 2002)	**6 months:** visual acuity comparable to that of an adult (Slater, 2001)	**2-3 years:** visual field (field of vision) corresponds to the size of an adult's (Dobson, Brown, Harvey, & Narter, 1998), but cannot yet be used equally well, due to cognitive mechanisms (e.g. attention) (Martin, 2010)	**3-4 months:** infants can recognise three-dimensional shapes (Kraebel, West, & Gerhardstein, 2007). **from 4 months onwards:** depth perception is possible (Pieper, 1990) **between 5-7 months:** development of the ability to process depth information in two-dimensional images (Pieper, 1990)	
4 years	**4 years:** child can ride a tricycle or similar safely in a focused manner (Michaelis & Niemann, 1999) **4 years:** pedalling and steering at the same time (Michaelis & Niemann, 1999) **4 years:** hopping forward on both legs approx. 30-50 cm from a standing start, with reliable balance control (Michaelis & Niemann, 1999) **4-5 years:** children find it difficult to interrupt their actions, only 33% of the 4 to 5-year-old children needed less than 1 second to interrupt their action (cranking toy cars attached by string over a long plank using a hand crank) in response to a signal (Limbourg, 1995) **up to 5 years:** children rely greatly on visual information and lose their balance when they close their eyes (Bremner, Lewkowicz, & Spence, 2012)	**4 years:** holding a pencil correctly (with 3 fingers) (Michaelis & Niemann, 1999) **4 years:** child draws and comments on objective things; draws people consisting of a circle for the head and lines for the limbs (Michaelis & Niemann, 1999)	**4-5 years:** riding a bicycle/scooter is possible, as the child has a sense of balance (Limbourg, Höpfner, & Niebling, 1977; Limbourg, 2008; Klöck & Schorer, 2011)				**< 5 years:** no distinction between stopped and moving vehicles is possible (Limbourg, 1995)	**4 years:** children can find their way in a maze using simple maps; reference stimuli such as trees, roofs or buildings are more important than verbal explanations on the map (Blades & Spencer, 1985) **4-5 years:** children cross the road quickly and without prior orientation (Limbourg, 1976) **4-5 years:** only 11% can correctly estimate speeds (Günther & Limbourg, 1977)
5 years	**5 years:** climbing and descending stairs safely and without holding on, alternating leading leg (Michaelis & Niemann, 1999) **5 years:** catching larger balls (diameter approx. 20 cm) with hands, arms and body, when they are thrown from a distance of 2 m (Michaelis & Niemann, 1999) **from 5 years onwards:** balance has developed further; standing on one leg, rolling and catching balls (Schneider & Lindenberger, 2012) **5 years:** children with an average amount of training can master simple manoeuvres on a bicycle (riding in a straight line, cornering, etc.)(Weber et al., 2005)	**5 years:** child can cut along a straight line using safety scissors (Michaelis & Niemann, 1999) **5 years:** child can write individual letters, numbers, names in large letters (also still laterally inverted) (Michaelis & Niemann, 1999) **5 years:** child paints and draws easily recognisable images (Michaelis & Niemann, 1999) **5-6 years:** shapes such as circles, triangles or crosses can be copied (Michaelis & Niemann, 1999) **approx. 6 years:** only one hand should be used when painting (Balster, 1998)	**4-6 years:** improvement in motor skills and fewer accidents after coordination training (Kambas et al., 2004) **5-6 years:** children stop at the side of the road 50% of the time (Savelsbergh, Davids, van der Kamp, & Bennett, 2003) **from 5 years onwards:** balance has developed further. Prerequisite for riding scooters and bicycles is in place (Schneider & Lindenberger, 2012) **5 years:** children can master simple manoeuvres on a bicycle (riding in a straight line, cornering, etc.) (Weber et al., 2005) **5-13 years:** only slight performance improvement when riding between two boundary lines on a bicycle between 5-13 years, performance only increases rapidly from 14 years (Arnberg et al., 1978)	**5 years:** colour perception (>85%) (Van der Molen, 2002) **5 years:** child recognises and names basic colours (blue, green, yellow, red, black, white) (Michaelis & Niemann, 1999; Kellmann & Arterberry, 2006) **5 years:** ability to distinguish brightness and colour continues to develop up to 5 years of age, but distinguishing between red and green is not a problem, brighter whiteish light is perceived as closer than dark, coloured light (Limbourg, 2008)	**5 years:** limited accommodation in the sense of restricted near-far perception (Warwitz, 2009) **5 years:** visual acuity matures at 5 at the earliest; some studies find adult levels for the first time in teenagers (Leat et al., 2009)		**5 years:** perspective depth perception is developing (Warwitz, 2009) **5 years:** adequate estimate of speed (only 50-85%) (Van der Molen, 2002) **5 years:** adequate estimate of distances (only < 50%) (Van der Molen, 2002) **5 years:** concept of speed and distance is mastered (Siegler & Richards, 1979) **5 years:** adequate movement perception (Van der Molen) (>85%) (Michaelis & Niemann, 1999)	**5-6 years:** safe behaviour in traffic is still weak (stopping on the pavement in good time, looking out for approaching traffic, looking in the wrong direction) (Zeedyk, Wallace, & Spry, 2002) **5-6 years:** decisions taken by children when crossing the road in connection with time gaps in the flow of traffic and the speed of approaching cars: children make dangerous decisions, as the absolute spatial size of the gap is used as the basis for the decision and not the speed (Connelly, Conaglen, Parsonson, & Isler, 1998) **5-7 years:** children decide whether to cross the road based only on whether they can see cars from their position, further information such as confusing crossing points, visual obstructions or complex crossings is not taken into account (Ampofo-Boateng & Thomson, 1991) **5-11 years:** children focus on irrelevant features of the situation that have nothing to do with road traffic (Tolmie et al., 2005)

Table 1: TRAFFIC SKILLS AND THEIR FOUNDATIONS

	ACOUSTIC PERCEPTION		COGNITIVE DEVELOPMENT					
Age	General hearing ability, directional hearing and noise differentiation	Effects in traffic	Attentiveness (selective, duration, divided, distractibility)	Ability to adopt other perspectives	Thinking	Social and emotional competence	Hazard perception	Effects in traffic
up to 3 years:	**6 months:** threshold values for general hearing ability are reached at approx. 6 months (Tharpe & Ashmead, 2001) **3-4 years:** hearing ability reduced by 7-10 decibels (cars heard later) (Pieper, 1990)		**2-6 years:** selective attention develops slowly in the first 2 years of life, with significant developmental gains up to approx. the 6th year of life (Garon, Bryson, & Smith, 2008) **3 years:** child plays in a focused and in-depth manner: "make believe" games, games with cars, dolls, building blocks, Playmobil, etc. (Michaelis & Niemann, 1999) **up to approx. 4 years:** attention is exclusively controlled by environmental stimuli. Children are hardly able to pay attention in the manner necessary for their safety (Limbourg, 1995)	**3-6 years:** egocentric adoption of perspective in the sense of "I see the car, therefore the car sees me!"; differences between him/herself and others are perceived, but not differences to his/her own social perspective (Piaget, 1983) **3-7 years:** stage of subjective interests (Warwitz, 2009)	**2-6 years:** pre-operational stage (Piaget, 1983) **2-4 years:** descriptive-situational and causal thinking (an event has a cause), self-centred perception and thinking. Egocentrism is based on the reactions of adults (Böttcher, 2005)	**2-4 years:** impulsive and need-based actions take place without fine control and without insight into social rules (Böttcher, 2005) **3 years:** playing together with other children for at least 5 minutes (Michaelis & Niemann, 1999) **3 years:** child can stay with people known to him/her for several hours, and also stay outside the house without a caregiver (Michaelis & Niemann, 1999) **3 years:** imitates adult activities in role play; would like to help with household activities (Michaelis & Niemann, 1999)	**3-4 years:** only very vague basic understanding that traffic can be dangerous (Briem & Bengtsson, 2000)	**3-4 years:** only very vague basic understanding that traffic can be dangerous; children only had dolls use the zebra crossing by chance, and hardly looked and waited before they crossed the road (Briem & Bengtsson, 2000) **3-7 years:** children are often emotionally engaged in the process of riding a bicycle. Mixing of reality and fantasy, bicycle is viewed as a horse for example. This leads to distraction and poor hazard perception (Walter, Achermann Stürmer, Scaramuzza, Niemann, & Cavegn, 2012)
4 years	**4-5 years:** acoustic perception/location (>85%) (Van der Molen, 2002)		**4-5 years:** high level of distractibility due to irrelevant stimuli (Pasto & Burack, 1997) **4-5 years:** children pay less attention to oncoming traffic than older children (Barton & Schwebel, 2007) **4-5 years:** attention is more focused on things that are not relevant to traffic (Günther & Limbourg, 1977)	**from 4 years onwards:** children begin to understand meta-representations of the world by developing theories about what others think or know (theory of mind). These theories make it easier for them to predict the behaviour of others (Premack & Woodruf, 1978) **4-5 years:** children can deduce that someone sees something they cannot themselves see (Flavell, 1992) **4-6 years:** children understand that their perception of the world can differ from that of others and also that there can be incorrect beliefs (Wimmer & Perner, 1983)	**4 years:** child asks "W" questions (Michaelis & Niemann, 1999) **4 years:** child distinguishes and names identical objects of different sizes, and is able to differentiate these (for example large and small apples) (Michaelis & Niemann, 1999) **4 years:** children are already showing the beginnings of successful inhibition in inhibition tasks that are simple (e.g. only inhibiting response) and more complex (e.g. inhibiting response and displaying alternative response) (Bjorklund, 2005). **4-6 years:** more integrated thinking (details move into the background), purposeful thinking, events are conceivable, symbolic thinking, extension of knowledge through visual acquisition (Böttcher, 2005) **< 5 years:** children are only able to sort objects by one criterion (Brooks, Hanauer, Padowska, & Rosman, 2003)	**4-6 years:** child can carry out requested actions, basic understanding of the rules of games, but the use of these is variable (Böttcher, 2005) **4 years:** start of games with rules (board games) (Michaelis & Niemann, 1999) **4 years:** child is ready to share (Michaelis & Niemann, 1999) **4 years:** child is generally able to regulate his/her emotions concerning everyday events him/herself, certain tolerance to sadness, disappointment, joy, fear, anticipation, stress (Michaelis & Niemann, 1999) **4 years:** child knows that he/she is a boy or girl and behaves accordingly (Michaelis & Niemann, 1999)	**4-5 years:** children have only a very rudimentary concept of danger, with situations being recognised as dangerous more readily than objects (Hill, Lewis, & Dunbar, 2000) **4-5 years:** visual obstructions are not perceived as dangers by children of this age (Thompson, 1997) **4-5 years:** children are able to identify dangerous situations and accidents, but do not understand the cause of the accident or how to avoid danger (Hargreaves & Davies, 1996)	**4-5 years:** children cross the road quickly and without prior orientation (Limbourg, 1976)
5 years	**5 years:** "slow hearing" with regard to registration, identification, classification, unreliable discrimination, inaccurate localisation (Finlayson, 1972) **5 years:** directional hearing is facilitated by looking in the relevant direction (Warwitz, 2009) **5-10 years:** Depending on the pitch (frequency), children attain the hearing threshold of adults between the ages of 5 and 10. Prior to this, noises are only heard clearly from a higher frequency (Werner & Marean, 1996)	**5 years:** the speed of loud cars is overestimated, quiet cars are perceived as slower, which makes control perception necessary (Warwitz, 2009) **5 years:** children are poor at identifying oncoming vehicles or those driving away from them using acoustic signals, meaning that no directional hearing is possible (Pfeffer & Barnecutt, 1996)	**5 years:** if you ask a child to focus only on the road traffic, he or she will do so for 15 minutes at most. Longer periods of deliberate attention place excessive demands on the child (Walter et al., 2013). **from approx. 5 years onwards:** children develop systematic strategies for attention (Limbourg, 2008) **5 years:** deterioration of performance when processing tasks concerning the ability to distinguish visually due to minor acoustic distraction; children made more frequent mistakes and strayed away from the task (Higgins & Turnure, 1984) **5-7 years:** attention can be more consciously controlled, but distractibility as a result of environmental stimuli is still present (Limbourg, 1997; 2008)		**5 years:** 5-year-olds need approximately twice as long as adults to make a decision as a pedestrian (Schieber & Thompson, 1996) **from 5 years onwards:** children can sort objects by 2 criteria, e.g. cards by colour and shape (Brooks et al., 2003) **5-8 years:** children have more difficulties choosing safe routes to cross the road than older children (Schwebel et al., 2012)	**5 years:** child can share toys and sweets fairly between him/herself and others (Michaelis & Niemann, 1999) **5 years:** Child invites other children, is invited (Michaelis & Niemann, 1999) **5 years:** occasionally still looks for close physical contact: when tired, exhausted, ill and similar (Michaelis & Niemann, 1999) **5 years:** Child can report on embarrassing, frustrating, unpleasant incidents (Michaelis & Niemann, 1999) **5 years:** Children play a lot of role-playing games (including with other children), dress up as heroes, role models (Michaelis & Niemann, 1999)	**5 years:** Targeted individual training (better than group training) can improve the safety strategies (selection of safe route) in 5-year-old children (Thompson, 1997) **5 years:** dangerous situation creates vague feeling of fear that paralyses or leads to panicky behavioural outbreaks (Warwitz, 2009; Piaget, 1983) **5 years:** children can generally recognise danger; their weakness lies in transferring and applying their knowledge (Dunbar, Lewis, & Hill, 1999) **5-6 years:** beginning consciousness of risk (Limbourg, 2001) **5-6 years:** Term "accident" is falsely equated with injury (near-misses are not classified as danger) (Rollett, 1993) **5-6 years:** Compared to 7-8-year-olds, children take more risks when crossing the road and accept smaller gaps between cars, which increases the risk of a collision (Barton & Schwebel, 2007) **5-7 years:** have low capacity to detect dangers when crossing the road (Ampofo-Boateng & Thompson, 1991) **5-7 years:** the most direct route is also seen as the safest route when crossing the road, lack of awareness for dangers originating from obstacles at the side of the road or other visual restrictions (Ampofo-Boateng et al., 1993)	**from approx. 5 years onwards:** children can be educated using pedestrian training based on the psychology of learning (Funk, Hecht, Nebel, & Stumpf, 2013) **5 years:** compared to 3-4-year-olds, they have a better basic understanding of the fact that traffic can be dangerous. Children made dolls use the zebra crossing more often, but still paid little attention to the traffic. They had problems explaining their actions. More than 50% believe that they can see better at night with a reflector and that a helmet prevents them from falling (Briem & Bengtsson, 2000) **5 years:** laboratory-based training on crossing the road does not result in any long-term, significant change in actual behaviour when it comes to real traffic (Young & Lee, 1987) **5 years:** detection of a safe crossing place after training (50-85%) (Van der Molen, 2002) **5-7 years:** When assessing safe places to cross roads, children focus on whether or not there are any cars travelling there. They either wait a very long time to cross or choose places after corners, hilltops, bridges, etc. from which it is scarcely possible to see cars. I.e. decisions are taken based only on whether cars can be seen from the selected location, without taking other information such as confusing crossing points, visual obstructions or complex crossings into consideration (Ampofo-Boateng & Thomson, 1991) **5-11 years:** children between 5 and 11 years of age tend to concentrate on other things (e.g. play areas, dogs), if they are not expressly instructed to pay attention to the traffic during the study (Percer, 2009).

Table 1: TRAFFIC SKILLS AND THEIR FOUNDATIONS

	MOTOR SKILLS			VISUAL PERCEPTION					ACOUSTIC PERCEPTION	
Age	Gross motor skills	Hand motor control / finger dexterity	Effects in traffic	Perception of colour / light and dark	Visual acuity and accommodation	Peripheral vision	Depth perception and spatial perception	Effects in traffic	General hearing ability, directional hearing and noise differentiation	Effects in traffic
6 years	**6 years:** stopping as a pedestrian (>85%) (Van der Molen, 2002) **6 years:** at least 5 sec. standing on one leg (Michaelis & Niemann, 1999) **6 years:** hopping on one leg (Michaelis & Niemann, 1999) **6 years:** motor development shows significant increase in learning capacity (Limbourg, 2008) **6 years:** catching a ball (Michaelis & Niemann, 1999) **6 years:** riding a bicycle (Michaelis & Niemann, 1999) **6 years:** overestimation of physical abilities when performing physical exercises (Plumert, 1995)		**6 years:** once they have started movement patterns, children are frequently unable to interrupt or control them promptly. They would not come to an abrupt halt even if it were necessary (Brück, 2009) **6 years:** while 8-year-olds already make use of learning effects in their self-assessment regarding their vertical reach and their judgment is therefore more accurate, this is not yet possible for 6-year-olds; they still tend to overestimate (Plumert, 1995).		**5-6 years:** visual acuity values correspond to those of adult test subjects (Lai, Wang, & Hsu, 2011) **6 years:** visual acuity and sensitivity to contrast are comparable to what is found in adults (Ellemberg, Lewis, Liu, & Maurer, 1999).	**6-7 years:** peripheral vision is 70% developed, objects approaching from the side are outside the field of vision for a long time (Walter, Achermann Stürmer, Scaramuzza, Niemann, & Cavegn, 2013) **6 - 8 years:** children in this age group need longer to react to optical stimuli in their peripheral field of vision than 11-year-olds and adults (David, Foot, Chapman, & Sheehy, 1986).	**6 years:** adequate estimation of distances (50-85%) (Van der Molen, 2002) **6-7 years:** difficulties in interpreting the speed and direction of moving objects/ vehicles (Joly, Foggin & Pless, 1991) **6-7 years:** adequate understanding of spatial relations (50-85%) (Van der Molen, 2002)	**6-7 years:** only 32% are able to estimate speeds correctly (Günther & Limbourg, 1977) **6-7 years:** when crossing the road, children principally oriented themselves on the edge of the pavement, then ran across the road without additional orientation (Limbourg 1976)	**6 years:** still uncertainty with noise localisation, noises are only correctly attributed from in front or behind (Dordel & Kunz, 2005)	**from 6 years onwards:** hearing ability fully developed, but not yet regularly drawn on in traffic (Finlayson, 1972)
7 years	**6-7 years:** stopping actions after they have been started is possible, but is linked to guidance (Limbourg, 1976) **6-7 years:** 63% of the 6 to 7-year-old children needed less than 1 second to interrupt their action (cranking toy cars attached by string over a long plank using a hand crank) in response to a signal (Limbourg, 1995) **6-7 years:** posture in balance tasks is 3-6 times more unstable compared to adults, due to children's higher centre of mass. Children have only 15% of the capability of 25-year-old adults (Basner & de Marées, 1993) **7-8 years:** developmental leap in psychomotor skills with a significant improvement in performance (Arnberg, Ohlsson, Westerberg, & Öström, 1978)		**7-8 years:** better performance in terms of balance regulation following increased cycle training or increased bicycle use (Basner & De Marees, 1993) **Primary school age:** children with motor impairments are not able to master whole basic requirements when it comes to cycling. This affects safely staying in lane while looking sideways or backwards, above all when combined with intended changes of direction and the indication of these (including to the right) (Günther & Degener, 2009)			**from 7 years onwards:** peripheral perception required for stimuli encountered in traffic is fully developed (Schwebel, Davis, & O'Neal, 2012)	**7-8 years:** improvement regarding visual search strategies in traffic (Whitebread & Neilson, 2000) **7-8 years:** improvement in gaze behaviour, more frequent directional changes in visual attention and reduced gaze duration in one direction lead to an improvement in collecting information from various directions (Whitebread & Neilson, 2000).	**from 7 years onwards:** peripheral perception required for stimuli encountered in traffic is fully developed (Schwebel et al., 2012) **< 7-8 years:** children younger than 7-8 years tend to be less efficient in their visual search and to ignore disturbing information. They also perform more poorly in pedestrian crossing tasks (Barton, 2006) **7-8 years:** the move to an effective application of visual search abilities appears to take place at the age of 7-8 years (Whitebread & Neilson, 2000). **7-8 years:** when cycling, 7 to 8-year-olds focus more on central vision, in order to maintain their balance on the bicycle, while less attention is paid to information relevant to traffic in the peripheral area (Ellis, 2014) **7-10 years:** unfavourable visual search strategies (Tapiro, Oron-Gilad, & Parmet, 2016): surroundings are scanned in a hectic manner using more frequent and shorter fixations		
8 years	**8 years:** child can master difficult manoeuvres on a bicycle (riding a slalom, stabilising the bicycle while riding slowly, etc.) (Pfafferott, 1994) **8 years:** children are able to estimate physical abilities more accurately when performing physical exercises (Plumert, 1995) **8 years:** cycling without wobbling when stopping (>85%) (Michaelis & Niemann, 1999) **8-9 years:** 91% of the 8 to 9-year-old children needed less than 1 second to interrupt their action (cranking toy cars attached by string over a long plank using a hand crank) in response to a signal (Limbourg, 1995) **8-10 years:** on average, children required 0.8 seconds of reaction time, 10-year-olds required 0.6 second and adults only 0.4 seconds (Hoffmann, Martin, & Schilling, 2003)		**8-9 years:** children cross the road at normal walking speed and orientate themselves by the various areas of the road (pavement, edge of pavement, line of sight) (Limbourg, 1976)	**> 8 years:** contrast sensitivity develops fully between 8 and 19 years of age (Leat, Yadav, & Irving, 2009)		**8 years:** for 8-year-olds, central vision is predominantly important in order to maintain balance in a stable manner. In comparison, for 6-year-olds and/ or 10-year-olds, central and peripheral vision is equally important for stable postural control (Nougier, Bard, Fleury, & Teasdale, 1998). **8-9 years:** peripheral perception (>85%) (Van der Molen, 2002)	**8-9 years:** understanding of spatial relationships (>85%) (Van der Molen, 2002) **8-9 years:** adequate estimation of distances (>85%) (Van der Molen, 2002)	**up to 8 years:** children had problems looking in a different direction to the direction of travel. If they did try to do so, they had great difficulties in keeping their balance (Küting, Boigs, & Winkler, 1979) **8-9 years:** only 43% of the children were able to estimate speeds correctly (Günther & Limbourg, 1977) **< 9 years:** when deciding whether to cross the road, children principally take visual stimuli into consideration, i.e. whether or not a car is visible (Ampofo-Boateng & Thompson, 1989)	**from 8 years onwards:** adequate interpretation of sound impressions (Wildner et al., 2009) **from 8-9 years onwards:** directional hearing functions (Pfeffer & Barnecutt, 1996) **8-9 years:** due to the greater negative impact of reflecting sounds, directional hearing in a real-world road setting appears only to be fully developed from the age of 8-9 years (Barton, Lew, Kovesdi, Cottrell, & Ulrich, 2013).	**8 years:** hearing is regularly called on in traffic (Finlayson, 1972) **8 years:** less than 50% of the vehicle sounds (driving away vs. approaching) could be correctly recognised (Pfeffer & Barnecutt, 1996).
9 years	**from 9 years onwards:** significant improvement in cycling one-handed (Basner and De Marées, 1993) **9-10 years:** motor skills for cycling, such as maintaining balance, braking, steering, staying in lane or keeping to a line in corners, are developed (Limbourg, 1997)						**9 years:** depth-of-field perception is fully developed (Limbourg, 2008) **9-10 years:** adequate estimation of speeds (>85%) (Michaelis & Niemann, 1999)		**from 9 years onwards:** signal direction is recognised (Wildner et al., 2009)	

Table 1: TRAFFIC SKILLS AND THEIR FOUNDATIONS

	COGNITIVE DEVELOPMENT					
Age	**Attentiveness (selective, duration, divided, distractibility)**	**Ability to adopt other perspectives**	**Thinking**	**Social and emotional competence**	**Hazard perception**	**Effects in traffic**
6 years	**6 years:** children in traffic direct their attention to relevant stimuli just as frequently as irrelevant stimuli (Tolmie et al., 2005) **6-8 years:** children have a system of paying attention that functions comparably well to that of an adult (Ristic, 2009). **6-10 years:** performance improves significantly in tasks where unimportant stimuli are incorporated into the task and a test is carried out to see how focused the child remains on the important aspects (Gómez-Pérez & Ostrosky-Solís, 2006)	**6 years:** children already have a kind of "theory of mind" (Cox, 1991) **6-8 years** (Limbourg, 2008) **or 6-7 years** (Piaget, 1983)**:** subjective adoption of perspective: The child is able to understand that another person also has his/her own perspective, based on his/her own thinking. This may be similar to one's own perspectives or not. The child is only ever able to concentrate on one perspective. However, he or she understands that other people's actions, just like his or her own, are partly determined by thoughts and feelings, and knows the difference between intentional and unintentional actions.	**6-8 years:** simple strategies for drawing conclusions, acquisition of systematic, ready-to-use knowledge begins, if-then thinking: naming of causes based on practical experience (Böttcher, 2005) **6-12 years:** concrete-operational stage (Piaget, 1983)	**6-8 years:** learning social norms and rules, switch between non-binding use and very close monitoring in shared play (Böttcher, 2005) **from 6 years onwards:** children are more motivated to complete tasks on their own, explore their own limits and those of the group (Kellmann & Arterberry, 2006) **from 6 years onwards:** children become increasingly independent of caregivers (Kellmann & Arterberry, 2006)	**< 6 years:** the speed of an approaching car is perceived as a greater potential risk factor compared to its distance (Rosenbloom, Nemrodov, Ben-Eliyahu, & Eldror, 2008) **6-7 years:** children can recognise accidents, dangerous situations and preventative measures more comprehensively than younger children. They begin to recognise their role as possible cause of a situation (Hargreaves & Davies, 1996) **6-7 years:** detection of a safe crossing place without training (<50%) (Michaelis & Niemann, 1999) **6-8 years:** accident risk increases continually (Richter, Gruner, Rollow, & Schneiders, 2006) **6-9 years:** inexperience and lack of knowledge are the main causes of accidents (Schneider, 2001) **6-17 years:** fearful children have just as many accidents as very lively, extroverted children; boys are involved in accidents more frequently than girls (Richter, Schlag, & Schupp, 2006)	**6 years:** children are more easily distracted by irrelevant stimuli than older children (Barton & Morongiello, 2011) **6 years:** children know that a helmet cannot prevent a fall, can distinguish between "falling" and "being injured", and understand that reflectors contribute to their own visibility. However, there is mostly still no understanding of reciprocal communication between children and other traffic participants at a zebra crossing (Briem & Bengtsson, 2000) **6-7 years:** while safe road behaviour at lights and zebra crossings is learned somewhat earlier, crossing the road at unregulated points and those with restricted visibility is still very difficult for 6 to 7-year-old children (Limbourg, 2010) **6-14 years:** children have the highest risk of having an accident as cyclists in traffic, a medium risk as pedestrians and a low risk as car passengers and train/bus users (Richter et al., 2006)
7 years	**7-8 years:** easy stimulation/distraction during processing of a task led to fewer mistakes; there were indications that the ability to gain an overview of the situation decreased as noise levels increased (Higgins & Turnure, 1984)	**7 years:** there is a consciousness that people make assumptions about other people's assumptions, and that these can be incorrect. If a child is aware of the existence of incorrect second order beliefs, he or she can draw conclusions as to the reasons for these (Astington, Pelletier, & Homer, 2002)	**7 years:** distinction between left and right possible (Limbourg & Senckel, 1976)		**7-8 years:** hazard perception is based on the existence of certain objects (e.g. a large car), while the object's surroundings are ignored (Underwood, Dillon, Farnsworth, & Twiner, 2007) **7-8 years:** while hazard perception is still rather idiosyncratic and self-centred at the age of 7-8, in older children (11-12 years) this changes to a more global perspective on traffic events (Underwood et al., 2007) **7-9 years:** children react less often to potential dangers (Meir, Oron-Gilad, & Parmet, 2015a, 2015b)	**7-8 years:** when organizing images of traffic situations based on their own safety criteria, 7 to 8-year-olds demonstrate a very individual, special perspective compared to the overall, integrated perspective of the older children (Underwood et al., 2007) **7-9 years:** children can be trained in hazard perception as pedestrians: children who had undergone training recognised possible dangers related to a restricted field of vision more often than those in the control group (Meir et al., 2015a) **7-9 years:** 7 to 9-year-old children recognised fewer situations (restricted field of vision due to parked cars) as dangerous compared to older children and adults (Meir, et al., 2015b) **7-10 years:** 7 to 9-year-old children and 9 to 10-year-old children recognised fewer situations (restricted field of vision due to a bend in the road) as dangerous compared to adults; 10 to 13-year-olds scored significantly better here than 7 to 9-year olds (Meir et al., 2015b) **7-10 years:** in a virtual study, it was possible to show that children increase their speed when crossing the road as soon as the traffic conditions become more risky (Morrongiello, Corbett, Milanovic, Pyne, & Vierich, 2015) **7-11 years:** the ability to predict the driver's intention correctly improves significantly with increasing age (Foot et al., 2006) **7-13 years:** In both 7 to 13-year-old children and adults, crossing the road is negatively affected by mobile phone communication. Influence of age: adults scored significantly better, followed by 11 to 13-year-olds. 7 to 8-year-old children had the worst score. Differences were apparent above all in maintaining a safe distance from approaching cars (measured by the time that passes until arrival of the next car after crossing the road): this safety distance increased from the 7 to 8-year-olds, through the 9 to 10-year-olds to the 11 to 13-year-olds and adults. 7 to 8-year-olds demonstrated the worst behaviour in this regard, with their safety distance being significantly less than that of all other age groups (Tapiro, et al., 2016) **7-13 years:** virtual study with 7 to 13-year-olds (7 to 9-year-olds, 9 to 10-year-olds, 10 to 13-year-olds) and adults: with increasing age and increasing experience, the attention paid to possible dangers rises and the ability to anticipate forthcoming events when crossing the road improves (Meir, Parmet, & Oron-Gilad, 2013)
8 years	**8 years:** in comparison with 11-year-olds, 8-year-olds have more difficulties in coordinating and controlling the focus of their attention (Irwin-Chase & Burns, 2000) **from 8 years onwards:** concentration is possible for a relatively long period of time (Limbourg, 1997) **>8 years:** children are less skilled at directing their attention to relevant information than older children (Miller & Weiss, 1981; Welsh, Pennington, & Groisser, 1991; Trick & Enns, 1998) **8-9 years:** selective attention is developed (Tabibi & Pfeffer, 2003)	**8-10 years:** subjective adoption of perspective: child can place him/herself in the position of someone else and knows that the other person can do the same (Limbourg, 2008). The child knows that, in principle, everyone can reflect on the behaviour of other people. Children of this age are able to form chains of perspectives. For example: "I know that the other person knows that I know…"	**8-9 years:** it is not the shortest route that is selected, but rather the safest (Günther & Limbourg, 1977) **8-10/11 years:** development of theoretical and simple deductive thinking, thought processes are uncoupled from concrete objects, causal thinking: cause and effect relationships, ascertaining of complex structures and understanding of proportions (Böttcher, 2005)	**8-10/11 years:** binding norms and rules determine social behaviour; change of rules when those involved agree (Böttcher, 2005)	**approx. 8 years:** forward-looking awareness of risk develops (Limbourg, 2001) **approx. 8 years:** children are increasingly competent at putting a reflective, less impulsive style of behaviour into practice, and this is reflected in safety-conscious actions (Rollett, 1993) **8-10 years:** boys demonstrate more risky behaviour than girls of the same age (Walesa, 1975) **8-11 years:** children can recognise dangers in relation to their perspective and that of the adults. They can distinguish between coping and avoidance strategies when dealing with dangers (Hargreaves & Davies, 1996)	**8 years:** children can control their attention to some extent. They can distinguish between relevant, irrelevant and neutral stimuli. These stimuli may facilitate paying attention in a selective manner or hinder it (Pearson & Lane, 1990). **8-9 years:** up to the age of approximately 8, children's behaviour as pedestrians is risky and not very reliable. Even older children (8 to 9 years) can sometimes still be distracted and then cease to exhibit safe road behaviour. Both as pedestrians and cyclists, boys are more at risk than girls, due to their leisure activities and their greater willingness to take risks (Limbourg, 2010). **8-9 years:** detection of a safe crossing place without training (50-85%) (Michaelis & Niemann, 1999)
9 years					**< 9 years:** children show a low awareness of possible dangers when crossing the road (Oron-Gilad, Meir, Tapiro, & Borowsky, 2011) **9 years:** speed and distance are evaluated separately as potential risk factors, but not in combination; risks are evaluated in the same way for children as for adults (Rosenbloom et al., 2008) **9-10 years:** preventative risk awareness is present (Limbourg, 2001) **9-10 years:** perception and anticipation of risks (>85%) (Michaelis & Niemann, 1999)	**9-10 years:** older children, who are more cautious, are also more resistant to distracting information than younger children (Dunbar, Hill & Lewis, 2001; Tabibi & Pfeffer, 2003). **9-13 years:** 9 to 13-year-olds cross roads (in a virtual study) more hesitantly than experienced adults (Meir, et al., 2013)

Table 1: TRAFFIC SKILLS AND THEIR FOUNDATIONS

	MOTOR SKILLS			VISUAL PERCEPTION				
Age	Gross motor skills	Hand motor control / finger dexterity	Effects in traffic	Perception of colour / light and dark	Visual acuity and accommodation	Peripheral vision	Depth perception and spatial perception	Effects in traffic
10 years	**from 10 years onwards:** significant improvement in cycling through gates (Arnberg et al., 1978) **10 years:** cycling without wobbling when slowing down, when riding in a straight line, when looking back, when riding one-handed (hand signals) (>85%) (Michaelis & Niemann, 1999)					**10-12 years:** identical performance to adults in standard tests of peripheral perception (Martin, 2010)	**10-14 years:** improvement of the ability to adjust their own behaviour in relation to other objects (Plumert, Kearney, Cremer, Recker, & Strutt, 2011; Stevens, Plumert, Cremer, & Kearney, 2013)	**< 10 years:** children often choose smaller gaps between approaching cars than older children and adults. When leaving the road, 6, 8 and 10-year-olds had significantly less time and more collisions with cars than 14-year-olds and adults (O'Neal et al., 2018) **10-12 years:** (with bicycles) Children had problems estimating the speed of vehicles (how long it would take until vehicles reached the crossing line) (Plumert, Kearney & Cremer, 2004); children underestimated the time that they would need to reach the other side, but overestimated their ability to get their bicycle moving (Plumert et al., 2004; Schwebel & Plumert, 1999); from the time of the decision, children needed longer to initiate the movement (entering the intersection) than adults (Plumert et al., 2004; Pitcairn & Edlmann, 2000) **10-11 years:** when crossing the road, children have not only noticed the current road situation, but have also anticipated what will happen in a few seconds (Whitebread & Neilson, 2000)
11 years							**11 years:** visual search strategies/skills in traffic comparable to those of adults (Whitebread & Neilson, 2000)	**from 11 years onwards:** when cycling, children demonstrated a significant improvement with visual orientation to the rear (Arnberg et al., 1978)
12 years			**12 years:** children more frequently choose safe gaps to cross the road than 5-year-olds (Plumert, Kearney, & Cremer, 2007) **12 years:** the main skills for safe cycling are largely fully developed between the ages of 11 and 12 (Zweuts, Vansteenkiste, Cardon, & Lenoir, 2016).			**up to 12 years:** field of vision approximately one third smaller than in adults (Wildner, Heissenhuber, & Kuhn, 2009) **from 12-14 years:** field of vision the same size as in adults (Berger, 1992)	**12 years:** performance in estimating the speed of approaching vehicles is comparable to that of adults (Hoffmann, Payne, & Prescott, 1980)	**<12 years:** compared with adults, children have insufficient skills to adequately estimate the speeds of approaching vehicles when crossing a busy road (Wann, Poulter, & Purcell, 2011).
13 years	**13 years:** cycling without wobbling when slowing down (>85%) (Michaelis & Niemann, 1999) **13-14 years:** further developmental leap in psychomotor skills – significant performance improvement in motor skills (Arnberg et al., 1978) **13-14 years:** all skills (motor and cognitive) necessary for safe cycling are developed (Limbourg, 2003; Borgert & Henke, 1997) **13-15 years:** on their bicycles, children can master difficult, often unforeseeable and unknown situations in real-world traffic (Basner & de Marées, 1993)		**5-13 years:** only slight performance improvement in cycling between 2 boundary lines between 5 and 13 years of age; performance only improves rapidly from 14 years of age onwards (Arnberg et al., 1978)					
14 years-18 years	**14 years:** reaction time reaches adult level (Bächli-Bietry, 1998; Uhr 2015)					**14 years:** peripheral vision not yet fully developed (Schützhofer, 2017) **15 years:** significant performance decline in peripheral vision due to puberty (Schützhofer, 2017)		**14 years:** the timing of stepping onto the road improves with increasing age and reaches the level of an adult at the age of 14 (O'Neal et al., 2018).

Table 1: TRAFFIC SKILLS AND THEIR FOUNDATIONS

	ACOUSTIC PERCEPTION		COGNITIVE DEVELOPMENT					
Age	General hearing ability, directional hearing and noise differentiation	Effects in traffic	Attentiveness (selective, duration, divided, distractibility)	Ability to adopt other perspectives	Thinking	Social and emotional competence	Hazard perception	Effects in traffic
10 years	**10 years:** auditory perception first reaches the level of an adult at the age of approximately 10 (Johnson, Hannon, & Amso, 2005; Werner & Gray, 1998). Younger children, in particular, are less able than adults to recognise auditory stimuli at higher frequencies (Werner & Gray, 1998)			**10-12 years:** reciprocal adoption of perspective: children can now step away from a two-person interaction and place themselves in the position of a third person (Limbourg, 2008)		**10-11 years:** understanding of ambivalent emotions (Schneider & Lindenberger, 2012)	**10-11 years:** the frequency of rarer accidents (e.g. drowning) is overestimated, while the frequency of more common accidents (e.g. bicycle accidents) is underestimated; children are subject to the optimism bias: they estimate the chance of having an accident themselves, compared to their peers, as generally less likely (Joshi, MacLean, & Stevens, 2018) **10-11 years:** hazard perception among cyclists: children demonstrate inefficient gaze behaviour, a later focus on danger and slower reactions to danger than adolescents (Zeuwts, Vansteenkiste, Deconinck, Cardon, & Lenoir, 2017) **10-12 years:** detection of a safe crossing place without training (>85%) (Michaelis & Niemann, 1999)	**up to 10 years:** when crossing, children focus on distance and not on the speed of the vehicles. As a result, they always choose the same size of gap, irrespective of the situation (Walter et al., 2012) **< 10 years:** children often choose smaller gaps between approaching cars than older children and adults. When leaving the road, 6, 8 and 10-year-olds had significantly less time and more collisions with cars than 14-year-olds and adults (O'Neal et al., 2018) **10-11 years:** crossing the road while talking on the telephone leads to significantly more risk-taking (Schwebel et al., 2012) **10-11 years:** it is first at the age of approximately 10 to 11 that cognitive abilities for cycling are developed to the extent that children are able to meet the requirements regarding road traffic, at least when in an emotionally neutral mood and without any peer-group influence (Uhr et al., 2017). **10-11 years:** the ability to recognise safe and dangerous road crossing points and to distinguish between them is present; compared to adults, children still need more time to recognise these (Tabibi & Pfeffer, 2003) **10-14 years:** children still allow themselves to be distracted on the road, particularly by social interactions with their peers (Walter et al., 2013)
11 years	**11 years:** were able to correctly identify 60% of vehicle noises (driving away vs. approaching) (Pfeffer & Barnecutt, 1996)						**11 years:** children can estimate risks when crossing the road (Ampofo-Boateng & Thomson, 1991)	**11 years:** children are able to make adequately safe estimates to cross the road safely (Ampofo-Boateng & Thomson, 1991).
12 years			**up to 12 years:** it is difficult for the child to process multiple characteristics of a situation simultaneously (Schieber & Thompson, 1996) **12-13 years:** when working on a task, it was easier for children to adjust to the distraction/sound level (acoustic stimulus), and in this process the children were able to focus/concentrate more intensively on the task than in the "quiet" conditions (Higgins & Turnure, 1984)		**12-14 years:** shifting/task switching as components of executive functions is successful even in complex situations where it is necessary to switch between mental states, actions or tasks (Best, Miller, & Jones, 2009; Best & Miller, 2010)		**11-12 years:** perception of complex traffic situations takes place both effectively and in full (Pettit & Janks, 1996)	**Executive functions:** adolescents are able to estimate risks in a rational manner with similar accuracy to adults, yet they still behave in a more risky fashion as their behaviour is more strongly controlled by rewards (recognition of their peers) (Konrad, Firk, & Uhlhaas, 2013)
13 years			**13-14 years:** attention and concentration fully developed (Dordel & Kunz, 2005) **13-14 years:** all skills (motor and cognitive) necessary for safe cycling are developed (Limbourg, 2003; Borgert & Henke, 1997) **13-14 years:** development of attention is not complete until around 13-14 years of age (Limbourg, 1997)			**13-16 years:** taking risks and making risky decisions decreases with increasing age (3 age groups: 13-16 years, 18-22 years, adults from 24 years). For younger age groups (13-16 years and 18-22 years), the presence of a peer group leads to riskier behaviour and riskier decisions than is the case with adults (Gardner & Steinberg, 2005).		**13-14 years:** the willingness to comply with rules and to behave in a risk-aware manner falls significantly, while the peer group's influence on risk behaviour in traffic increases (Schützhofer, 2017)
14 years-18 years			**up to 14 years:** speed of perception not yet fully developed (Schützhofer, 2017) **up to 15 years:** resistance to distraction is not yet fully developed (Van der Molen, 2002) **15 years:** significant performance decline in speed of perception due to puberty (Schützhofer, 2017)		**Adolescence:** the limbic system (responsible for reward) develops rapidly, while the prefrontal cortex (control centre) only develops gradually (Uhr, 2015; Steinberg, 2008; Luna et al., 2001). This may result in risky and spontaneous behaviour (Schützhofer, Rauch, & Banse, 2017).	**14 years:** neuronal circuits for affect regulation are still developing during adolescence and have not yet reached adult levels (Passarotti, Sweeney, & Pavuluri, 2009) **14-16 years:** children and adolescents are often in the "conformist stage". Adaptation in line with the peer group is important. (Crone, 2011; Westenberg & Gjerde, 1999; Schützhofer, 2017) **14-15 years:** young people in the conformist phase of adolescence are significantly less willing to abide by rules and norms than 11 to 13-year-olds or 16 to 18-year-olds (Schützhofer, 2017). **16 years:** individuality and tolerance become more important, the "self-confident stage" begins (Crone, 2011; Westenberg & Gjerde, 1999)	**14-17 years:** accidents are increasingly caused by conscious rule violations (Schneider, 2001)	**14 years:** the time at which to enter the road between two moving cars improves constantly over the course of development and reaches the level of an adult at the age of 14 (simulation study on crossing the road) (O'Neal et al., 2018) **14-15 years:** risk appetite in road traffic reaches its peak and then falls with increasing age (Schützhofer, 2017) **Up to 15 years:** in children up to 15 years of age, the percentage of perception errors among cyclists (particularly incorrect focus of attention) and, connected to this, the failure to observe details relevant to traffic, is higher than among older cyclists (Platho, Paulenz, & Kolrep, 2016) **16 years:** the peer group loses its relevance; behaviour in line with the rules in traffic once again reaches the level of 12 to 13-year-olds (Schützhofer, 2017)

References to Table 1

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How did you become a driver: differences in history of traffic offenses and accident involvement?

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ABSTRACT: *Novice drivers are considered as the riskiest group of drivers due to caused accidents and injuries related to inexperience and propensity to take risks on the road. Thus, prospective analysis of importance of driving learning history for the novice drivers' future involvement in traffic violations or road accidents is extremely encouraged. This study is aimed to evaluate the importance of learning to drive experience and driving test (theory and on-road) performance for the prediction of objective traffic rules violations and later accident involvement in Lithuanian novice drivers. 598 learner drivers who obtained their driving licence for the first time participated in the longitudinal study. Information concerning their learning to drive experience before taking driving test, theory test and on-road driving test performance was obtained in the first stage of the study. Later information on the number of recorded traffic offenses committed by participants and number of accidents during the first year of their independent driving was obtained from the police records. The results showed that worse driving theory test performance, but not on-road driving test performance was related to the fact of being fined for traffic rules violations. While age and experience of learning to drive were not important predictors of being a traffic offender. Gender and length of independent driving were also important predictors for later traffic violations.*

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KEYWORDS: *Learner drivers; traffic rules offences; accident involvement; driving theory test performance; on-road driving test performance*

1. INTRODUCTION

Novice drivers are considered as the most vulnerable group of drivers all over the world (Boccara, Delhomme, Vida-Gomel, & Rogalski, 2011; de Winter, 2013). In Europe drivers aged from 16 to 24 years have 1.7 times more chances to die in an accident compared to other age groups and such high crash rates among novice drivers remain quite stable (Traffic Safety Basic Facts, 2016). Lithuania together with Poland, Romania and Bulgaria are leading countries of traffic injuries caused by novice drivers in Europe. For example, in 2015 12.3 percent of all traffic accidents were caused by novice drivers with less than two years of experience of independent driving (Recorded accident statistics in Lithuania, 2016). Moreover, statistics show that novice drivers tend to violate traffic rules, which can increase the probability of accident on the road. The most common violations according to Lithuanian Police Service (2017) are speeding (78.8 percent of novice drivers), drunk driving (20 percent of them), and other different violations (2.2 percent).

Different psychological characteristics have been studied as correlates of risky driving in novice drivers. Personality traits, especially such as sensation seeking, impulsivity, and aggressiveness (Berdoulat, Vavassori, & Sastre, 2013; Ge, Qu, Jiang, Du, Sun, & Zhang, 2014; Harris et al., 2014; Poó & Ledesma, 2013; Yang, Du, Qu, Gong, & Sun, 2013), positive attitudes towards risky driving (Cacciabue, 2007; Isler, Starkey, & Sheppard, 2008; Ram & Chand, 2015), low resistance to peer influence (Møller & Haustein, 2014; Shope, 2006; Shope, Raghunathan, & Patil, 2003), or poor ability to deal with own emotions (Berdoulat et al., 2013; Trógolo, Melchior, & Medrano, 2014) were found to be important contributors to the increased risk of traffic rules violations or accidents in this group of drivers. However,

most authors confirmed the first 6 or 12 months of independent driving to be a crucial period for road accident involvement and traffic rules violations because of insufficient driving experience and overestimation of own driving skills (Baughan, Sexton, Simpson, Chinn, & Quimby, 2006; Borowsky & Shinar, & Oron-Gilad, 2010; Boufous, Ivers, Senserrick, & Stevenson, 2011; de Winter, 2013; Redshaw, 2005; Scott-Parker et al., 2014).

It is expected that driving training develops appropriate driving skills and safe driving attitudes and provides necessary driving experience for safe independent driving. But generally, in most countries driving training is focused on manoeuvring and car control skills rather than on driving safety. Even though Baughan and colleagues (2006) noted that candidates choose to take driving test not prepared enough: when their driving competence give only a moderate probability of passing the test. Therefore, the fact of passing the driving test does not guarantee being a good or even a moderate driver. In fact, those novice drivers, who barely pass a driving test, later independently drive less mileage, avoid driving in challenging conditions and thus may hinder the further development of their driving skills (Baughan et al., 2006; Harré, Foster, & O'Neill, 2005; Sexton & Grayson, 2010; Wells, Tong, Grayson, & Jones, 2008). On the other hand, further skill training due to more frequent driving after being licenced might lead to increased driving self-confidence. Thereby novice drivers overestimate their abilities to manage challenging road situations and develop limited hazard perception skills that might contribute significantly to increased accident involvement and intentional traffic rules violations too (Baughan et al., 2006; Starker & Isler, 2016; Vassallo et al., 2014).

In line with these findings history of learning to drive and driving test performance might be important predictors of novice drivers' future involvement in traffic violations. Nevertheless, research focusing on driving related issues in the training period and later accident involvement is scare (Boufous et al., 2011; Vassallo, et al., 2007). Actually, we were able to find only four studies that investigated this relationship between driving test performance and later accident involvement in novice drivers. Three studies examined the impact of the driving test outcomes on the likelihood of traffic accidents in three different cohorts of novice drivers in UK (Baughan et al., 2006; Baughan & Sexton, 2002; Maycock & Forsyth, 1997; Sexton & Grayson, 2010) and one study reported data from the sample of Australian novice drivers (Boufous et al., 2011). So, this study is aimed to investigate the predictive value of learning to drive experience and driving test (theory and on-road) performance for the prediction of objective traffic rules violations and later accident involvement in Lithuanian novice drivers. Driver education and training program in Lithuania is not structured and mostly focused on knowledge of traffic rules and car control skills (Šeibokaitė, Endriulaitienė, Markšaitytė, & Žardeckaitė-Matulaitienė, 2011) while Australia, UK and some other European countries use the Goals for Driver Education model which focuses more on safety issues in driving training and testing (Mynttinen et al., 2009; Simons-Morton & Ehsani, 2016). Thus, we hope that this study would add beneficial information to the existing knowledge in the field.

Baughan and colleagues (2006) found that longer supervised driving training might decrease accident risk of novice drivers during the first 6 months of their independent driving. Nyberg & Gregersen (2007) stated that structured driving training also helps to perform better during on-road driving tests. However, Maycock & Forsyth (1997) did not find any relation between length of driving training and later accident involvement. They even argued that accident vulnerability increased with more supervised driving practice because less competent learner drivers took more driving lessons from different supervisors just to pass the driving test. Thus, we hypothesize that those novice drivers who had more diverse driving training experience (not only under the supervision of driving instructor) would be more prone to violate traffic rules and would be more likely to become involved in an accident while independent driving.

Previous research confirmed the positive relationship between failures during on-road driving test and higher accident involvement while later independent driving in novice drivers (Baughan et al., 2006; Baughan & Sexton, 2002; Boufous et al., 2011; Maycock & Forsyth, 1997; Sexton & Grayson, 2010). However, Sexton & Grayson (2010) stated that first-time passers of on-road driving test reported riskier driving style even though had lower accident involvement liability. De Winter (2013) also confirmed that traffic rules violations during simulation-based driver training were related to later self-reported violations while independent driving. Based on this we assume that novice drivers who passed the on-road driving test at the first attempt would be more prone to violate traffic rules but less involved in accidents.

While those, who pass theory test from the first attempt, would be less prone to violate traffic rules as they had better initial knowledge and understanding about proper driving requirements. Unfortunately, none results on accident liability or traffic rules violations due to performance in driving theory test were reported in previous literature.

2. METHODOLOGY

2.1. Participants

Learner drivers were invited to participate in this study on voluntary basis. The invitation was sent using web-page of the state enterprise "Regitra", which is responsible for drivers' licensing in Lithuania. Using this online platform, participants were given informed consent and were asked to fill in the self-report questionnaire, concerning various psychological characteristics and learning to drive features before they made a reservation time for their on-road driving test procedure. Participants' personal information (name and surname) was asked in order to relate their data to the driving test (theory and on-road) performance and police records on traffic rules violations during the first year of independent driving. Ethical approval for the study was obtained from the Ethics Committee of Psychology at the Department of Psychology at Vytautas Magnus University in Lithuania.

598 learner drivers (262 males, 336 females) participated in this study. Their age ranged from 17 to 58 years (M=23.63, SD=8.31). Female participants were slightly older than males (mean age of females M=24.72, SD=9.07, mean age of males M=22.22, SD=6.98, Student t=-3.81, df=595.9, p<.001). Two-thirds of all participants (71%) were younger than 25 years. 22.9 percent of the respondents had university education and 77.1% of them had lower than university education. The mean of the driving days after being licensed was 360.43 days (SD = 92.83, range was from 1 to 512 days). No gender differences in the duration of independent driving were found (Mann Whitney U = 42005.50, p = .34).

2.2. Measures

For the purposes of this paper, information about learning to drive experience (one question "With whom you learned to drive?": (1) only with driving instructor, (2) with driving instructor and under supervision of other experienced drivers; (3) with instructor, other drivers and independently) and theory as though as on-road driving test performance variables (number of attempts) were collected. Additionally, demographical data concerning gender, age, education level and duration of independent driving was also obtained. Information about drivers committed traffic rules violations and accident involvement during the first year of independent driving was obtained from the police records.

3. RESULTS

First, information concerning learner drivers training experience, driving test performance, objective traffic rules violations, and accident involvement was analysed. The descriptive statistics are presented in Table 1. It could be seen that more male than female learner drivers were learning to drive not only under the supervision of other drivers but also independently (while not being licenced). Higher number of male novice drivers was fined for any traffic rules violations and more males were fined more than one time for these violations compared to female novice drivers. Also, those novice drivers, who were fined for any traffic rules violations, reported longer independent driving after being licensed (Mann Whitney U = 16701.00, p = .001).

More thorough analysis of traffic rules violation types showed that more than a half of traffic rules offenders were those who exceeded speed limits (57.3 percent; n=43); additionally, 10.7 percent of them (n=8) drove without seat belt or disregarded traffic signs. However, due to low number of novice drivers who were fined for the traffic rules violations during the period of their independent driving (12.5 percent), only two types of traffic offenders' groups were analysed later: being fined for the traffic rules violations (yes/no) and number of fines for the traffic rules violations (none/one/more than one) without splitting them according to driver gender or type of committed violation.

When analysing the driving test performance and traffic accident involvement no gender differences were observed. Approximately two thirds of learner drivers passed theory test and almost one third passed the on-road driving test on the first attempt. And only 3.5 percent of all study participants were involved in an objectively recorded traffic accident during first year of independent driving.

Table 1: Sample characteristics.

Characteristic	Total sample (N=598)	Male (N=262)	Female (N=336)	χ^2
Learning to drive				14.99**
With driving instructor	254 (42.5 %)	116 (44.3 %)	138 (41.1 %)	
With driving instructor and under supervision of other drivers	315 (52.7 %)	124 (47.3 %)	191 (56.8 %)	
With driving instructor, other drivers, and independently	29 (4.8 %)	22 (8.4 %)	7 (2.1 %)	
Driving theory test performance				.87 ns
Number of attempts	1-13	1-13	1-11	
Passed at the first attempt	401 (67.1 %)	181 (69.1 %)	220 (65.5 %)	
Passed at the second or later attempt	197 (32.9 %)	81 (30.9 %)	116 (34.5 %)	
On-road driving test performance				1.08 ns
Number of attempts	1-17	1-13	1-17	
Passed at the first attempt	183 (30.6 %)	86 (32.8 %)	97 (28.9 %)	
Passed at the second or later attempt	415 (69.4 %)	176 (67.2 %)	239 (71.1 %)	
Being fined for the traffic rules violations				25.12**
Yes	75 (12.5 %)	53 (20.2 %)	22 (6.5 %)	
No	523 (87.5 %)	209 (79.8 %)	314 (93.5 %)	
Number of being fined for the traffic rules violations				25.13**
None	523 (87.5 %)	209 (79.8 %)	314 (93.5 %)	
One time	62 (10.3 %)	44 (16.8 %)	18 (5.4 %)	
More than one time	13 (2.2 %)	9 (3.4 %)	4 (1.2 %)	
Accident involvement during the first year of independent driving				.29 ns
Yes	21 (3.5 %)	8 (3.1 %)	13 (3.9 %)	
No	577 (96.5 %)	254 (96.9 %)	323 (96.1 %)	

*p<.01; **p<.001

Table 2: Analysis of traffic rules violations according to the learning to drive experience and driving test performance.

Characteristic	Being fined			Number of fines			
	Yes (N=75)	No (N=523)	χ^2	No fines (N=523)	One (N=62)	2 and more (N=13)	χ^2
Learning to drive							
With driving instructor	32 (12.6 %)	222 (87.4 %)	.05 ns	222 (87.4 %)	29 (11.4 %)	3 (1.2 %)	5.02 ns
With driving instructor and under supervision of other drivers	39 (12.4 %)	276 (87.6 %)		276 (87.6 %)	31 (9.8 %)	8 (2.5 %)	
With driving instructor, other drivers, and independently	4 (13.8 %)	25 (86.2 %)		25 (86.2 %)	2 (6.9 %)	2 (6.9 %)	
Driving theory test performance							
Passed at the first attempt	44 (11.0 %)	357 (89.0 %)	2.73 ns	357 (89.0 %)	35 (8.7 %)	9 (2.2 %)	3.53 ns
Passed at the second or later attempt	31 (15.7 %)	166 (84.3 %)		166 (84.3 %)	27 (13.7 %)	4 (2.0 %)	
On-road driving test performance							
Passed at the first attempt	30 (16.4 %)	153 (83.6 %)	3.57 ns	153 (83.6 %)	24 (13.1 %)	6 (3.3 %)	3.85 ns
Passed at the second or later attempt	45 (10.8 %)	370 (89.2 %)		370 (89.2 %)	38 (9.2 %)	7 (1.7 %)	

*p<.01; **p<.001

Later the importance of learning to drive experience and driving test performance for traffic violations was evaluated. Cross tabulation of being fined for the traffic rules violations or accident involvement in the groups of different learning to drive experience as though as driving test performance was made using Chi-square criteria. Results are presented in Table 2 and Table 3.

It could be seen from Table 2 that none of the independent variables (theory and on-road driving test performance or type of learning to drive) was related to the traffic rules violations when all these variables were analysed separately. The same results were obtained when analysing accident involvement: neither learning to drive experience nor theory or on-road driving test performance differed according to the novice drivers' accident involvement during the first year of independent driving (Table 3).

In order to evaluate the cumulative effect of all important demographical factors, driving experience and driving test performance variables for prediction of traffic rules violations, binary logistic and ordinal regression analysis were conducted. Firstly, prediction of being fined for the traffic rules violations was done using gender, age, duration of independent driving after being licenced, learning to drive experience as well as theory test and on-road driving test performance as significant variables which might be

Table 3: Analysis of accident involvement according to learning to drive experience and driving test performance.

Characteristic	Accident involvement		
	Yes (N=21)	No (N=577)	χ^2
Learning to drive			1.51 ns
With driving instructor	8 (3.1 %)	246 (96.9 %)	
With driving instructor and under supervision of other drivers	13 (4.1 %)	302 (95.9 %)	
With driving instructor, other drivers, and independently	0 (.0 %)	29 (100.0 %)	
Driving theory test performance			
Passed at the first attempt	13 (3.2 %)	388 (96.8 %)	.61 ns
Passed at the second or later attempt	8 (4.1 %)	189 (95.9 %)	
On-road driving test performance			
Passed at the first attempt	9 (4.9 %)	174 (95.1 %)	.22 ns
Passed at the second or later attempt	12 (2.9 %)	403 (97.1 %)	

*p<.01; **p<.001

Table 4: Predictions of being fined for traffic rules violation by learner drivers' gender, age, type of learning to drive, duration of driving experience, and driving test performance (N=598).

Variables	B	SE B	Wald	β
Age	-.04	.02	3.39	.96 ns
Gender (male) [a]	1.22	.28	19.44	3.140**
Duration of driving experience	.00	.00	5.86	1.00*
Driving theory test performance (at the first attempt)	-.52	.27	3.85	.59*
On-road driving test performance (at the first attempt)	.23	.27	.73	1.26 ns
Learning to drive [b]				
Only with driving instructor	.20	.59	.12	1.22 ns
With driving instructor and under supervision of other drivers	.09	.59	.02	1.09 ns
Nagelkerke R^2	.13			
Chi-square	42.20**			

*p<.01; **p<.001; [a] reference category – females; [b] reference category – with driving instructor, other drivers, and independently.

related to the traffic rules violations in the regression model. Results, presented in Table 4, show that the regression model is statistically significant and probability to become a traffic offender during the first year of independent driving could be predicted by some variables measured beforehand. Probability of being fined for the traffic violations is larger for male novice drivers, those who have longer experience of independent driving, and those who were not first-time passers of the theory test. On-road driving test performance was not important predictor of fines for traffic rules violations.

Later ordinal regression analysis was made with dependent variable "number of traffic offences" (reference category – none), and all aforementioned independent variables. The results are presented in Table 5. The analysis showed that only gender (being male) and duration of driving (more days of independent driving) after being licenced were important predictors differentiating number of traffic rules violations. Theory test and on-road driving test performance or type of learning to drive were not important for the prediction of number of traffic violations.

Analysis of accident involvement prediction (1 = being involved in accident; 0 = not being involved in accident) by participants' gender, age, type of learning to drive, duration of independent driving and driving test performance was not possible as binary logistic regression model was not statistically significant (Chi-square = 7.65; df = 7; p < .36; Nagelkerke R square = .05). So, it could be said that accident involvement could not be predicted by factors, related to driving learning experience and other demographical variables in this study sample.

4. DISCUSSION

Previous research has highlighted the importance of different psychological characteristics that contribute to high vulnerability of novice drivers; however, the importance of learning to drive history and driving test performance remains under-investigated. Thus, this paper is devoted to assess the predictive value of learning to drive experience and driving test (theory and on-road) performance for objective traffic rules violations and accident involvement in Lithuanian novice drivers.

Data of this study revealed that 67 percent of study participants passed driving theory test and only 30.6 percent of them passed on-road driving test at the first attempt. The pass rate of theory test was very similar to those reported in the literature: first-time passers usually make up from 49 to 98 percent of all candidates in different countries (Nyberg & Gregersen, 2007; Sexton & Grayson, 2010; Singapore police force, 2018; Statista, 2018; Wells et al., 2008). But the pass rate of on-road driving test was

Table 5. Prediction of number of fines for traffic rules violations by learner drivers' gender, age, type of learning to drive, duration of driving experience, and driving test performance (N=598).

Variables	B	SE B	Wald
Number of being fined for the traffic rules violations [a]			
More than one time	-5.04	1.05	23.08**
One time	-3.10	1.01	9.34**
Age	.04	.02	3.50 ns
Gender (male) [b]	-1.22	.28	19.30**
Duration of driving experience	-.00	.00	5.77*
Driving theory test performance (at the first attempt)	.51	.26	3.65 ns
On-road driving test performance (at the first attempt)	-.25	.27	.82 ns
Learning to drive [c]			
Only with driving instructor	-.11	.58	.03 ns
With driving instructor and under supervision of other drivers	-03	.57	.00 ns
Nagelkerke R^2	.12		
Chi-square	42.27**		

*p<.01; **p<.001; [a] reference category – no fines for traffic rules violations; [b] reference category – females; [c] reference category – with driving instructor, other drivers, and independently.

lower in our sample compered to international data. For example, Boufous et al. (2011) reported that approx. 65 percent of Australian candidates pass their on-road test at first attempt. a bit lower numbers were observed in the Netherlands and UK: respectively 48 percent (de Winter, de Groot, Mulder, Wieringa, Dankelman, & Mulder, 2009) and 43-48 percent depending on the information source (Baughan et al., 2006; Statista, 2018; Nyberg & Gregersen, 2007; Sexton & Grayson, 2010; Wells et al., 2008). Singapore police force (2018) declared that first-time on-road test passing rates depended on driving school and varied from 35.6 to 61 percent. It appears that Baughan and colleagues (2006) suggested a good explanation of such low first-time passing rates: firstly, many learner drivers come to on-road driving test not skilled enough and more likely are trying their luck than demonstrating competence to drive a vehicle properly. And secondly, multiple failures on on-road driving test might be related to the overestimation of candidates' own driving skills because of high level of support from their driving instructors and parents or because of competition with friends. Also driving test performance might be related to wrong attribution of a failure on driving with instructor either during the test to external factors (such as bad examiner, challenging situation or behaviour of other drivers) but not to lack of own driving skills (Baughan et al., 2006). On the other hand, learner drivers might underestimate their driving competence or feel too anxious prior to and during tests (Boufous et al., 2011).

Current findings revealed that not more diverse learning to drive, but longer independent driving experience and being male predicted the probability of being fined for the traffic violations. The fact that males violate traffic rules more often than females is not surprising and repeats previous findings (Ho & Gee, 2008; Nyberg & Gregersen, 2007). Also, these results confirmed findings of Maycock & Forsyth (1997) that there was no relation between driving training experience and later accident involvement. Meanwhile, the relationship between driving experience and traffic offences during the first year of driving is quite obvious. The longer novice driver drives, the more traffic violations he or she commits and the greater chances of being caught by the police are (Baughan et al., 2006; Sexton & Grayson, 2010; Tao, Zhang, & Qu, 2017). And this finding is very important for novice drivers, as they may have the impression that if they repeatedly violated traffic rules and do not experience any negative consequences, such behaviour is reasonable and would continue.

Contrary to expectations, performance on on-road driving test was not related to either traffic offences or accident involvement. But, as expected, the first-time passers of theory test were less prone to violate traffic rules during independent driving. Thus, it shows that knowing the traffic rules might lead to the compliance. The absence of any other relations might be due to very low rates of violations (12.5 percent) and accident involvement (3.5 percent) in our sample. Such small numbers of offenders reduced the statistical power to detect significant relationships between the analysed variables (Tabachnick, Fidell, & Osterlind, 2001). Unfortunately, the prediction of accident involvement was even not possible. Thus, this self-selection bias is the major limitation of this study. It might be that this happened because of voluntary participation in the study as statistical data provide much higher numbers of recorded offences in Lithuania (Lithuanian Police Service, 2017; Recorded accident statistics in Lithuania, 2016) not mentioning self-reported violations for which novice drivers were not fined.

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Young people, drug use and drugged-driving

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ABSTRACT: *According to World Health Organization (WHO) road traffic injuries are a leading cause of death globally, leading to the death of 1.2 million people each year. Data from National Authority for Road Safety (ANSR-Portugal) points to age group between 18 and 24 years old as the most vulnerable facing road dangers. In the last 10 years 15% of fatalities, 18% of serious injuries and minor injuries happened in this age group. It is also in this younger group that most accidents occur during weekend nights compared to the other days of the week. This article aims to present the results of a preliminary study about drug use and drugged-driving, through the application of the DDYP-Scale Questionnaire to 140 young people. For data analysis, descriptive and inferential statistical analyses were applied.*
Results presented here, although somewhat different from American and European studies, indicate a clear tendency to the recreational use of marijuana and drugged-driving, among younger populations.

KEYWORDS: *Young people; Drug Use; Drugged-Driving; Road Traffic; Road Safety.*

1. INTRODUCTION

Driving is a complex activity present in our daily day lives that requires alertness, attention, concentration, eye-hand-foot coordination and ability to process visual, auditory and kinesthetic information quickly (Larkin, 2015). It is well established that alcohol impairs driving, but less is yet known about the effects of psychotropic substances consumption and how drugs affect driving behaviors (Robertson, Hing, Pashley, Brown and Vanlaar, 2017).

Until recently, society did not focus on problems related with drugged driving. However, the governmental law changes and the existence of a commercially regulated cannabis market opened the discussion and analysis about the possible change in consumption patterns, high lightening the importance of regulation and evaluation of consumption behaviors and consequences, being road safety and drugged driving one of them. Although its known that drugs impair driving, less is yet known on how and in what degree this happens and there are many misperceptions about drugged driving, such as: drugged driving is not a serious problem, some drug use does not adversely affect driving, some drugs improve driving ability and even that drugged-driving isn't illegal (Holmes, 2017). A Gallup poll made in the U.S. (2016) found that most Americans consider that driving under the effects of alcohol is a very serious problem (79%), but only 29% considered that driving while impaired by marijuana is a "serious problem". Poor attention to tasks, distortion of time and distance perception, impact on reaction time with slower braking, poor perception of speed and its maintenance, poor lane tracking and more steering corrections and slower driving are some of the effects of marijuana in driving (Holmes, 2017; WHO, 2016).

The European Report of Drugs (2017b) found that in the last year 18,7 million young adults (15-34 years) consumed drugs and more that 93 million people already experimented illicit drugs, being cannabis the most common followed by cocaine. In Portugal, the use of illicit substances seems to have been decreasing over the past decade and cannabis remains the most frequently used drug (EMCDDA, 2017b). The 2015 European School Survey Project on Alcohol and Other Drugs found that 5,1 % of young adults reported using cannabis in the last year.

The data also shows that males are more likely to report drug use than females.

European Monitoring Center for Drugs and Drug Addiction (EMCDDA) found that, in 2017, 21% of young people reported to drive after using illicit drugs. The report also highlights that the risk of road traffic accident increases 1-3 times with the use of cannabis, 2-10 times with the use of cocaine and 5-30 times with the use of amphetamines. The DRUID Project (Driving under the influence of drugs, alcohol and medicines) created by the European Union to analyze the relation between traffic safety and the use of psychoactive drugs investigated the presence of alcohol and drugs in killed drivers and found that drugs were frequently detected (ranging between 2.3% and 12.6%), especially in combination with alcohol (2.3% - 13.2%) and cannabis was the most commonly detected drug (Albrecht, 2008). In Portugal the most prevalent drug was opioids (EMCDDA, 2017b). The World Health Organization (WHO, 2016) reported that of the 1 252 071 road traffic deaths, in 2013, 39 625 were relates to drug use (51% related with amphetamines, 22% with cannabis, 14% with cocaine and 13% with opioids use). Robertson et al., in 2017, also found that male drivers were more expected to report using marijuana and other illegal drugs before driving. Among fatally injured drivers, males were also more likely to test positive for any drug, cocaine or marijuana while females were more likely to test positive for CNS-depressants.

Given this data, EU countries are making efforts and creating task forces to address drugged driving through the creation of legislation and its reinforcement, but due to numerous factors the situation is complex: "drugs" encompasses a wide variety of substances (some prescribed, other illegal); detecting and measuring levels of psychoactive substances is more complicated than detecting alcohol in breath, since requires samples of blood, urine or saliva, the crash risk for drugs is more complicated to ascertains because different types of drugs stay in the bloodstream for different lengths of time and lack of scientific evidence in the links between drug levels, impairment and crash risks, making difficult to set threshold limits for each substance (WHO, 2016). Nevertheless, the effort is being made. Some commonly used strategies by policymakers are: creation of legal limits, impairment legislation and zero tolerance laws. Drugged driving needs to start being treated as a risk factor for road safety and the creation campaigns is one way to address this issue. People need to know that drugged driving is illegal but also what are the associated risks and the specific ways drug use impairs driving. The creation of training programs for police focused on professional skills for detection and recognition of external symptoms of illegal substance use, the creation of easy and quick devices for roadside tests, the establishment of threshold limits to substance use, similar to BAC levels for alcohol and the creation of international research programs focused on drug-driving are some of the pinpoint governmental and social actions for the fight against drugged-driving (Holmes, 2017; ETSC, 2017; Flieger, 2017).

Portugal is one of the countries committed the elimination and reduction of drug use, through the adoption of a national plan for the reduction of addictive behaviors and dependencies (2013-2020) that recognizes the need for specific prevention, given the context, being road safety one of them (SICAD, 2014). In 2017, Portugal held the Third International symposium on drug-impaired driving aiming to bring together key stakeholders to share their experience and lessons learned and to develop next steps to effectively address drug-impaired driving (EMCDDA, 2017a).

2. AIMS OF THE STUDIES

Coimbra is a city in the center of Portugal, which is characterized primarily for being a university town. The academic festivities with its 30.000 students are known worldwide. The academic traditions are associated with the academic festivities: The "Receção ao Caloiro" (Freshmen Welcome Party) and the "Queima das Fitas" (Burning of the Ribbons Party). For a week the city is dressed in tradition, with thousands of people (national and international students). Associated with these moments are the abuse of alcohol and drugs. This study results from a joint initiative led by InOutCister, in a partnership with the Applied Research Institute (IIA) – Robocorp - School of Higher Education of the Polytechnic Institute of Coimbra, counting as partners other public and private entities (Academic Association of Coimbra; National Authority for Road Safety, and others).

We aim to contribute to the expansion of knowledge on drugged driving, through the analysis and characterization of drug usage patterns and drugged-driving practices in young people, in Portugal.

3. MATERIALS AND PROCEDURE

The data was collected through the application of the Drugs, Driving and Young People- DDY-P (Silva; Mendes; Girão & Diogo, 2017) questionnaire to young drivers, living in Coimbra. This questionnaire was created by a Traffic Psychology International (TPI) member, in collaboration with other experts in the field. Its aim was to characterize and map the main patterns of psychoactive substances' consumption, in young people and its relation to driving and thus road safety. It has three mains topics: (a) sociodemographic data, such as genre, age, professional status, academic habilitations, regular way of transportation and if the subject owns a vehicle and have's driver's license; (b) drugs and behavior as a driver, which included a question about the most frequent road used by the subjects: road city, rural, urban, highway, or fast track road and (c) behavior, drugs and driving, with several questions related to the consumption of psychoactive substances, the frequency of the consumption, ranging from "Just tried once" to "daily" (with the following options: "rarely", "monthly", "weekly" and "more than twice a week"), items related to drugged driving and items that, through Yes/no" answers, characterized subjects perceptions about the relation between drugged-driving and road traffic safety. The DDY-P was randomly distributed among young adults in paper format between March and May of 2017. Quantitative statistical analyzes of the data were carried out using SPSS Statistics (v. 22.0). The results are presented in the next section.

4. RESULTS

4.1. DRUGS, DRIVING AND YOUNG PEOPLE

4.1.1. SAMPLE DESCRIPTION

140 subjects, 57.9% women and 42.1% men comprise the sample. Their ages range from 18 to 27 years old, but more than half of the subjects (56.5%) are between 20 and 23 years old (M=21.12; SD= 2.10). The majority are students (72.9%), others being workers (14.3%), working students (3.6%) and unemployed (9.3%). Regarding their academic qualifications, 64.3% have completed the 12th grade (High School), 23.6% are graduated and 3.6% have a master degree (See Table 1).

Almost half of the subjects (47.9%) reported that they usually move by driving a car, while the others reported that they typically move by walking (29.3%), by public transports (17.9%) or by a car driven by others (2.9%). More than half (71%) have a driving license for 36 months or less than this period. Also, more than half of the subjects (50.7%) own a car. Regarding the type of routes where the subjects drive, 57.1% reported that they are used to drive in mixed routes (urban and rural). 33.6% reported driving usually in urban routes. In Table 5, 6 and 7 we can see the representation of these values (See Table 2).

Table 1: Demographic characteristic of the participants (n=140)

	Total	%
Gender		
Male	59	42.1
Female	81	57.9
Age of the participants		
18-19	38	27.4
20-23	79	56.5
24-27	22	15.7
Missing	1	0.7
Occupation		
Students	102	72.9
Workers	20	14.3
Working-students	5	3.6
Unemployed	13	9.3
Academic Qualifications		
9th grade	7	5.0
12th grade	90	64.3
Bachelor	3	2.1
Graduations	33	23.6
Master	5	3.6
Missing	2	1.4

Table 2: Participant's transportation method, Car-ownership and most common route used (n=140)

	Total	%
Transportation Method		
Car driving	67	47.9
Walking	41	29.3

Public Transports	25	17.9
Carpool	4	2.9
Missing	3	2.1
Car owner		
Yes	71	50.7
No	60	42.9
Most Common Routes		
Urban	47	33.6
Rural	18	12.9
Mixed	80	57.1
Freeway	6	4.3
Highway	13	9.3

4.1.2. RESULTS

Less than a third of the participants (26.4%) reported that had already tried psychotropic substances, being cannabis the most frequently used substance (81.1%). Only 3 subjects reported having tried ecstasy, 6 reported the usage of other substances and there were no reports of cocaine use. Subjects could indicate more than one substance use and four subjects reported so. Regarding the frequency of the use of cannabis, 25.9% reported that they only tried once, 25.9% reported having rarely used it and only 14.8% mentioned its daily use. All participants that mentioned using ecstasy reported that only did it once. For other substances, half of the subjects that reported having tried them indicated having tried them only once. These values are summarized in Tables 3, 4 and 5.

Among the subjects who reported having already used psychotropic substances, 16 subjects (44.4%) stated that they had already driven a car after having used any of these substances (See Table 6). Regarding the frequency of this behavior, 7 subjects (46.7%) reported that made it rarely and 3 subjects (20%) reported having done it only when they tried the substance (See Table 7). When asked if they had already driven a car while using simultaneously a drug, 7 subjects (19.4%) gave a positive answer and all of them mentioned cannabis as the drug that they used while driving.

Table 3: Psychotropic substances ever tried

	Yes	%	No	%	Total	%
Substance use	37	26.4	103	73.6	140	100

Table 4: Substances used by subjects who reported having already tried them

	Cannabis		Ecstasy		Cocaine		Others	
	n	%	n	%	n	%	n	%
Yes	30	81.1	3	8.6	-	-	6	17.1
No	7	18.9	32	91.4	35	100	29	82.9

Table 5: Frequency of the substance use

		One Time	Rarely	Monthly	Weekly	+2x Week	Daily
Cannabis	**n**	7	7	2	5	2	4
	%	25.9	25.9	7.4	18.5	7.4	14.8
Ecstasy	**n**	3	-	-	-	-	-
	%	100	-	-	-	-	-
Other	**n**	3	1	1	1	1	-
	%	50.0	16.7	16.7	16.7	16.7	-

We also analyzed the pattern of consumption of psychoactive drugs and its difference in subjects' academic qualification. Although it is not completely clear neither representative, the results show that most subjects that already tried psychoactive substances only have 12th Grade of education (See Table 8).

Concerning the attitudes towards drugs and driving, most of the subjects (92.9%) considered that the use of psychotropic substances is illegal in car driving, while 5.7% answered that it is legal. Moreover, most of them (92.1%) considered that psychotropic substances impair driving a car, while 6.4% did not consider it. Regarding the liberalization of the use of psychotrop-

Table 6: Car driving after using substances

	Yes	No	Total
N	16	20	36
%	44.4	55.6	100

Table 7: Frequency of car driving after having used substances

	One time	Rarely	Monthly	Weekly	+2x Week	Daily	Missing
N	3	7	3	-	2	-	1
%	20.0	46.7	20.0	-	13.3	-	0.7

Table 8: Relationship between drug consumption and subjects' academic qualifications

Have you ever tried drugs?	Academic Qualification					Total
	9th Grade	12th Grade	5th Bachelor degree	Graduation	Master	
Yes	1	25	1	9	1	37
No	6	67	2	23	5	103

Table 9: Quantification of participants' answers to the following to the questions: Is drugged-driving illegal? Do psychotropic substances impair driving? and Should Psychotropic substance be liberalized?

	Total	%
Is drug driving illegal		
Yes	130	92.9
No	8	5.7
Missing	2	1.4
Does drugs impair driving?		
Yes	129	92.1
No	9	6.4
Missing	2	1.4
Should psychotropic substances be liberalized?		
Yes	42	30.0
No	96	68.6
Missing	2	1.4

ic substances, most of the subjects (68.6%) answered negatively. Only 30% agreed with the liberalization. The results are summarized in Table 9.

Of those who stated having consumed psychoactive drugs more than once (20), sixteen consider that drugs are a problem in traffic and four consider that are not and of those who reported having consumed drugs only once (N=7), six said that that drugs are a problem in traffic and impair driving and only one said it wasn't (See table 10).

4.1.3. ANALYSIS

In order to measure the existence of sex differences regarding the use of drugs (if they had ever tried psychotropic substances) and driving after substance use, chi-squared test was conducted. As the results show there are no significant differences between men and women in the previous use of drugs and in driving behavior after the substance use (See Table 11).

Next, we aimed to analyze the existence of age differences regarding the use of drugs (if they had ever tried psychotropic substances) and driving after substance use. For this purpose, t-student tests were carried out (See Table 12). The results show that participants whom already tried drugs are older that the ones that didn't and this difference is significant [$t(137) = 2.177$, $p < .05$].

No significant differences were found between age and drugged-driving (See Table 13).

Table 10: Relation between psychoactive consumption and subject's perception on drugged driving and drug impairment of driving

		Do you think drugs impair driving and affect traffic safety?	
		Yes	**No**
Consumed psychoactive substances	**No**	107	4
	Only one	6	1
	More than one	16	4

Table 11: Chi-squared tests measuring sex differences regarding substances use and driving after substance use

		Male	**Female**	**Total**	χ^2	**p**
Substance use	**Yes**	19	18	37	1.749	.130
	No	40	63	7		
Driving after consuming	**Yes**	8	8	16	.089	.515
	No	11	9	20		

Table 12: T-student measuring age differences regarding the use of drugs (if subjects ever tried psychotropic substances)

	Yes (N=37)		**No** (N=102)			
	M	**SD**	**M**	**SD**	**t**	**p**
Age	21.76	2.11	20.89	2.05	2.177	.031

Table 13: T-student measuring age differences regarding driving after substance use

	Yes (N=16)		**No** (N=20)			
	M	**SD**	**M**	**SD**	**t**	**p**
Age	21.56	1.86	22.0	2.34	-.609	.547

5. DISCUSSIONS AND CONCLUSION

The results confirm national and European reports on drug use and addictive behaviors, showing that in Portugal, 26.4% of the inquired subjects have already tried psychotropic substances, and cannabis was the most commonly mentioned. A smaller number of participants reported having tried ecstasy and a residual number reported having tried other substances, but no reports of cocaine were mentioned. Older subjects reported to have consumed more drugs that younger subjects and among those who tried drugs, most reported having used them once, although in the case of cannabis a minority admitted making a daily use of this substance. When inquired about drugged-driving, the majority of the subjects that reported having already consumed some type of drugs also admitted having already driven after its consumption. The results presented here are somewhat contradictory to the American answers to the Gallup poll, since most inquired subjects considered that drugged-driving is illegal and that drugs impair driving. This can be due to cultural differences and to a smaller sample.

Results also show that there are no significant differences between men and women in the previous use of drugs and in driving behavior after the substance use. These data are not in accordance with the European Drug Report of 2016, which revealed that men tend to consume more than women, but this can be due to a small sample.

The results previously discussed have some limitations. The sample is not representative and does not allow generalization of results. Despite of the fact that this is only a preliminary study that needs further development to consolidate the findings, our aim to map the young people perception on drug use and drugged-driving was reached. Another limitation of our study is the solely focus on quantitative analysis. We propose further investigation, with a qualitative approach. This could lead to other results and interpretations, such as the explanation if youngsters' reporting that drugs consumption impairs driving were the ones that already drugged-drove and in which ways they felt that drugs impair driving. This methodological approach could also allow understanding many "whys" still answered, such as: Why does youngster drugged-drive? Why do youngsters consume psychoactive drugs?

Despite these limitations, our study alerts us to the need to define new investigations on the field with the main goal on the creation of strategies and public policies to prevent excessive consumption of drugs and drugged-driving.

In the future we can study the behaviors concerning alcohol, drugs and driving habits of adults in context parties and compare them with the same behaviors of young people. This type of investigation would also be interesting to carry out in the workplace, in different organizations, in order to understand what the knowledge and behavior of employees is and the existence of good practices of awareness implemented by organizations.

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Drunk driving prevention and cultural influences: the SAFE ROADS 4 YOUTH (SR4Y) project

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ABSTRACT: *Driving under the influence of alcohol is an important factor in road fatalities all over the world. However, an important significant heterogeneity among countries was found regarding this issue. Why is such a discrepancy found among countries? Several specificities might explain the differences, such as enforcement practices, cultural values, or drinking patterns. The aim of this study was to test whether the social influence (descriptive and injunctive norms) on drunk driving is country-dependent and to explore whether the differences can be attributed to the contextual and/or cultural specificities of the countries.*

We used data from the SAFE ROADS 4 YOUTH (SR4Y) project, with the objective to implement and evaluate drink driving prevention actions using a common conceptual framework in three developing countries over three continents: Vietnam, South Africa and Argentina. 11300 students aged between 13 and 25 were surveyed.

We conducted a regression analysis of social norms on the intention to resist to drunk driving in each country. In all three countries, family injunctive norms were correlated with drunk-driving (DD) intention. The link was strongest in Argentina and weakest in South Africa. In South Africa, friends' injunctive norms had negligible link with DD intention, no link was found with friends' descriptive norms. The link between injunctive norms and DD intention was stronger in Vietnam than in Argentina. Friends' descriptive norms had stronger link with DD in Argentina than in Vietnam.

Overall these results suggest differences in social influence on drunk driving intention depending on national cultures.

KEYWORDS: *Alcohol; culture; young people; drinking and driving; risk perception; norms*

1. INTRODUCTION

All over the world, drink-driving is an important factor in road fatalities. However, some differences between countries were found regarding this issue. In 2010, the share of road fatalities linked to drink-driving was lower than 10% in many countries such as Japan, Austria, Germany or the Netherlands whereas it was higher than 30% in many other countries such as France, Greece, Spain, Canada or the USA (International Transport Forum, 2018). Why was such a discrepancy found among countries? Several country-specific factors (enforcement, alcohol consumption or cultural values) might explain these differences (Cestac, Kraïem & Assailly, 2016). According to the Lederman's Law (1956): the level of alcohol-related harm in a country, such as cirrhosis, fights, traffic crashes, etc. is correlated to the yearly average consumption of the population. Moreover, the Driving Under the Influence of Drugs (DRUID) project conducted in 13 European countries (Houwing et al., 2011) found that an average of 3.48% of all European drivers on the road have alcohol in their blood (varying from 0.15% of drivers in Hungary to 8.59% in Italy). These frequencies of drink-driving have of course a great impact on alcohol-related road fatalities, but why some countries have more drunk drivers than do others?

One of the factors that may predict drunk driving is social influence (Fernandes et al., 2010). In several countries, it has been observed that risky behaviors may be influenced by peers, we may therefore consider it as a "universal" process. Though the relation between peers' and individuals' behaviors has been moderated by cultural values in some studies (Gazis et al., 2009). The discrepancy between countries regarding alcohol-related fatalities may thus be linked to differences in the level of peer influences on drunk driving (Cestac, Kraïem & Assailly, 2016). Moreover, the driving context (traffic laws, infrastructures, en-

forcement levels, etc.) depends on the country and these contextual factors may also influence drunk driving and moderate peers' influences on this behavior. The social context may influence behaviors, and for example alcohol use and driving behavior are particularly sensitive to others' expectations and behaviors. The social norms, either descriptive or injunctive (see Deutsch and Gerard, 1955), have been often studied in their links with risk-taking at the wheel. For example, Forward (2009) showed that speeding and dangerous overtaking were influenced by descriptive norms. More recently, the interplay of descriptive and injunctive norms on the speeding intentions among young French drivers have been observed (Cestac, Paran & Delhomme, 2014). Alcohol use (Larimer et al., 2004) and impaired driving (Brown, 1998; Fernandes et al., 2010) are also related to peers' drinking behaviors and drunk driving respectively.

If the relation between personal behaviors and friends' behaviors has often been analyzed as a social influence, it has also been argued that it could be the consequence of a *selection bias*, that is, people selecting as friends others who behave like them (Curran et al., 1997). Nevertheless, the desire for conformity is linked with the motivation to be integrated in the group and is reinforced by the fear of social sanction. It is thus possible that socialization and selection operate simultaneously. Still, Stok and colleagues (2014) observed a direct influence of descriptive norms on behavior in an experimental setting.

Other important determinants of social norms are individual beliefs about risk and safety. These beliefs may be false and induce erroneous attitudes and behaviors. False beliefs can be the consequence of ignorance about actual risks or of perception biases. They can be transmitted through peer and/or parental influence and are sensitive to the cultural context (Assailly, 2011).

Cultural effects

Culture has been described as a collective state of mind shared among members of a specific population (Hofstede, 2001). It covers norms, values, and beliefs that varies among subgroups of populations. Differences between driving styles in countries or groups of countries have been identified by cross-cultural researchers. Driving behaviors have been compared in six European and Middle Eastern countries: in Western/Northern European countries slightly more ordinary violations are observed (i.e., speeding on a motorway) but less aggressive violations (get angry, give chase) and errors (e.g., nearly hit cyclist while turning right) than in Southern European and Middle Eastern countries (Özkan et al., 2006). The relationship between the culture and the number of accidents is also under the influence or these driving behaviors. These differences were again observed in a more recent comparison of Northern European countries (i.e., Finland and Sweden) and Southern European countries (i.e., Greece and Turkey), and significant differences in drunk driving across these countries have been recorded (Warner et al., 2011). Though, differences between Southern European countries also exist. For example, Italian and Greek students' risky behaviors have been compared: Italian students comply more with safety measures but report more drunk-driving behaviors (Antonopoulos et al., 2011).

We thus have decided to study social influence on drink driving intention among young students with a cross-cultural perspective. Cultural values and social norms can be considered as two kinds of norms. Peer influence is the consequence of a social norm at the individual level (what significant others are expecting or doing). More general normative influences such as national cultures may also have an impact at the individual level. Some moral norms are transmitted by cultural values (what is morally acceptable in the country), and some legal norms belong to the driving context in a country (driving laws, infrastructures, or education). These norms may vary across individuals and situations and therefore may be conflictual (Engel, 2007).

If social influences on drunk driving has been well studied, cultural effects are less well known. Cross-cultural research on driving behavior has compared different countries about their driving style but has given much less explanations about how a culture may influence drunk driving (Antonopoulos et al., 2011; Özkan et al., 2006; Warner et al., 2011). One objective of this study is to see the ways in which culture and national contexts affect drunk driving, in particular the ways in which they affect social influence. Another determinant of violations is one dimension of risk perception which is false beliefs. These misperceptions about alcohol use (for example, "coffee decreases the blood alcohol concentration") or speed (for example, "speed is not the cause of crashes, I can drive fast safely") may lead to a dangerous driving style. These misperceptions may be under the influence of cultural or contextual factors (for example, lack of education or communication on these risk factors).

2. RESEARCH QUESTIONS AND HYPOTHESES

The objective of this study is to see whether the social influence on drunk driving is dependent of the country and to analyze if the differences can be attributed to the contextual and/or cultural specificities of the countries. More specifically, we have proposed two general hypotheses guiding our work.

First, as demonstrated by Ando et al. (2007) and Cestac et al. (2016), the strength of the descriptive norm's influence on one's behavior may vary across cultures. We thus expect that the link between friends' expectations and behaviors and respondents' behaviors will be stronger in some countries than in others. Indeed, normative influence, in particular injunctive norms influence on behaviors, is stronger in collectivistic countries where the interdependence between society members is high. We thus assume that this influence will be the greatest in Vietnam and the lowest in South Africa (Hypothese 1).

Second, we expect that false beliefs about alcohol use and about drunk driving will vary across cultures. Moreover, it seems logical to expect higher risk taking and crashes in countries with more false beliefs (Hypothese 2).

3. METHOD

The SAFE ROADS 4 YOUTH (SR4Y) project is an international project, led from 2012 to 2016, with the objective to implement and evaluate drink driving prevention actions using a common conceptual framework in three developing countries over three continents: Vietnam, South Africa and Argentina. It aimed to determine what types of community programs are most effective in preventing drink driving and how their effect varies across countries, traffic policy contexts and cultures. The project had a very large scope including before/after measures with prevention interventions in some schools and some control groups. Moreover, in some countries the project was also interested in professional drivers. However in the present paper we focus our analyses on a smaller part of the data: students aged between 13 and 25 and only for the first wave of measures (i.e., before any specific intervention) with N=11300. Detailed characteristics of each national convenience sample can be found in Table 1. We observed differences between the samples regarding mobility patterns with much lower overall motorized trips in South Africa and more moped drivers in Vietnam, $\chi^2(2, 11496) = 223$, $p<.001$. There were also differences in overall alcohol consumption which is much higher in Argentina, and regarding the gender gap in alcohol consumption which is very large in Vietnam.

The three countries involved in the project can be compared using existing data (see Table 2) from Hofstede, Hofstede & Minkov (2010)[1]. Argentina and South Africa appear to be relatively close to each other regarding these dimensions compared to Vietnam. However they differ in Individualism which is greater in South Africa and in Uncertainty avoidance

Table 1: Descriptive statistics of national samples

	Argentina	**South Africa**	**Vietnam**
N	5448	1033	4819
M Age (SD)	17.6 (2.4)	17.6 (2.1)	18.1 (2.8)
% Women	56.8	58.2	52.6
% moped drivers	6.9	3.8	14.4
% motorcyclists drivers	29.6	6.9	23.7
% car drivers	22.5	18.2	2.4
% of alcohol abstainers. *Total*	14.3	53.3	60.6
% of alcohol abstainers. *Females*	15.9	53	78.3
% of alcohol abstainers. *Males*	12.2	54	41.4

1 Note than on should be careful when using these data because it has been collected almost 50 years ago.

which score is higher for Argentina. The high level of Uncertainty avoidance in Argentina lead to a very dense legislation including a large number of specific laws, sometimes contradictory. In Vietnam, Power distance is very high, which means that hierarchical order and inequalities are well accepted by the population, more than in the two other countries involved in the present study. Vietnam is also clearly a collectivistic country, meaning that people feel a high responsibility for other members of their groups and that offences often lead to shame.

Table 2: Country scores on Hofstede's (2010) dimensions

	Argentina	South Africa	Vietnam
Power distance	49	49	70
Individualism	46	65	20
Masculinity	56	63	40
Uncertainty avoidance	86	49	30
Long term orientation	20	34	57
Indulgence	62	63	35

The measures analyzed in the present study are detailed below. For the first four variables answers were collected using 5-points Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). For the beliefs questions answers were "True", "False", "I don't know".

- Intention to resist drunk-driving: "*My intention in the future is to drink very little or nothing at all before I have to drive"*.
- Friends' injunctive norm: "*Most of my friends think that alcohol in road traffic should be avoided"*.
- Friends' descriptive norm: "*A lot of friends of mine would drive a car, even if they have had quite a few drinks"*.
- Family injunctive norm: "*My family would not approve if they knew I were driving after drinking"*.
- Beliefs measure consisted of 12 affirmations, such as "*Alcohol makes a driver feel less tired and more awake"* or "*Drinking black coffee helps the sobering up process"*, that students had to evaluate as true or false. A "false beliefs" index was then created, summing up the number of erroneous answers out of the 12 questions. "I don't know" answers were considered as missing values.

4. RESULTS

The number of reported crashes is the greatest in Vietnam and the lowest in Argentina and the average number of false beliefs is highest in South Africa and lowest in Argentina (see Table 2). Tuckey's HSD tests indicate that all the paired differences are significant with p<.001 for both analyses. Overall there is a link

Table 3: Reported behaviors and beliefs

	Argentina	South Africa	Vietnam	F	eta²
Average number of crashes in the last year	0.39	0.60	1.13	189***	.03
False beliefs (out of 12)	3.56	4.54	4.23	259***	.04

Note: *** = p<.001

Table 4: Regression of social norms on the intention to resist to drunk driving

	β South Africa *adj. R² = .02*	β Vietnam *adj. R² = .08*	β Argentina *adj. R² = .09*
Friend's injunctive norms	.08*	.20***	.15***
Friend's descriptive norms	ns	-.04**	-.10***
Family injunctive norms	.10***	.14***	.21***

Note: * = p<.05, ** = p<.01, *** = p<.001

between the number of false beliefs and number of reported crashes, $F(2, 11235) = 17.4$, $p < .001$, however the effect size is negligible ($eta^2 < .01$).

In each country, we conducted a linear regression analysis of social norms on the intention to resist drink driving. All condition indices were lower than 15, for each country, indicating no collinearity issue. In all three countries, family injunctive norms were linked with drunk-driving (DD) intention. The link was strongest in Argentina and weakest in South Africa. In South Africa, friends' injunctive norms had negligible link with DD intention, no link was found with friends' descriptive norms. The link between friends' injunctive norms and DD intention was stronger in Vietnam than in Argentina. Friends' descriptive norms had stronger link with DD in Argentina than in Vietnam. Overall, based on Cohen's (1988) recommendations for interpretations of effects sizes, we found social norms had a very weak impact on intention to resist drunk driving in South Africa and a moderate link in Vietnam and Argentina.

The three regression models were significantly different from each other. According to the Chow (1960) test, the model for South Africa is different than the model for Vietnam $F(3, 5891) = 2013$, $p < .001$, the model for South Africa is different than the model for Argentina $F(3, 6359) = 1295$, $p < .001$, and the model for Argentina is different than the model for Vietnam $F(3, 10306) = 516$, $p < .001$.

5. CONCLUSION AND DISCUSSION

Concerning our hypotheses on the social influences, both were confirmed: social norms influences can be observed in the three countries, but are not identical and the strength of the influence of descriptive norms on one's behavior vary across cultures.

In the same way, the frequencies of false beliefs are different according to the country; there is a link between number of false beliefs and number of reported crashes, however the effect size is negligible.

The present study suffers from several limitations. Indeed, as a correlational and field study it was not possible to control for any potential confounding variables, as it is always the case for cross-cultural studies. The moderate level of the observed correlations further confirm that other variables are at play when it comes to explain the intention of resisting drink-driving.

Other observations stemming from this project are interesting for the study of cultural factors:

A first and important finding of our work is that amount and frequency of alcohol use among young people has been underestimated in emerging countries. The amount and frequency of alcohol use is increasing nowadays among young people of developing countries precisely because of modernization: enrichment, destabilization of family relationships, pace of social change, rising expectations for academic performance, urbanization and emigration from rural areas, changing gender roles, etc. All these are factors and pressures affecting risk behaviors and alcohol use.

We have seen also from our baseline survey how traffic safety is an important issue among young people in developing countries. The problem is very severe in Vietnam, due to chaotic two-wheel traffic, where half of the subjects had at least one accident in the last three years, compared to 30% in South Africa and 25% in Argentina. Due to the two-wheel traffic, accidents are more severe (in terms of injuries) in Vietnam; the economic burden of this safety problem is enormous for this country.

Our survey gives new elements on the well-known issue of gender and risk behaviors. With the comparison of the three countries, we see the influence of culture on gender-related differences, as the gender gap is smaller in South Africa than in Vietnam. For example, in South Africa, 30% of girls have had traffic accidents in the previous three years, the same proportion as boys, which is a very unusual observation in traffic safety research. No difference was observed concerning the severity of the accidents, which is different than in western countries. 9% of girls declare drink driving, the same proportion as boys. 26% had been the passenger of a drunk driver, compared to 20% of boys. The amount and frequency of alcohol use are very similar between boys and girls, which is not the case in most western countries.

Gender differences are a good example of the relationship between universal and cultural factors: the vulnerability of males concerning alcohol-related accidents and offences has universal biological (effect of hormones), psychological (adherence to gender stereotypes) and anthropological (concern for others and orientation of violence) mechanisms, which are very much the same around the world. However, the historical trend towards the reduction of gender difference varies according to country-specific cultural factors, and the gender equality agenda. Let

us take as an example the drink driving offense: in some countries where women have no access to car driving or to alcohol, male vulnerability is 100%. Conversely, in the most feminist countries (Scandinavia, Iceland, Australia), the gender gap is reduced to the point of becoming nonexistent. Finally, in southern Europe for instance, gender differences in drink driving are still significant, due to a greater adherence to sex stereotypes.

Concerning the difference between South Africa and Vietnam about alcohol use among boys/girls, another hypothesis could be raised. Since cultural factors, and the descriptive and injunctive norms (what others/parents/ peers will think about me if I drink too much) are stronger in Vietnam than in South Africa, this may put more pressure on Vietnamese girls than on South African ones. This may be understood as a culture/context effect : in Vietnam, the ancient Confucean doctrine still influence the respect of parents and of parents' views of thinking, whereas in South Africa, children are much more "let to themselves", with very few parental supervision. All this is also subject to historical evolutions: the situation was probably different 20 years ago in both countries.

So, in the three countries, the gender differences concerning alcohol use and accidents present an historical evolution and become less important than in the past (impacts of globalization and of the gender equality and women's rights agenda). The more gender equality exists in a country, the smaller are the gender differences in drinking behavior as it gives more legitimacy and fewer stigmas for women to adopt "masculine" behaviors.

Finally, we now have a better understanding of the psychological mechanisms leading to drink driving, and this suggests tracks for the preventive actions to be implemented:

a) tracks from the hypotheses and the results presented above :

- Lack of knowledge and misperceptions: Very large proportions of subjects do not know the legal limit and overestimate the number of drinks to be consumed in one hour to drive legally or safely. Educational actions in various settings may improve this.
- False beliefs leading to overconfidence: Such as "drinking a little alcohol can improve a driver's reflexes", or "drinking coffee helps to lower the blood alcohol concentration". False beliefs may be associated to accident involvement.

b) tracks from the general outcomes of the entire SR4Y project :

- Discrepancy between subjective norms: Subjects report that most of their peers would disapprove or even condemn drink driving but that ... most of their peers do it sometimes. Peer-to-peer approaches such as group discussions, role-play, etc are shown to be useful on this topic.
- Positive drinking expectancies: To have fun, release tension, favor group integration or sexual life. This suggests messages for preventive actions: to try to keep the same objectives for the subjects, but with different strategies (ex: how to have fun without or with less alcohol).
- Lack of parental supervision, failure in resisting peer pressure and absence of nighttime trips planning: three important factors of alcohol-related accidents, which have been reported in our survey. Parent-based interventions and "life-skills training" type actions may improve these phenomena.
- Underage drinking and unlicensed driving have been revealed by our survey, when we compare the modes of mobility and the ownership of licenses reported. More generally, fear of detection of underage drinking, or of unlicensed driving or drunk driving, is still very low in the three countries. A capacity building of police enforcement could produce positive effects on these behaviors.

To conclude, differences in social influence on traffic behaviours is a promising field of study and of preventive actions in developing countries, as traffic safety policies have to take into account these specificities.

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Process of learning to drive by young persons with autism: experiences of the young persons themselves, parents, and driving instructors

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ABSTRACT: *Certain groups have been overlooked in the field of transportation research, for instance, drivers with an autism spectrum disorder (ASD). In this article, we describe exploratory research into barriers and facilitators in the process of learning to drive for young people with ASD. Questionnaires were distributed in three groups involved in this process: young persons with ASD, parents or caregivers, and driving instructors. Respondents were asked about their experience of the process of learning to drive and to give suggestions for improving current driving training. Furthermore, they indicated their perceived impact of specific characteristics often associated with ASD on their ability to drive. The results show that young persons with ASD have a good knowledge of traffic rules, experience difficulties in violating traffic rules when necessary, as well as with multitasking and responding to unpredictable situations, and display perfectionism. Moreover, they show a need for structure and more – but shorter – lessons. Driving instructors consistently perceived the impact of ASD-related characteristics higher than the other respondents. Several proposals for adjusting driving training were made which suggests the need for more systematic research and the propagation of new training methodologies. Finally, we highlight the need for an increase of attention, as well as of means and resources for research on certain groups such as ASD in transportation.*

KEYWORDS: *awareness raising; autism spectrum disorder; driver training.*

1. INTRODUCTION

Half a decade ago, Gössling (2013) argued that mental diagnoses are a dimension that has so far been largely overlooked in studies of transport behaviour and mobility consumption. Mental diagnoses include, for instance, anxiety, mood disorders, substance abuse and personality disorders, each of which affects only up to a few per cent of the population in industrialised countries. However, together, clinical groups influence large parts of the population and we need to know how they affect understanding, evaluation, and the use of transport modes (Gössling, 2013). For that reason, we investigated the impact of autism spectrum disorder (ASD)[1] on learning to drive. Individuals with ASD often exhibit a number of cognitive symptoms and patterns of behaviour such as core social communication and behavioural deficits as well as poor motor coordination, weak central coherence and executive functioning weakness. Additionally, certain comorbid medical symptoms are more likely to occur in individuals on the spectrum (Brooks et al., 2016). Despite a recent upsurge, we believe that the field of transportation could invest more attention, means, and resources, to research into groups such as ASD. Indeed, one important barrier is the obtainment of funding for this type of research, which is partly caused due to the fact that such research is situated at the intersection of transportation and psychology. Both fields have their own priorities, for instance, vehicle technology, autonomous driving, elderly drivers, etc. on the one hand, and early identification, transition phases, and treatment on the other hand. Therefore, it can be hard to convince policy makers and

funding channels of the importance of research in this domain. Nevertheless, driving and independent mobility also contribute to the quality of life. Moreover, we believe it to be essential that the voices from the group itself are included in this type of research. Therefore, with the current article, we aim to raise attention to research into certain groups in the field of transportation, based on a case study investigating the process of learning how to drive for young persons with ASD, in which the opinions of persons with ASD are also included.

1.1 ASD symptoms and their relation to driving

ASD is one of the most commonly reported neurodevelopmental disorders. Recently, the Centres for Disease Control and Prevention (CDC) in the US increased the estimates of the prevalence for ASD with 15 percent, affecting 1 in 59 children aged 8 years. Although they stress that these findings may not be generalizable to all children aged 8 years since the test sites do not provide a representative sample of the entire US (Baio et al., 2018). An ASD diagnosis is based on official systems such as the American Psychiatric Association's Diagnostic and Statistical Manual of Mental of Disorders (DSM). The DSM was last updated from DSM-IV (i.e., from 1994) to DSM-V in 2013. A big change in the ASD diagnosis consisted of the removal of ASD subtypes (e.g., Asperger). Instead, the DSM-V identifies specific ASD-related characteristics together with non-ASD specific characteristics, which both vary in people with ASD. Therefore, we speak of a spectrum, indicating a broad range of people with autism, all with varying ASD (and non-ASD related) characteristics. In addition, the triad of symptoms from the DSM-IV (i.e., relating to social communication, social interaction, and social imagination) considered communication deficits separately from social impairments and language difficulties. The DSM-V, however, speaks of two domains, where the ASD-specific symptoms only relate to social-communication deficits and restricted and repetitive interests/behaviours. The DSM-V includes specifiers, rather than subtypes. These specifiers indicate non-ASD characteristics such as, for instance, known ethology (e.g., genetic syndrome, or environmental exposure), intellectual impairment, and language impairment (Volkmar & McPartland, 2014).

As individuals with ASD transition into adulthood, they are expected to integrate into the community and participate in educational, vocational and social experiences (Chee et al., 2017). Independent driving can be a prime facilitator for the engagement in that type of activities (Brooks et al., 2016; Chee et al., 2015; Almberg et al., 2017; Wade et al., 2017). However, a recent retrospective cohort study including the US Children's Hospital of Philadelphia healthcare network patients, with 609 patients with ASD indicated that by the age of 21,one in three adolescents with ASD acquired a driving license, in contrast to 83.5% of neurotypical adolescents. In addition, they obtained their licence at a later point in time (i.e., 9.2 months according to the median) (Curry, Yerys, Huang, & Metzger, 2017). Driving is a complex and goal-directed activity, which consists of different parallel subtasks that have to be alternated smoothly (e.g., changing gears, steering, lane changing, and giving way). One also has to adapt to changing environments (e.g., heavy traffic, weather circumstances). The driving task is dependent on perceptual and motor skills, e.g., to assess distances and to plan motor actions (Bouillon, Mazer & Gelinas, 2006; Kirby, Sugden, & Edwards, 2011). Driving also requires executive functions, a set of cognitive processes that support goal-directed behaviour (Best & Miller, 2010) and allow control over behaviour and emotions (Dahl, 2008). Specific ASD symptoms can interfere with learning to drive and with driving itself. For instance, visual information processing problems, and a limited ability to understand and predict the behaviour of other individuals, may lead to problems with respect to hazard perception (Sheppard, Ropar, Underwood, & van Loon, 2010; Zalla, Sav, Stopin, Ahade, & Leboyer, 2009). Another symptom consists of motor problems. A former study indicated that ASD was associated with an atypical motor development, i.e., a similar performance at a young age increasingly deteriorated when developing into adolescence and young adulthood. Furthermore, manual motor performance is related to daily living skills (Travers et al., 2016). Driving is a skill that is learned in adolescence or young adulthood that also requires motor control (e.g., shifting gears, steering) and therefore, motor problems may interfere with driving. Moreover, according to a recent meta-analysis, executive dysfunction, or reduced cognitive control, is not only present in ASD, but is also stable across development (Demetriou et al., 2018), which may lead to disturbances in driving such as slowed driving style or stress while driving. Finally, increased rule-boundedness (Jameel, Vyas, Bellesi, Cassell, & Channon, 2015) can have positive

effects (e.g., fewer violations), but in case of rigidity and lack of flexibility, it can also have negative effects (e.g., unwillingness/inability to cross a full white line in order to avoid an obstacle).

1.2 Research on ASD and driving

Past studies on the driving behaviour of young persons with ASD already revealed some difficulties. Some of these studies related driving to executive functioning (Classen et al., 2013; Cox et al., 2016; Daly et al., 2014; Chee, Lee, Patomella, & Falkmer, 2017, Ross et al., In review). For instance, Classen et al. (2013b) and Daly et al. (2014) linked increased driving errors (e.g., speed regulation, lane maintenance) to executive functioning difficulties (e.g., selective and divided attention) in both pre-licensed and licensed adolescents with ASD. Moreover, in the latter study, licensed adults with ASD considered themselves 'poor drivers' and reported they committed more driving errors than non-ASD participants. As another example, Cox et al. (2016), showed a different response to working memory load induced by a dual task in an ASD sample aged 15 to 23 years old. Increased working memory demands resulted in decreased steering and braking performance in the ASD group, whereas it increased steering and braking performance in the control group during a simulated drive. In the United Kingdom, the hazard perception of persons with ASD was studied by means of traffic videos. Participants with ASD identified fewer social hazards than non-ASD participants. However, this was not the case for non-social hazards. Additionally, participants with ASD were slower to respond to hazards compared to non-ASD participants (Sheppard et al. 2010). A follow-up eye-tracking study showed that the differences between ASD and non-ASD participants manifested itself in the orientation of attention to driving hazards, rather than the detection of hazards itself. Looking at autistic traits, independent of a diagnosis of ASD, those with high autistic traits oriented their attention slower towards road hazards. Once hazards were fixated, responses were equally fast between ASD and non-ASD participants. Differences between social and non-social hazards were not replicated. Finally, participants with lower verbal IQ narrowed their spread of search more than those of higher IQ, possibly due to less attentional resources (Sheppard et al., 2017). In a study carried out in the United States a driving simulator and eye-tracking system were used to study the driving behaviour of young persons with ASD. The participants were tested in situations with and without distraction. The results showed that young persons with ASD tended to orient themselves towards the horizon (e.g., above active parts of the roadway scene), while control persons oriented themselves towards objects low in the visual field, e.g., dashboard, lead and oncoming vehicles. ASD participants displayed a higher heart rate compared to the control groups, although this did not reach significance. According to the authors, this could indicate an increased level of stress and anxiety in the ASD group. In situations where added cognitive demands were required, their heart rate was unvaried, compared to the control group, which showed typical arousal and recovery. Moreover, they also showed gaze patterns suggestive of a diversion of visual attention away from high stimulus areas of the roadway, which was not found in the control group. This pattern deviates from what is presumed to be optimal safe driving behaviour (Reimer et al., 2013). In support of potential anxiety when (learning how to) driving, Chee et al. (2015) revealed different driver profiles in ASD. Some drivers with ASD perceived themselves to be confident and independent whereas other drivers preferred different transportation modes (e.g., public transport and walking). Anxiety was one of the barriers to driving. Furthermore, in a simulated driving pilot study, Wade et al. (2014) found that ASD adolescent drivers had higher skin conductance levels and skin conductance response rates, compared to a neurotypical group. Ross et al. (2018), employed the Driving Attitude Scale Parent-Report (DAS-PR) as an indication of driving apprehension. Responses were compared for the parents of 66 novice drivers with ASD and 166 neurotypical novice drivers. After three months of various driver trainings for ASD drivers, 60 of the 66 parents completed the DAS-PR again. The parent responses indicated that novice ASD drivers displayed more negative, and less positive, attitudes towards driving at baseline than the neurotypical drivers. These attitudes improved after the driving simulator training, albeit not up to the level of the neurotypical control group. These results indicated apprehensive driving, which may interfere with (safe) driving (Ross et al., 2018).

1.3 ASD and learning how to drive

It is clear that ASD symptoms not only affect driving behaviour itself, but also the process of learning to

drive (driving training) (Cox et al., 2017). Cox et al. (2012) surveyed parents/caregivers of young persons with ASD who were attempting, or had previously attempted, to learn to drive. The survey contained questions related to reasons for current driving status, driving experiences, the relation between ASD and driving, as well as teaching strategies (i.e., effective and ineffective) for the process of learning young persons with ASD to drive. Results showed that, compared to relatively easy driving skills such as maintaining lane position, complex driving skills such as merging into traffic or multi-tasking, were reported as problematic for young persons with ASD. Ross et al. (2015) extended on Cox et al. (2012) by surveying driving instructors as they are important sources of information that might be complementary to the opinion of parents/caregivers by more objectively reflecting on the teaching process. Tyler (2013) also focused on the experiences of driving instructors who teach young persons with ASD. These instructors highlighted several educational issues in persons with ASD. The impairment of social skills can lead to misunderstanding and poor communication during driving lessons. Pupils with ASD may have a limited ability to 'read' facial expression and gestures and some will often look down or avert their gaze to avoid eye contact. For driving instructors, this can impair their ability to gain feedback on the level of effective learning taking place. Therefore, other means of getting feedback have to be found. Direct communication, where all connotations and double meanings are removed, works well for pupils with ASD. If the communication is not direct, pupils with ASD may focus on understanding the mystery behind the instructor's comment, rather than on the actual task of driving. The main aim of a driving instructor is to develop a bond with pupils with ASD, but also to keep their primary focus on driving and to teach them to identify possible and actual dangers. Pupils with ASD are limited in their ability to take in more than one piece of information at a time and are more likely to fixate on a smaller detail and analyse this rather than see the overall context of that detail within the larger picture. When pupils with ASD are overloaded with input, their coping switch overloads, thus creating fear, frustration, anger and/or stress issues. At this point, intervention by a trained instructor is required in order to stop driving and refocus on the task through appropriate methods (Tyler, 2013). In summary, pupils with ASD will generally take longer to complete driving training (also observed by Curry et al., 2017) because they need to learn coping strategies and develop social communication skills on top of driving skills. It is necessary to teach pupils with ASD all the road regulations, gestures and courtesies in driving; even the ones not listed in the books, which neurotypical drivers may understand more easily. The ultimate goal for this research is to adjust driving training and testing in such a way to equip these road users sufficiently with the necessary skills to ensure their own safety as well as that of other road users (Tyler, 2013).

Several authors indicated the need for further exploration of concrete facilitators and barriers to driving training and the success rates of young persons with ASD (e.g., Almberg et al., 2017; Cox et al., 2016). Further support mechanisms and specific training courses are needed to help increase education for parents, young persons and driving instructors (Lindsay, 2017; Tyler, 2013). Silvi, Scott-Parker and Jones (2017) point to the possible use of the GADGET-matrix (Guarding Automobile Drivers through Guidance Education and Technology) (Hatakka et al., 2002). The ability to break down different driving skills and techniques within each level of GADGET positions it as a prospective, advantageous driver-training method for drivers with ASD, as it may be adapted to ASD-related characteristics and comorbidities. To be able to do this, a general understanding of the challenges experienced by drivers with ASD during their learning and driving experiences is necessary. This understanding can be build up by combining information of young persons with ASD themselves, their parents or caregivers and driving instructors (Lindsay, 2017; Ross et al., 2015).

2. RESEARCH QUESTIONS

In the current article, we aim to explore the experiences of the process of learning to drive of young persons with ASD for all three groups involved, namely young persons with ASD themselves, parents/caregivers and driving instructors.

Specific research questions are:

1. Which barriers do young persons with ASD and people who teach them experience when learning to drive?
2. Which support mechanisms are needed by young persons with ASD and people who teach them when learning to drive?

3. METHOD

The current article describes an exploratory study, by examining opinions regarding ASD and driving of three different target groups that were collected in three different projects. The respondents of the three groups did not have an interrelationship. This means that the questionnaire for the parents/caregivers dealt with other young persons than the one for the driving instructors, which in turn dealt with other young persons than the questionnaire for the young persons with ASD themselves. Moreover, slightly different questionnaires were used for all three target groups. We focused on information that was provided in all questionnaires, in order to provide an exploratory view on different viewpoints of the young persons themselves, parents and driving instructors.

3.1. Questionnaires

The data was collected during three different studies belonging to the 'Yes I Drive' project in Flanders, Belgium. The questionnaire for the persons with ASD was collected during a driving simulation study investigating the relationship between executive functioning and driving errors, executed at Hasselt University's Transportation Research Institute (Ross et al., In review). Participants in this study brought an official ASD diagnosis form to the test site. The questionnaire for the parents was collected during a master thesis project of Hasselt University's Faculty of Rehabilitation Sciences in collaboration with the Transportation Research Institue, IMOB, Hasselt University. It consisted of a weblink that was distributed via ASD support groups/blogs/social media. Finally, the questionnaire for the driving instructors was collected as part of a PhD project of Hasselt University's Transportation Research Institute by sending a weblink to driving schools (Ross, 2016). Part of this data (i.e., of 52 driving instructors) was presented at the 8th Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design (Ross et al., 2015). Each questionnaire consisted of both open-ended and closed-response questions. Each questionnaire also contained demographic data (e.g., age, sex and driving experience). From each questionnaire, similar topics and questions were extracted, which are detailed later in this article.

3.2. Respondents

3.2.1. Young persons

For this questionnaire, we initially had 21 respondents, but the data was only complete for 20 of those. Of the sample, 66.7% was male and the average age was 20.45 (SD: 2.96). At the time when the questionnaire was filled in, all of the respondents had a (provisional) driving licence since at least 1 month to at most 37 months (average: 12.53; SD: 10.09). 7 young persons, had driving lessons at the driving school, 5 young persons were trained by others (e.g., family members) and the remaining 8 young persons combined lessons at the driving school with training by others.

3.2.2. Parents/caregivers

For this questionnaire there were 29 respondents: 1 father, 1 ambulatory assistant and 27 mothers. They based their answers on 6 girls and 23 boys, ranging in age from 17 to 25 (average: 21.21; SD: 2.569). 14 young persons already had a permanent driving licence and this for an average period of 18.7 months, while 11 young persons had a provisional licence for an average period of 18.6 months. 3 other young persons were trying to obtain a provisional licence at the time of the questionnaire. 4 young persons were taking driving lessons at the driving school, 8 young persons were being trained by others and 16 young persons had a combination of the two systems.

3.2.3. Driving instructors

This questionnaire was submitted to driving instructors of different driving schools in Flanders. 79 of them answered it satisfactorily, which is a considerably higher number than that of the young persons or the parents. Of the 79 driving instructors, 55 had given driving lessons to a young person with ASD at least once. The 24 other driving instructors indicated they educated young persons with specific characteristics that could possibly be indicative of ASD. These instructors were removed from the study because of possible misunderstandings about the characteristics of ASD. The 55 remaining driving instructors had a teaching experience of at least 1 to at most 37 years (average: 14.84; SD: 9.402) and were between 18 and 65 years of age (average: 48.11; SD: 9.668). The majority (approx. 80%) was male.

3.3. Questions

The questions were based on previous research (i.e., Cox et al., 2012) and on the input of different experts in Belgium, i.e., Dr Mark Tant (expertise: Fitness to Drive; VIAS, CARA), Dr Peter Vermeulen (expertise: ASD; Autisme Centraal), Prof dr Marleen Vanvuchelen (expertise: ASD; UHasselt, Faculty of Rehabilitation Sciences), and Dr Ellen Jongen/Dr

Veerle Ross (expertise: traffic safety and psychology; UHasselt, Transportation Research Institute).

3.3.1. Open-ended questions

When reporting the results, we will show the specific open-ended questions in the way they were presented to the studied group. When a combination of questions offers useful information, this will also be shown. Input will only be reported if the same or a similar answer to a question (or a combination of questions) is given at least twice in the specific group. For the group of driving instructors, a minimum of 3 equal or similar answers is needed, because of the higher number of respondents in this group.

3.3.2. Closed-response questions

These questions describe possible perceptual, motor and cognitive characteristics of ASD and were based on earlier research (Cox et al., 2012). More specifically, they are about motor planning, multitasking, concentration and attention, predicting the behaviour of other road users, emotional self-regulation, generalizing information, tolerating unexpected changes in routine, tolerating others' violation of rules, violation of rules when necessary, and sensory overload. The questions deal with the experienced impact of these characteristics on the process of learning to drive. Not every questionnaire dealt with each characteristic in the same way. In the questionnaires for parents/caregivers and for driving instructors, the characteristics were queried directly. In the group of young persons, this is not the case for every characteristic. The questionnaires for the latter group contained questions that - in combination with each other - give a good approximation of some of the characteristics. For these questions, averages are given of the responses for characteristics that were not queried directly. More specifically, the following questions were combined to get a picture of the characteristics:

Motor planning:
- To what extent did/do you have trouble starting the car and departing when learning to drive?
- To what extent did/do you have trouble steering when learning to drive?
- To what extent did/do you have trouble accelerating when learning to drive?
- To what extent did/do you have trouble braking when learning to drive?
- To what extent did/do you have trouble changing gears when learning to drive?

Concentration and attention:
- To what extent do you experience problems driving in busy cities?
- To what extent do you experience problems driving long distances (driving for longer than 2 hours continuously)?

Predicting the behaviour of other road users:
- To what extent did/do you have trouble establishing contact with other road users in order to apply traffic rules and because of safety concerns (e.g., to gesture to a pedestrian that he has right of way and can cross the road) when learning to drive?
- To what extent did/do you have trouble predicting the behaviour of other road users interpreting signals they give to you (e.g., flashing lights or hand gestures) when learning to drive?
- To what extent did/do you have trouble predicting the behaviour of other road users without them signalling anything, when learning to drive?

Emotional self-regulation:
- To what extent do you experience fear or panic when you are driving?
- To what extent do you experience anger or rage when you are driving?

The answers were given on a 5-point Likert scale, from 1 to 5 for the young persons and driver instructors, and from 0 to 4 for the parents/caregivers. To make them comparable, 1 point was added to each answer of the parents. The higher the score, the higher the impact of the characteristic on the process of learning to drive.

4. RESULTS

4.1. Open-ended questions

4.1.1. Negative aspects for young persons with ASD when learning to drive

Young persons
- According to you, what are negative aspects of your autism spectrum disorder when learning to drive?
- Do you feel you have to make extra efforts to learn to drive in comparison to your peers? Explain the reasons.

According to the young respondents, multitasking is the most common problem when learning to drive. Some young persons indicated to experience a lot of stress. Furthermore, assessing situations and reacting to unpredictable situations was sometimes mentioned, especially when the traffic rules have to be violated. Some young persons also indicated that they need more time compared to their peers, suffer from a loss of concentration and have trouble following instructions. However, a lot of young persons did not answer the question concerning the extra efforts in comparison to their peers.

Parents/caregivers

- Does the autism spectrum disorder of your son/daughter have a negative impact on his/her driving experience? Explain.
- Which were the most and least useful strategies or exercises that helped your children with an autism spectrum disorder during the process of learning to drive?

Most of the parents indicated that extra time and patience is needed in their children's process of learning to drive and obtaining their driving licence. Some parents indicated that their child reacts and/or drives slower. Furthermore, assessing situations and anticipating to other traffic is a problem for their children. Some parents were quite well-prepared for the driving lessons, because of their children's problems with following instructions. Some indicated to use the same route all the time or to experience difficulties when driving along a new route. Some parents indicated to reduce the duration of their lessons because of a loss of concentration. Finally, a lack of motivation was mentioned when their son/daughter was not convinced of the benefit of having a driving licence.

Driving instructors

- What is striking in young persons with an autism spectrum disorder when they learn to drive?
- What are the needs that young persons with an autism spectrum disorder have in order to learn to drive?

The most important answer here is the difficulty with regard to communication (to assimilate information and/or instructions). Many agreed that young persons with ASD need more time, with ideally shorter lessons or more frequent breaks. Furthermore, some driving instructors prepare the lessons more carefully and make sure that there is more structure. A good link between the pupil's confidence, the driving instructor, and the vehicle helps to overcome many difficulties. Driving instructors also reported difficulties with their pupils' ability to multitask (some of them recommended the use of an automatic gearbox), a loss of concentration, difficulties handling unexpected situations and difficulties with the possible necessity of having to ignore traffic rules. Finally, instructors mentioned the negative impact of perfectionism on their pupils (e.g., difficulty in handling situations that cannot be approached as planned, they want to do it perfectly).

4.1.2. Positive aspects for young persons with ASD when learning to drive

Young persons

- According to you, what are positive aspects of your autism spectrum disorder when learning to drive?

The most recurrent positive aspect is a good memory and the application of traffic rules. The ability to concentrate and being attentive to small details were also mentioned several times. Finally, some young persons indicated that they do not see any positive aspects.

Parents/caregivers

- Does your son/daughter with an autism spectrum disorder have strengths that contribute to his/her driving ability? Explain.

Similar to the young respondents, parents also mentioned their children's good knowledge of traffic rules. A good concentration is also mentioned, as well as the ability to keep calm and a strong motivation to learn. Here also, some respondents did not see any positive aspects.

Driving instructors

- Do you notice strengths in young persons with an autism spectrum disorder when driving?

Some driving instructors indicated that the young persons with ASD pay close attention to instructions and do as asked. An equal number of respondents did not notice any positive aspects. Some respondents mentioned a good application of the traffic rules and some mentioned their pupils' strong motivation to learn and a good concentration.

4.1.3. Adjustments to the driving lessons

The questionnaire of the young persons with ASD did not contain any questions about suggestions for driving lessons or examination.

Parents/caregivers

- Do you have additional remarks and suggestions for the driving lessons of persons with an autism spectrum disorder? Explain.

The most important suggestion is the importance of a good driving instructor. This should always be the same person and he/she should be aware of the impact of ASD. The use of an automatic gearbox for persons with ASD who are learning to drive was also mentioned.

- Do you have additional remarks and suggestions with regard to examining the driving ability of persons with an autism spectrum disorder? Explain.

The examiner and others in the car should not talk about anything other than the required instructions. Furthermore, the need for a good preparation of the examiner before the exam is mentioned, in order to let the pupil know exactly what to expect.

- Would it have been helpful for your son/daughter with an autism spectrum disorder to train driving skills in a driving simulator (like a flight simulator during pilot training) before entering public roads? Explain.

Almost half of all respondents answered yes to this question. They explained that it would be safer in comparison to entering public roads immediately and it was also considered easier. Pupils would be better able to estimate the consequences of their driving behaviour. However, other respondents argued that a driving simulator is not sufficiently realistic.

Driving instructors

- How can present-day driving lessons be adjusted to meet the needs of young persons with an autism spectrum disorder?

The most frequently mentioned suggestion is a better training of the driving instructors themselves, so they can interact with pupils with ASD. Some respondents were in favour of driving lessons specifically tailored to pupils with ASD. Another recurrent suggestion made by the respondents is a special, reduced price for driving lessons for persons with ASD, because of the extra hours needed to attain the same level as neurotypical pupil drivers. Some driving instructors indicated they want to consult with the parents, possibly even carry out driving lessons together with a parent. The need for shorter lessons, extra attention to structure and the same driving instructor all the time were also mentioned. Finally, the possible implementation of an automatic gearbox was mentioned.

4.1.4. Familiarity with CARA (Centre for Driving Ability and Vehicle Adjustment)

In Belgium, CARA is a legally approved supervisory institution for driving ability. People who suffer from reduced functional abilities that could have an impact on how safely they can operate a motor vehicle, can contact the institution. Composed of a multidisciplinary team of physicians, psychologists and road experts, CARA assesses the conditions and restrictions in people's ability to drive and proposes potential changes to adapt their cars.

Familiarity with CARA was only part of the questionnaire of the group of parents/caregivers.

- Are you familiar with the service of the Centre for Driving Ability and Vehicle Adjustment (CARA) which evaluates the impact of a medical condition on driving behaviour?

3 respondents (10.3%) were aware of the existence of CARA, 1 of them had already contacted the institution.

4.2. Closed-response questions

In Table 1, results for the different groups of respondents are presented. The driving instructors gave all but 2 characteristics a score that is higher than the average for all groups (average = 3). They give the highest impact score for emotional self-regulation and difficulty with tolerating unexpected changes in routine. In the group of parents/caregivers and in the young persons group, the scores are systematically lower. The highest score in the group of parents/caregivers is also for emotional self-regulation. Furthermore, difficulties with tolerating others' violation of rules and tolerating unexpected changes in routine obtain high scores. Driving instructors and parents/

caregivers seem to share similar experiences. The young persons gave the highest impact score for multitasking and the lowest for emotional self-regulation. The latter is in contrast to the scores of the parents/caregivers and those of the driving instructors.

Characteristics for which we have data in all groups of respondents are visually presented in Figure 1.

Because of the lack of interrelationship between the different groups of respondents and the differences in sample sizes, a statistical comparison of the scores in the different groups is not meaningful. But the same kind of research, with groups of interrelated young persons, their own parents and their driving instructors, is a next step in gaining insight in the experienced impact of characteristics of ASD on the process of learning to drive. We only present the results for the three groups together to show the importance of collecting experiences of all groups involved

Table 1: Impact of specific characteristics of ASD on the process of learning to drive

	Young persons			Parents/caregivers			Driving instructors		
Characteristic	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Motor planning	20	2.33	0.69	28	2.14	1.38	54	2.98	1.04
Multitasking	20	3.15	0.99	28	2.75	1.38	55	3.56	1.07
Concentration and attention	20	2.88	1.00	28	3.07	1.18	55	3.80	1.03
Predicting the behaviour of other road users	20	2.62	0.84	28	3.18	1.06	53	3.83	0.96
Emotional self-regulation	20	2.08	0.71	28	3.64	1.31	55	4.11	0.98
Generalizing information	n/a	n/a	n/a	28	2.86	1.46	55	3.69	0.98
Tolerating unexpected changes in routine	n/a	n/a	n/a	28	3.14	1.48	54	4.00	0.95
Tolerating others' violation of rules	n/a	n/a	n/a	27	3.52	1.31	52	3.63	1.21
Sensory overload	20	2.50	1.15	27	2.15	1.13	52	2.94	0.98
Violation of rules when necessary	20	2.45	1.28	n/a	n/a	n/a	53	3.38	1.18

1= no impact, 5= high impact, n/a=not applicable

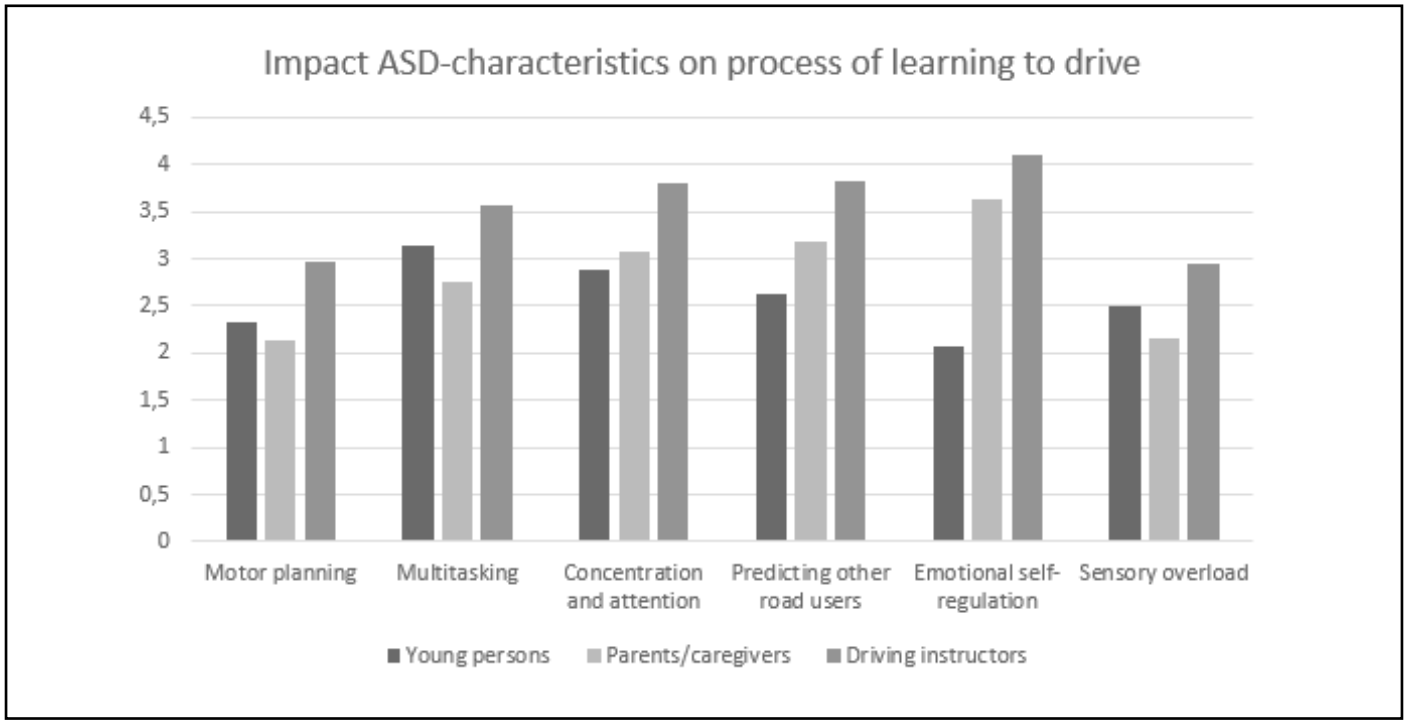

Figure 1: Impact of characteristics of ASD on the process of learning to drive, according to different respondents

in the process of learning to drive. Restriction to just one group of respondents likely gives an incomplete picture of the situation.

5. DISCUSSION

5.1. Experiences during the process of learning to drive

The barriers in the process of learning to drive due to ASD that were most frequently mentioned in the open-ended questions are: problems with multitasking, reacting to unpredicted situations, violating traffic rules when necessary, communication and perfectionism. Furthermore, parents/caregivers and driving instructors of young persons with ASD report the need for structure in driving lessons, and more frequent (because of tardiness in the learning process) but shorter (because of problems with concentration) lessons. This corresponds with the results of earlier research (Almberg et al., 2017; Cox et al., 2012). Not all respondents were able to indicate facilitators resulting from ASD. The most recurring facilitators are: a good memory, a good knowledge and application of traffic rules, attention and concentration, and motivation.

The above-mentioned results show that experiences with regard to characteristics of ASD vary between respondents. Concentration for instance, is sometimes mentioned as a facilitator in the process of learning to drive and as a barrier by others. These opposite experiences mostly occur in the groups of parents/caregivers and of driving instructors. They might be attributed to differences in the specific young persons that are assessed by specific parents and driving instructors. Because of the spectrum diagnosis of autism, young persons in this group do vary in characteristics related to ASD as well as in individual characteristics such as personality, intelligence etc. (Ross et al., 2015). Furthermore, the personal appreciation of characteristics can also play a role in opposite experiences. A good knowledge and application of traffic rules seems to be a strength of persons with ASD that is experienced by all respondents. This fact was confirmed by Chee et al. (2017) in an on-road driving study. Drivers with ASD performed better with regard to abilities related to traffic rules (e.g., use of indicators), but they performed worse in manoeuvring/operating the vehicle.

When linking the open-ended with the closed-response questions, some barriers from the former were confirmed in the latter. For instance, all groups appeared to indicate that multitasking can be an issue for persons with ASD. This constitutes a problem since driving inevitably requires multitasking. For instance, checking your mirror to keep track of surrounding vehicles while steering and shifting gears in order to take a turn. Considering the recent upsurge in technology (e.g., GPS), this may cause difficulties when persons with ASD need to combine driving with a secondary task such as finding their way.

When considering the closed-response questions, the responses between the groups seemed to differ per characteristic. This was especially evident with regard to emotional self-regulation, which scored much lower in the group of persons with ASD. Emotion regulation has already been proposed by Mazefskya & White (2014) to be a likely issue in ASD, being a factor in the production of aberrant behaviour. However, emotion regulation can apply to different concepts, e.g., conscious or unconscious, response-focused (e.g., telling yourself to calm down) or antecedent-focused (preceding the emotion) (Mazefskya & White, 2014). The current questionnaire did not distinguish between these concepts, possibly causing different interpretations between groups. Also related to different viewpoints, driving instructors indicated the highest impact for all characteristics, compared to parents/caregivers and young persons with ASD themselves. Because driving instructors are experts in the field of driving behaviour, we can intuitively comprehend this result. But it could also be the case that the pupils reported about by the driver instructors in our study are more impacted by the characteristics of ASD than the pupils in the group of parents/caregivers and of young persons with ASD. However, these are speculations at best since, in the current study, it is difficult to draw conclusions regarding group comparisons.

5.2. Adjustments to the driving lessons

Driving instructors as well as parents/caregivers indicated the need for shorter lessons for young persons with ASD. Furthermore, they indicated that young persons with ASD need more time to bring the driving lessons to a successful conclusion. Because of the extra costs of additional lessons, the suggestion for financial support was put forward. The coupling of a single driving instructor to a pupil with ASD allows the creation of an important link of confidence. Ideally, also the same vehicle is used for all lessons.

Some of our driving instructor respondents were in favour of specific driving lessons tailored to persons with ASD. Today, not all driving instructors are informed about ASD. However, driving instructors can be seen as key players in the development of safe driving skills and attitudes (Bartl et al., 2005; Boccara, Vidal-Gomel, Rogalski, & Delhomme, 2015). Therefore, driving instructors are very important to help learner drivers with ASD to overcome potential difficulties such as those described above, already during the learning phase. Thus, systematic education about the characteristics of ASD and their impact on driving lessons is certainly useful. Especially because parents indicated the need to look for driving instructors who are aware of the characteristics of ASD. Concepts and symptoms related to ASD should be included in such educational programs. For instance, symptoms such as context blindness (i.e., reduced spontaneous use of context, Vermeulen 2015), potential co-morbidities and their additional complications, etc. Furthermore, when dealing with ASD, the general literature prescribes the use of structure, overview, clarity, imagery, concreteness, etc. for persons with ASD (Cox et al. 2012; Vermeulen, 2013). Therefore, the education of driving instructors should not only raise awareness of the characteristics of ASD, but it should also provide them with clear guidelines on the practical approach and teaching instructions of driving lessons, e.g., how to communicate, how to refocus a pupil that is distracted, how to relieve fear etc.

Finally, almost 50% of the parents/caregivers in the study indicated to be interested in the introduction of a driving simulator for the driving lessons. Cox and colleagues (2017) describe several befits that driving simulation may offer to persons with ASD, i.e., repetition in a safe and controlled environment, a naturalistic setting, a visual world, the inclusion of different scenarios that lead to generalization of learned abilities, an individualized method, computer interaction, less boredom or fatigue, and the potential inclusion of eye-tracking. Therefore, driving simulator lessons could be useful for learner drivers with ASD.

All recommendations and support mechanisms mentioned above could be integrated in new methodologies to accommodate the learning needs of persons with ASD. These methodologies should subsequently be propagated in driving schools and within groups of other people instructing young persons with ASD. In Belgium, an institution like CARA could play an important role in this process. When specific methodologies and procedures are in place to support young persons with ASD, this could also enhance the number of positive decisions concerning the pursuit of a driving licence. At present, research suggests that there may be an important discrepancy between a strong interest in driving and relatively lower licensure rates among adolescents with ASD (Curry et al., 2017).

5.3 Future research

Future experimental research can focus on the difficulties that arose in this study, for instance, by investigating the use of technology, such as hands-free phoning or GPS-use, while driving to measure issues with multitasking. Importantly, further qualitative research should include triads of interrelated persons (persons with ASD – parents – driving instructors). By doing so, the potential group differences (e.g., issues with emotional self-regulation) found in the current study can either be confirmed, or rejected. After that, a next step forward in gaining insight in barriers and facilitators in the process of learning to drive could be a more systematic inventory of the characteristics that hamper or facilitate the process of learning to drive. Silvi, Scott-Parker and Jones (2017) suggest to use a framework like GADGET (Hatakka et al., 2002). In this framework, Knowledge, Risks and Self-evaluation on 4 levels of traffic behaviour result in a 3x4 matrix, wherein the driving task can be deconstructed in essential parts. The barriers and facilitators for persons with ASD could be incorporated in this matrix as well.

Other studies may want to focus on the specific recommendations that were provided. Internationally, some attention has been given to the development of educational modules for driving instructors to learn how to deal with ASD learner drivers. Especially in the Netherlands, one can find several driving schools with a distinct approach for ASD learner drivers. This trend is also starting to develop in Belgium. However, to the best of our knowledge, effect evaluations and the follow-up of such programmes are missing. Another recommendation consisted of the inclusion of driving simulators in the driving curriculum of persons with ASD. Driving simulators were already successfully tested for persons with ASD. Brooks et al. (2016) used a driving simulator to train the motor abilities (e.g., use of pedals, steering) of persons with ASD. Wade and colleagues (2017)

assembled an adaptive driving simulator system for assessment and training purposes, and already published a pilot study where they relate visual attention to simulated driving performance. More specifically, in one study, they found more turning-related driving errors in an ASD young driver sample, compared to a neurotypical control group. In a second study, they found that simulated driving performance improved using both performance-based feedback and combined performance- and gaze-sensitive feedback (Wade et al., 2017). Another group tested the ability of a driving simulator to enhance driving performance and cognitive abilities related to driving in the process of learning to drive (Cox et al., 2017). In the latter study, not only the abilities of the participants improved, but also the positive attitudes towards driving did, as reported by their parents. Because of the explorative nature of the studies, more research is needed in the use of driving simulators in the process of learning to drive of young persons with ASD.

The final recommendations relate to the questionnaire that was used. First, the open-ended and closed-response questions were not related to each other, making it more difficult to compare the results. A better approach would be to base both parts on the exact same concepts, so that the results can be linked. That way, the closed-response questions would be a measure of severity or magnitude, while the open-ended questions provide more in-depth information. Furthermore, we based the content of the questionnaire on previous literature and the input from experts in different domains. A different approach would be to base it on interviews with the target populations (i.e., persons with ASD, parents/caregivers, and driving instructors). This could provide additional in-depth insight into the matter.

6. LIMITATIONS

Firstly, we have to mention some reservations concerning the use of questionnaires and self-reporting. While this technique was used before (e.g., by Camarena & Sarigiani, 2009) to assess the aspirations and thoughts of adolescents with ASD and their parents, we should take into account some of its limitations. Questionnaires not only encompass the risk of response bias because of socially desirable behaviour and of gaps in memory. Questions might also be misread or misinterpreted. But another fundamental consideration is to what extent young persons with ASD are able to reflect on their situation and the problems in their learning process. According to Grainger, Williams and Lind (2016), there is now reasonably consistent evidence that individuals with ASD manifest high rates of alexithymia (the inability to accurately identify and describe one's own emotions), and show a diminished performance in self-versions of classic mindreading tasks. The authors acknowledge however, that very little is known about the extent to which individuals with ASD are able to monitor other aspects of cognitive activity in themselves. In their study, they focused on metacognitive monitoring, more specifically the ability to monitor what information they already know and what they still need to learn. They found that individuals with ASD were equally good at making accurate assessments of learning as neurotypical individuals. So, while some aspects of cognitive activity (emotions) may be monitored inaccurately, other aspects (learning) seem to be assessed correctly by individuals with ASD. Knowing this, a question that remains is the extent to which the difficulties in the process of learning to drive of the young persons with ASD are caused by their disorder, and not just by the inexperience that all novice drivers face. To answer this question, experiences of young drivers without ASD should be included in future research. In the present research, the respondents with the best insight into this issue are the driving instructors, because of their experience in training pupils with and without ASD. But since we are also specifically interested in the experience of the young persons themselves, a group of other young persons is necessary.

Secondly, our study was based on 3 questionnaires. There were 20 respondents in the group of young persons, 29 in the group of parents/caregivers and 55 in the group of driving instructors. Especially in the case of young persons and parents/caregivers, these numbers are rather low and therefore a less accurate basis for drawing firm conclusions. Furthermore, we did not take into account possible effects or trade-offs of additional conditions and dysfunctions (e.g., ADHD). In addition, with regard to the diagnosis, we were only able to actually verify the diagnosis of the ASD group (i.e., via the diagnosis form). Respondents (i.e., parents/caregivers and driving instructors) to the online questionnaires indicated at the beginning of the questionnaire whether they were parents/caregivers of or driver instructors to young adults with an ASD diagnosis. We acknowledge that this recruitment has its limitations. Ideally, each

child/learner related to a certain respondent should have been diagnosed by a clinician. However, it is not always easy to reach a sufficient sample size using this method. Also, the diagnosis of the most relevant group, the persons with ASD themselves, was supported by an official document.

Thirdly, due to the fact that the 3 groups of respondents did not have an interrelationship, and received slightly different questionnaires, comparing the results between the groups is less meaningful, as previously mentioned. Nevertheless, this paper is able to provide exploratory results concerning the difficulties encountered when learning to drive for persons with ASD, as seen from three different viewpoints. Furthermore, with this paper, we are also able to increase attention for research on specific groups, such as for instance ASD, in transportation. More attention both to limitations, but also abilities, in such groups could be provided by researchers, funding channels, and policy makers in the field of transportation.

7. CONCLUSION

Our exploratory study indicates that young persons with ASD experience diverse barriers in the process of learning to drive, but also some facilitators. All involved groups – young persons with ASD, parents/caregivers, and driving instructors – agreed about the possible impact of characteristics of ASD. The experience of the extent of this impact seems to be unequal in the different groups. However, obtaining a driving licence is feasible for persons with ASD. The learning process can be adjusted and support mechanisms can be incorporated. In our study, several suggestions are made. Further research is needed to gain more systematic insight in barriers and facilitators. Enhanced insights should be translated in new training methodologies, which are subsequently propagated in all groups involved in the process of learning to drive. Finally, with the current case study investigating learning how to drive for persons with ASD, we hope to increase attention to research on specific groups in transportation research.

Footnote:

1 The authors want to highlight that they do not consider people on the autism spectrum as people with a 'disorder'. However, for the current article, bridging the gap between the field of psychology and transportation, they decided to opt for the formal definition and symptoms of autism in order to provide more knowledge to people in the field of transportation. In support, more information about an autism diagnosis was requested by the reviewers during the review process. Similar, the authors opted for the term 'clinical' in the introduction based on Gössling (2013) because they believe in the core message that can be deducted from his article, the inclusion of **all groups** in (research on) transport behavior and mobility consumption. They acknowledge that not all people with autism are patients or make active use of clinical mental health care. Rather, they believe autism to consist of an important group of people that are still often overlooked in research, or not being incorporated in the research themselves.

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Factors influencing the outcome of the Medical-Psychological Assessment of speed-affine drivers in Germany

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ABSTRACT: *In Germany, offenders with severe or repeated violations of traffic rules are required to pass a **M**edical-**P**sychological **A**ssessment (MPA) to regain their driving licence. The most common offence is speeding. The present research analysed 104 MPA files from speeding offenders in order to determine whether delinquency-related variables or characteristics of the driver's behaviour change process predicts the MPA outcome (positive or negative relapse risk). The results show that characteristics of the offences themselves (e.g. the number of speed violations) do not serve as valid predictors. However, whether the offenders had voluntarily participated in a driver improvement program prior to the MPA did predict the MPA outcome. Moreover, the most suitable predictors were problem awareness and self-criticism demonstrated in the psychological assessment. Furthermore, the results underpin the suitability and utility of the MPA as a measure to evaluate relapse risks.*

KEYWORDS: *speeding; repeat offender; Medical-Psychological Assessment, MPA; relapse risk*

1. INTRODUCTION AND LITERATURE REVIEW

Speeding is a serious, yet common offence, often related to mobility in a stressful modern world or a driver's pleasure seeking behaviour (Berry, Johnson & Porter, 2011; Shinar, 2017). In this paper, we use the term *speeding* to refer to the act of driving faster than the applicable speed limit and the term *speed-affine* drivers to refer to a specific group of drivers who have a strong tendency towards speeding, which is motivated by personality dispositions (Berry et al., 2011; Wagner, Keller & Jäncke, 2018).

Collision statistics suggest that around 30 % of all fatal crashes are a direct result of unadjusted speed (SafetyNet, 2009). Interestingly, an Australian study demonstrated that speeding can be as dangerous as driving under the influence of alcohol, with the increase in speed akin to an increase in blood alcohol concentration (BAC). Specifically, speeding at 5 km/h above the speed limit of 65 km/h is comparable to driving under the influence of alcohol with a BAC of 0.5 %. Exceeding the speed limit by 10 km/h is associated with the related accident risk as driving with a BAC of 0.8 % (Kloeden, McLean, Moore & Ponte, 1997). Aside from this, speeding also has a negative impact on the environment because of air and noise pollution.

Despite the known risks, speeding remains a mass phenomenon amongst drivers with 40 – 60 % of drivers habitually exceeding the speed limit and about 10 – 20 % driving constantly 10 km/h too fast (SARTRE III, 2004). According to the same study, 80 % of the drivers from 23 EU countries agreed that speeding is an important cause of accidents. Shinar (2017) stated that this issue is attributed to drivers considering themselves to be safe, despite acknowledging that they often exceed the relevant speed limit. Consistent with this suggestion, Rößger, Schade, Schlag and Gehlert (2011) interviewed 1009 drivers and observed that speeding is tolerated, even among those people who accept traffic rules in general. They also observed that drivers' speed compliance is predicted by informal norms, habits, situational factors and the subjective evaluation of risk and severity of punishment. This subjective evaluation is in the end of course influenced by the real frequency of enforcement. An increased enforcement density or even the continuous information about enforcement may result in significantly lower frequencies of speeding (Hössinger & Berger, 2012).

Whilst traditional research has investigated speeding behaviour as a dependent variable (Berry et al., 2011), recent studies have focused on speeding in combination with other road violations and the driver's criminal history (Watson, Watson, Siskind, Fleiter & Soole , 2014; Wagner et al., 2018). With this in mind, driving too fast can be seen as a "syndrome" of maladaptive behavioural patterns (Wagner et al., 2018; Watson et al., 2014). For example, Wagner et al. (2018) conducted a study among drivers from Germany and Switzerland (N = 361), demonstrating that a risk-prone subgroup of drivers exists (named *impulsivity subtype*), and that they appear to be speed-affine i.e., they have a strong tendency towards speeding behaviours. The members of this subtype tended to score high in impulsivity, low on compliance, high on affective responsiveness and described themselves as affordance-prone for breaking traffic rules when situational conditions are quite favourable, e.g. passing a red traffic light. With regard to traffic delinquency, these drivers reported having more speeding offences in their driving licence file, as well as admitting to overriding speed limits for more than 15 km/h more frequently. They also committed criminal acts with regard to aggression, vandalism, assault or robbery more often compared to other less risky subtypes. In line with these findings, Sucha and Cernochova (2016) compared speed-affine drivers, who had had to pass a traffic psychological examination because their licences had previously be revoked due to serious traffic violations, to a group of control drivers. They observed that the speed-affine drivers showed lower scores in conscientiousness, agreeableness, less self-control and responsibility and more sensation seeking and non-conforming behaviour.

Watson et al. (2014) investigated data from 84,465 drivers in Australia and identified a subgroup they labelled "high-range offenders". These individuals had committed two or more speeding offences with a recorded speed of 30 km/h or more above the speed limit in a specific timeframe (May 1996 to August 2007). In comparison to other drivers, the high-range offenders were more likely to be male, younger than 30 years old, were more likely to be in an accident, and had more traffic offences and even criminal offences in their record. This led to the conclusion that high-range offenders show a reduced ability to comply with norms in the traffic domain and beyond. As explained later in this paper, these people would receive hypothesis V2 in the German MPA process (DGVP & DGVM, 2013).

Extending beyond previous research, which has included a myriad of personal, social, situational and legal factors (see also Wagner, Keller & Jäncke, 2018) to explain speeding behaviour, it also seems worthy to examine factors that can moderate speeding behaviours in order to improve road safety. Thus, we structured this paper in the following way. First, it is to be acknowledged that speeding in Germany is generally tolerated and that the negative judicial consequences are negligible in cases of a (minor) single offence. Second, we present a brief description of the Medical-Psychological Assessment (MPA), which has been introduced as a measure to improve road safety in Germany. Third, we present an empirical study that investigates the contribution of drivers' traffic delinquency features (e.g. the number of speed violations), benefits of a professional driver improvement program (DIP) and findings from a psychological assessment for the prediction of the MPA outcome. This will also allow us to determine whether the MPA is a valid measure to enhance road safety. It should be noted, that this is the first empirical study addressing this topic.

2. SPEEDING OFFENCES IN GERMANY

Speeding is one of the leading factors of collisions in Germany with about 30 % of all fatal accidents as a direct result of a failure to adhere to the speed limit. Furthermore, more than 50 % of all entries in the Central German Register of Traffic Offenders are speeding offences (Wagner, Keller & Jäncke, 2018). These statistics are particularly alarming given the relatively mild consequences an offender faces if caught speeding. For example, if one drives more than 20 km/h above the limit they would have to pay a maximum fine of 35 euros. If one exceeds the limit for more than 50 km/h, the fine is around 240 euros, along with a driving ban for one month. In comparison to other EU-states the German fines range at the bottom level. Specifically, for the same offence of driving more than 20 km/h above the limit in France, a driver would have to pay a minimum of 135 euros; however, for the offence of driving more than 50 km/h above the limit, they would have to pay 1,500 euros. Surprisingly, there is no speed limit on German motorways, though it is recommended that the drivers keep to a so-called advisory speed limit ("Richtgeschwindigkeit") of 130 km/h. However, without legal reinforcement or consequences this advisory limit is largely

ignored. On the other hand, in accordance with § 3 section 1 of the road traffic ordinance (= "Straßenverkehrsordnung", a legal regulation level below the road traffic act), it is the drivers responsibility to ensure that their driving speed is suitable with regard to road and weather conditions, sight and traffic density. Additionally, they must ensure that their driving style prevents others from harm, injuries and inconveniences (basic traffic rules according to § 1 of road traffic ordinance). If the driver ignores the advisory speed limit on motorways, thereby being involved in an accident, he has to accept a joint liability of around about 20 % of the accident-related costs. This is true if the accident could have been prevented by driving at the advisory speed limit. In these cases, liability is determined in court on the advice of expert witnesses trained in technical accident analysis.

The negative legal consequences for speeding combine fines and driving bans with penalty points. In the case of a severe traffic offence (e.g. after joining a road race) or when the maximum of 8 penalty points is exceeded, the driving licence is revoked. In order to regain their licence the driver must pass a Medical-Psychological Assessment (MPA). The MPA represents a specific kind of examination that can be seen as an element of the popular concept of the four E's (e.g., education, enforcement, engineering, examination) to improve road safety (Groeger, 2011). The core idea of the MPA is to estimate the driver's future on-road risk and to give this information and advice, in the form of an expert report, to the driving licence authority.

3. MEDICAL-PSYCHOLOGICAL ASSESSMENT (MPA) IN GERMANY

Here we present a very short description of the MPA-procedure, however, for more information about this expert system, see Brenner-Hartmann et al. (2014). When people receive their driving licence in Germany they are automatically assumed to be fit to drive until they severely or repeatedly violate traffic rules or laws. All traffic offences registered by the police are recorded in the Central Index of Traffic Offenders in accordance with the German penalty point system. On January 1st, 2017, 10,100,000 people had a recording in the Central Index of Traffic Offenders, with 5,961,000 of these classed as speeded offences (Kraftfahrt-Bundesamt, 2018). Yearly around 90,000 drivers have to pass an MPA. In 2017, this number was 88,035, with 18 % of those offences not being the result of an impairment from driving under the influence of alcohol or drugs (Bundesanstalt für Straßenwesen, 2018).

To ensure that the diagnostic process is applied using standardized methods and assessment criteria, the scientific principles of MPA are summarized and defined within two important publications:

1. The guidelines for the evaluation of driver fitness of the Federal Highway Research Institute (Begutachtungsleitlinien zur Kraftfahreignung. Bearbeitet von Grächmann, N., Albrecht, M., Bundesanstalt für Straßenwesen - Verkehrsblatt Dokument Nr. B 4022, 2017)
2. Assessment criteria collected in *Urteilsbildung in der Fahreignungsbegutachtung – Beurteilungskriterien* (DGVP & DGVM, 2013), supporting the assessors as an expert working tool, including decision strategies of collecting and evaluating individual findings according to specific principles.

Assuming that there is a distinct rational behind the individual's offending behaviour, the MPA begins with the specific question of "Might we expect Mr/Mrs X realising further traffic offences in the future?" This initial question governs the following diagnostic process. In order to determine the individual's risk of reoffending, both a physician and a psychologist work together. The physician focuses on checking the general health of the individual, for example, they will check their vision and check for any health impairments, such as neurological disorders or attention deficit hyperactivity disorder (ADHD), which might be the reason for the traffic violations. Conversely, the psychologist firstly conducts a licence file analysis to gain a clear understanding of the driver's offending history. Following this, they can prepare a psychological interview. The interview has a structured dialogue to assess the client's problem awareness, self-criticism, and stability of changes in attitudes and behaviour according to the assessment criteria. The conclusive decision of whether the person is fit to drive is determined by the interview findings with regard to the evaluation criteria. It also gives a profile of personal resources to be changed to meet the requirements for a positive MPA prognosis, i.e., driving licence is regained.

The assessment criteria follow a hierarchical structure according to the diagnostic hypotheses, be-

ginning with the most serious disorder and moving on to less severe maladaptive behavioural patterns. The hypothesis includes a statement about the diagnostic assessment and the derived requirements for behavioural changes (DGVP & DGVM, 2013). The most severe hypothesis V1 (adjustment or personality disorder) is rare and not part of this study. Hypothesis V2 states that the rule violations are a result of an reduced adjustment ability, whereas clients receiving hypothesis V3 have a reduced motivation to comply with traffic rules. In order for a psychologist to be qualified to perform MPAs they must have worked for two years as a professional psychologist after completing their diploma or master's degree. They must then pass additional training in traffic psychology, run a minimum of 100 MPAs under supervision for one year and complete three days of continuing education each year. Following this training and experience, the traffic psychologist is then allowed and able to perform the MPA and distinguish between the three risk categories (V1 to V3). In addition to that, there are further hypotheses (e.g. V4: a disease, such as sleep apnoea, caused the offences) that have to be tested during the MPA. Those have nothing to do with attitudes or behavioural patterns, therefore they were not included into this study. For example, he will choose V2 hypothesis if several of the following criteria are true:

- repeated relapse after a former positive MPA or repeated licence revocation.
- relapse after participation at a driver improvement program with legal consequences.
- heterogeneous offences including both traffic and criminal offences.
- driving under the influence of alcohol or drugs (in addition to a speeding episode).
- the list of offences is characterized by an escalating severity or dysfunctional dynamics, i.e. persistent disregard of legal regulations, starting with mild administrative offences, later criminal offences.
- a considerable number of severe violations or serious criminal acts (followed by a prison sentence).

Since the underlying problem for the V2 hypothesis is more severe than V3, the criteria that have to be fulfilled to achieve a positive MPA result are more demanding. In German administrative law, the MPA is considered to be a prognosis of future traffic delinquency, but not in the sense of a statistical prognosis where measurable criteria of the future on-road-performance are collected. It is rather an expert's prognosis on whether a person, that has severely or repeatedly violated traffic rules or laws in the past, now shows stable changes in their personality, i.e. giving an answer to the initial question "Might we expect Mr/Mrs X realizing further traffic offences in the future?".

This paper intends to demonstrate the model fit of MPA. To achieve this, the study uses data in which different traffic psychologists have all used the same system (as described above) for the collection and evaluation of findings and have applied diagnostic strategies in a homogeneous way. We predict that speed-affine elements or traffic delinquency history are independent from the further tendencies to offend, as judged by a positive MPA result. Instead, a positive MPA should rely on the characteristics of the driver's coping process (as indicated by participation at a DIP) and correcting their problem awareness towards safety attitudes and beliefs and enhancing self-criticism. Of particular interest is the relative contribution of the different predictors for the final MPA result.

4. METHODS

4.1 Data base

The data were taken from written MPA-reports provided by the DEKRA MPA Centre in Dresden, Germany. A total of 110 of these case files fulfilled the requirement of at least 2 speeding offences followed by an MPA from January 2014 until March 2017, representing the speed-affine risk category according to Watson et al. (2014). All of the sample underwent the MPA because of severe or repeated traffic rule violations. None of the cases were selected due to DUI (driving under influence) offences.

A total of 6 of the people had undergone MPA assessment at the same place twice in the timeframe, therefore their data appeared twice. We only included the earlier MPA data. From the remaining 104 cases, 3 received a so-called H0 hypothesis, meaning they failed to cooperate or provide the assessor with relevant information to answer the MPA question. Those MPAs receive a negative result by default and were therefore excluded from the analysis. This resulted in 101 valid cases for analysis. The drivers in the sample analysed (96 male, 5 female) ranged in age

from 18 to 68 years (Mean [M] = 36.03, Standard Deviation [SD] = 12.40). Age was calculated as age at last speeding offence – this was done because it is possible that several years can pass between licence withdrawal and MPA. The overall MPA outcome was 43.6 % (N = 44) positive and 56.4 % negative. A total of 41 people received the more severe V2 hypothesis and 60 people received the milder V3 hypothesis. The number of speeding offences per person ranged from 2 to 11 (M = 4.44, SD = 2.11). No cases of V1 were observed in the data.

4.2 Method of data collection

MPA files include questionnaires about personal information filled in by the participant, detailed information about the offences from the Central Index of Traffic Offenders, criminal records, and certificates about participation in DIP. The file also contains the detailed file analysis of the psychological assessor and a copy of the entire MPA report. For each participant, 11 variables were collected and coded. Details about the variables, coding, and source of information can be obtained from table 1.

The result of the MPA as an outcome variable was extracted; as well as demographic variables such as age and gender. The collected predictors were reported hypothesis, voluntary participation at DIP prior to the MPA, problem awareness, self-criticism, and four offence characteristics with regard to speed-affine driving style and traffic delinquency history. In more detail, we summarized the number of speeding offences prior to the licence revocation and calculated the sum from the amount of km/h of the speed limit transgression across all speeding offences. More speeding offences with a high transgression of speed limits indicate probably a more serious adjustment problem, making it potentially more difficult to change the behaviour and achieve a positive MPA result. Another important variable is the temporal distribution, which is the proportion of offences committed in the last year before licence revocation compared to all committed offences. More offences committed in the relatively short period of one year, indicating an escalating dynamics in the distribution of traffic delinquency history, might be another indicator for a deeper adjustment problem. Finally, we counted the number of all non-speeding offences in the original offence file, for example using a mobile phone while driving, red light running, and hit-and-runs or driving without a valid licence. A heterogeneous mixture of offences also indicates a more serious behavioural problem in terms of hypothesis V2.

Table 1: Variable details and coding

Variable name	levels	source of information
gender	male-female	copy of MPA report
age	at the time of the last speeding offence	original offence file
MPA result	0 = positive, 1 = negative	copy of MPA report
report hypothesis	0 = V2; 1 = V3; 2 = other*	copy of MPA report
number of speeding offences	2 to 11	original offence file
km/h above speedlimit	sum score over all speeding offences	original offence file
temporal distribution: proportion of offences committed in the last year before licence withdrawal of all offences	between 0 and 1	original offence file
number of all non-speeding offences in the original offence file	0 to 9	original offence file
participation in DIP prior to the MPA (voluntarily)	0 = yes; 1 = no	submitted certificates
problem awareness	0 = existing; 1 = not existing	psychological assessment
self-criticism	0 = existing; 1 = not existing	psychological assessment

* Please note that „other“ means “other hypotheses”, such as V4. As only V2- and V3-hypotheses were included, “other” has the value N = 0. It was used to cross-check the data.

4.3 Methodical procedure

Written case reports from 5 experienced traffic psychologists and their assessment outcomes across the sample (N = 101) were analysed in March 2017. All statistical analyses were performed with IBM SPSS (Version 22). There were no missing values. The alpha level of significance was set at 0.05.

In order to obtain an overview of the relationships between the variables, a bivariate correlation analysis was performed on the data.

A hierarchical (also called stepwise) logistic regression was then performed on the data to determine which of the variables predicted MPA outcome. Logistic regression analysis has to be used instead of linear regression analysis since MPA outcome is a binary variable (can only have the value positive or negative), not a continuous variable.

On the first level, the four characteristics of the speed-affine driving style and traffic delinquency history were entered into the model, here we expected no relationship with the MPA-result. The second level adds the reported hypothesis (e.g. V2, or V3) as a predictor variable. As the hypothesis represents the severity of the person's maladaptive traffic behaviour this issue should be relevant for the MPA result. On the third level, the participation at a driver improvement program (which is not mandatory by legal regulations) was entered into the regression. Since problematic attitudes and behaviours are addressed within this measure, participants might benefit from the settings. This should lead to more positive MPA results. Finally, problem awareness and self-criticism (both demonstrated in the psychological interview) were entered into the last block of the prediction model. With regards to the MPA expert system, these factors are essential for the decision on the MPA result and should be the strongest predictors. Although Watson et al. (2014) state that "... high-range offenders were more likely to be male, younger than 30 years old, ... " we did not include age and gender in those analyses, since there is no theoretical foundation why these factors should influence the MPA outcome itself. In addition, there were only 5 women in the sample, which is not enough for a meaningful statistical interpretation.

5. RESULTS

Table 2 shows pairwise computed Pearson correlation coefficients among all variables used in the study. The result of the MPA is correlated negatively to reported hypothesis ($r = -.36$, $p < .001$), indicating that people with V3 hypothesis are more likely to receive a positive result. As expected, there is no correlation with the characteristics of the speeding offences (indicative of speed-affine behaviour) and the MPA result. On the other hand, positive correlations were observed between MPA result and participation at DIP ($r = .471$, $p < .001$), problem-awareness (Cramers's V $\Phi = .80$, $p < .001$) and self-criticism as demonstrated in the psychological interview (Cramers's V $\Phi = .7$, $p < .001$). The characteristics of the speeding offences do not correlate among each other, except for a negative correlation between km/h above the speed limit and number of non-speeding offences, as well as a positive correlation between number of speeding offences and km/h above the speed limit. This was expected, since km/h above speed limit was computed as a sum score, meaning more speeding offences result in a higher km/h number. Problem awareness and self-criticism are positively related to each other and to participation in a DIP and negatively related to the reported hypothesis.

As a next step, we performed a hierarchical logistic regression analysis as described above in order to estimate the contribution of the predictors for the final MPA outcome/prognosis. To assess whether multicollinearity might be a problem in our data, we looked at the Variance Inflation Factors (VIF) and the collinearity diagnosis. Both tests, implemented in SPSS to check for multicollinearity, indicated that this is not a problem in our data. The results of the hierarchical logistic regression analysis can be seen in table 3. Here, the 2nd column expresses the predictors entered in the equation, the influence on the outcome variable is displayed by beta-coefficient (b) and whether this influence is statistically significant. Nagelkerkes R^2 is a measure of how well the model fits the data, with 0 indicating no fit at all and 1 indicating a perfect fit. It can be interpreted analogically to $R^2_{adjusted}$ in linear regression analysis.

The quality of classification describes the classification result (positive or negative MPA outcome) based on the predictor entered in the model. 100 % means every participant was sorted into the correct group and 50 % indicates a classification at chance level.

If only the four offence characteristics are used, the classification is indeed close to chance level (56.4 %) with a very small Nagelkerkes R^2 (.015). In

Table 2: correlations between the variables

	MPA result	report hypothesis	number of speeding offences	km/h above speed limit	temporal distribution	number of non-speeding offences	participation in traffic therapy	problem awareness	self-criticism
MPA result	1	Φ = - .360** p < .001	r = .011 p = .912	r = .002 p = .983	r = .081 p = .422	r = .044 p = .665	Φ = .471** p < .001	Φ = .804** p < .001	Φ = .757** p < .001
report hypothesis		1	r = - .001 p = .989	r = - .072 p = .475	r = - .109 p = .279	r = - .247* p = .013	Φ = .012 p = .904	Φ = - .216* p = .030	Φ = -.267** p = .007
number of speeding offences			1	r = .915** p < .001	r = - .129 p = .200	r = - .163 p = .103	r = - .045 p = .655	r = .066 p = .513	r = .012 p = .905
km/h above speed limit				1	r = - .025 p = .803	r = - .258** p = .009	r = - .057 p = .573	r = .023 p = .822	r = .013 p = .900
temporal distribution					1	r = -.127 p = .204	r = - .024 p = .810	r = .040 p = .691	r = .060 p = .549
number of all non-speeding offences						1	r = - .010 p = .923	r = .108 p = .282	r = .040 p = .691
participation in driver improvement program							1	Φ = .446** p < .001	Φ = .389** p < .001
problem awareness								1	Φ = .740** p < .001
self-criticism									1

Note **p<.01,*p<.05, N=101

step one, since none of the regression weights are significant it can be concluded that the characteristics of the speeding offences and traffic delinquency history, indicative of speed-affine behaviours, alone do not predict the MPA result. When the reported hypothesis is added in step 2, the regression weight is significant and classification quality, as well as Nagelkerkes R^2, increases moderately. A traffic psychological intervention program added in step 3 increases the classification quality to 80.2 % and Nagelkerkes R^2 to .475. This is indicative of a good fit of the model to the data, which is not often reached in empirical settings. It also suggests that when MPA candidates participate at DIP the likelihood of a positive result notably increases. Finally, the addition of problem awareness and self-criticism in the fourth step lead to an almost perfect model fit. Since these aspects are essential for a positive MPA result, the result might not seem too surprising. However, the strength of the relationship between the two predictors and the outcome variable is quite high.

6. SUMMARY AND CONCLUSIONS

The aim of this study was to investigate the model fit of the medical-psychological assessment in Germany according to a standardized diagnostic process governed by guidelines and assessment criteria. More specifically, here we examined the predictors for the outcome of the MPA for a sample of speed-affine drivers who had previously had their licences revoked. We expected that speed offence-related characteristics and traffic delinquency history would not serve as predictors for the prognosis in future (represented by the outcome of the MPA).Instead we suggested that an individual learns to cope with their influencing factors from the maladaptive history with the help of a professional DI program (DIP), thus increasing their fitness to drive.

First, a correlation analysis was conducted. This revealed a positive correlation between a milder problem hypothesis (i.e. V3) and positive MPA outcome. A positive correlation was also observed between vol-

Table 3: Hierarchical regression MPA result

	predictors	b	Nagelkerkes R^2	quality of classification
Step 1	number of speeding offences	.093	.015	56.4%
	km/h above speedlimit	- .002		
	temporal distribution	.720		
	number of non-speeding offences	.052		
	Constant	- .264		
Step 2	number of speeding offences	.316	.192	63.4%
	km/h above speedlimit	- .012		
	temporal distribution	.515		
	number of non-speeding offences	- .087		
	hypothesis	1.807**		
	constant	- .245		
Step 3	number of speeding offences	.373	.475	80.2%
	km/h above speedlimit	- .014		
	temporal distribution	.823		
	number of non-speeding offences	- .098		
	hypothesis	2.485**		
	participation in driver improvement program	- 2.682**		
	Constant	.791		
Step 4	number of speeding offences	1.285	.927	95.0%
	km/h above speedlimit	- .035		
	temporal distribution	- 7.315		
	number of non-speeding offences	.292		
	hypothesis	4.329*		
	participation in driver improvement program	- 3.695*		
	problem awareness	- 24.789*		
	self-criticism	- 30.724*		
	Constante	53.185		

Note *p < .05, **p < .01

untary participation at a DIP prior to the MPA and a positive MPA result. Finally, a positive correlation between a positive MPA outcome and problem awareness and self-criticism (both as demonstrated in the psychological interview) was observed. The results of the regression suggested that speed-affine driving style and the sum of offences (as retrieved from official record files) do not predict the outcome of the MPA. Further, they also suggest that those individuals who attended a driver intervention program prior to undergoing the MPA were more likely to achieve a positive result on the MPA, i.e., they were more likely to get their driving licence returned.

Given that the variables added in step 1 of the regression explain almost none of variance in the MPA result, it can be suggested that a positive MPA result is nearly independent of offence-related characteristics (e.g. speeding offences and delinquency history). Taken together with the finding that problem awareness and self-criticism (as judged by the psychological assessment) and participation in DIP *does* predict MPA outcome, the present results suggest that the

MPA is a valid tool to help improving road safety, since high risk drivers are excluded from traffic (i. e. due to a negative MPA outcome, their driving licence is not regranted by the authority). These are positive news for the German MPA and Rehabilitation System, suggesting that the MPA can be interpreted not as a punishment but as a chance for an offender to regain his licence upon the provision that they are fit to drive (again).

It is worth noting, that problem hypothesis (V1 to V3) only moderately predicted the MPA result, it is harder for those with a more severe hypothesis to achieve a positive MPA. Therefore, we recommend that these offenders participate in DIP, especially when there is a reduced adjustment ability to traffic rules (i.e. people having received hypothesis V2). DIP allows the offender to reflect on past attitudes and behaviour, learn why they were wrong and build new lasting strategies to deal with emotions while driving. This process is important for the MPA result; hence DIP participation is a strong predictor of MPA outcome. Problem awareness and self-criticism demonstrated in the psychological interview were the strongest predictors for a positive MPA result, not surprisingly, since a positive result is not possible without changing cognitive factors. A possible recommendation is to focus especially on these two aspects in traffic psychological therapy.

6.1 Limitations

There are a few limitations in the present study that should be addressed. First, data was taken from existing records; as such there was no experimental manipulation. Second, the sample was restricted to 101 subjects who were examined in the same assessment institute in the capitol city of Saxony (Dresden). A larger and representative sample would be more favourable; however, this research is the first of its kind and will path the way for larger future studies on the MPA. Third, due to restricted personnel resources, the data were coded by one researcher. As such, no interrater-reliability could be computed. However to negate the possibility of coding errors and biases, a strict coding plan was utilized. This relied mostly on objective measures and the MPA report, which offered a detailed description and explanation of the findings. A final potential confound is that the MPA result is not only reliant on the change in behaviour. To achieve a positive prognosis, all criteria have to be confirmed, even those from the areas of medical and performance testing. However, health or psycho-functional impairments were not considered in this study.

6.2 Implications for the future

Speeding is a serious, yet common offence. So far, relatively little empirical research has been conducted in Germany, especially amongst MPA candidates. To the authors' knowledge, this is the first empirical study to examine traffic offenders, particularly speed-affine drivers, in relation to their MPA outcome. As our sample size was relatively small, future studies however could use a larger sample size. It would also be interesting to make an international comparison of traffic rehabilitation measures. The current findings also strongly suggest that participating in a DIP should be recommended for all those who are going to undertake the MPA. The DIP should focus especially on problem awareness and self-criticism since those were found to be the best predictors of MPA result. It might also be considered that offenders with V2 hypothesis are supervised after the MPA, for example, they could be given a mandatory traffic therapy consultation six months later in order to further stabilize the changing process. The penalty point system could consist of voluntary and mandatory intervention measures earlier in the offender's biography. Sadly, speeding is a widely spread and dangerous behaviour, yet interventions are relatively mild in Germany, with consequences only occurring after reaching the fairly generous limit of 8 penalty points.

The current composition of maladaptive drivers influencing measures should be reflected by the administration and there might be a rethinking towards the usefulness of mandatory DIP before reaching the red line of 8 penalty points.

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Assessing the Influence of Greenery on the Behaviour of Road Users[1]

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ABSTRACT: *The share of active mobility in traffic – walking and cycling - can be increased by enhancing of the urban vegetation; this is the core assumption of the Austrian project "GoGreen". The main objective of this research project was to elaborate criteria of the roadside greenery that need to be incorporated into the planning of urban and street spaces, and finally implemented in order to create a highly aesthetic and stimulating atmosphere in public spaces. In addition to literature studies, qualitative methods (expert interviews, focus groups) and quantitative methods (street surveys) were used in this project to identify the needs and wishes of the residents. Subsequently, internal and external workshops helped to design evaluation criteria and recommendations for ordinary measures for promoting and supporting active mobility. In this paper, we focus on the street surveys that allow a glimpse on how citizens perceive the relationship between appropriately set urban vegetation, with respect to safety and attractiveness among other things, and its potential to motivate (more) citizens to walk (more).*

KEYWORDS: *urban greenery; active mobility; life quality; road user behaviour*

INTRODUCTION

The desire for more green areas in urban environments is mentioned in several studies that investigate the needs of vulnerable road users (see e.g. Wunsch et al. 2007, Ausserer et al. 2009, Ausserer et al. 2014). International research, as well, showed that attractive design and equipment of roads, streets and places is one precondition for inciting people to walk instead of using the car for very short distances (< 1km; Gehl et al. 2013, Hancrenci 2013, Bowler et al. 2010, Zheng et al. 2014, de Vries et al. 2013, Krekel et al. 2015). In order to promote active and safe mobility, a useful and functional infrastructure together with the attractive design of open spaces, easily accessible and appreciated by the city's residents, are required. Providing green areas in the public space is one way to enhance attractivity. Design measures include compound types of green vegetation in the streets and the creation of recreational areas in public open spaces which have effect on many societal, social, ethnic and microclimatic factors. In the project GoGreen that was financed by the Austrian Ministry of Transport, Innovation and Technology the relation between active mobility and the provision and character of green areas was analysed in more detail. The goal of the project was to develop policy criteria to be applied in connection with road and transport planning in order to generate a public space that would motivate (more) people to walk (more), which would have positive effects for both public health and the environment. Green spaces would play an important role in this connection. The questions to be answered are: Where should green areas be placed, and how should they be designed in order to support active mobility?

Functions of Urban Greenery

There are various studies that outline the functions of urban greenery. Even though these studies do not explicitly refer to the positive effects of greenery they underline the link between road side greenery and mobility. Some of these functions are:

Climate function for the micro and meso climate: Urban greenery helps to avoid "heat islands" as

1 The project GoGreen was sponsored by the Austrian Research Promotionx Agency FFG and carried out by FACTUM Chaloupka & Risser OG in cooperation Mira Kirchner, MK Landschaftsarchitektur e.U

it cools and provides shade (see Bowler et al 2011, Mursch & Radgruber 2009, Ehmayer 2015). In addition, it improves the air quality (see Nowak et al 2006). These are important aspects when walking or cycling in the city.

Social function: Urban greenery has a positive impact on "community relations" and social cohesion. Social interaction and sociality promote the feeling of security and familiarity (e.g. Dinnie et al. 2013, Arnberger & Eder 2012, Peters et al. 2010).

Recreation – Health function: Urban greenery not only supports social contacts, but has a positive effect on the physical and psychological well-being, too. Studies underline that the presence of greenery helps to relieve stress and encourages people to be outdoors (e.g., Tyrväinen et al. 2014, Han et al. 2013, Van der Berg et al. 2007)

Comfort & Safety function: Urban greenery has a protective function (protection against rain and sun), an aesthetic function and a separating function. The latter is valid for avenue trees, lawn strips and patches of flowering that separate cars from pedestrian facilities (e.g. Adkins et al. 2012, Knoflacher 1996).

METHODS AND PROCEDURE

In a first step, national and international examples of best practice were searched for and summarised. Their potentials for application in an Austrian context were assessed. After that, the needs and wishes of inhabitants of Vienna were analysed with the help of a mixed methods combination. Qualitative methods – expert interviews, focus-group interviews and behaviour observations – were applied to identify aspects that would reflect what is of interest to the citizens. Quantitative methods – in this case road-side surveys – were applied to measure the distribution of those aspects in selected populations. Finally, suggestions for measures to enhance the introduction of green areas viz. to adapt and improve the design and the quality of such areas were developed in the frame of workshops with experts and citizens:

Literature Analysis

The literature analysis incorporated an internet research accompanied by expert talks with colleagues, in order to get an overview of the state of the art and of national and international good practice examples with respect to greenery projects in various urban areas.

Qualitative interviews: expert interviews, focus group interviews

13 interviews with experts - landscape architects, traffic planners, psychologists, representatives of Viennese authorities, and representatives of the Austrian Ministry of Transport, Innovation and Technology - and three focus group interviews with heterogeneous groups of road users were carried out. In addition, in-depth interviews with two ten-year-old children and four elderly people (80+) were conducted, as these age groups were not represented in the focus groups. These interviews gave an overview of requirements and needs of road users with respect to green infrastructure.

20 persons took part in the focus group interviews, 10 female and 10 male participants. One focus group consisted of 9 teenagers between 14 and 17 years of age. The participants in the other focus groups (n = 11) were aged between 20 and 75 years. The sample included walkers, cyclists, public transport users and car drivers. The focus groups lasted between 1½ and 2 hours.

Expert interviews and focus group interviews were used to gather relevant aspects connected to the subject of the study. With the help of these methods it is made sure that as many relevant issues and questions as possible are tackled in the frame of quantitative surveys to follow. The interviewers followed guidelines that were elaborated on basis of the literature study. The interviews were partly recorded and transcribed and partly journalised. The answers of the experts and focus group participants were anonymised and summarised per question. The results of these steps were used as a basis for the development of the quantitative survey instruments:

Quantitative verbal data: Surveys

Ten interviewers were trained and instructed for questioning. Then they carried out road-side surveys in all 23 districts of Vienna in November 2015. The weather was good at that time and the work could be done without much interruptions.

In total, 414 face-to-face standardised road-side surveys were carried out, with focus on the relation between green infrastructure and active mobility. Their results should display the residents' wish and willingness to participate actively in the designing of the public space. Furthermore, 200 face-to-face road-side surveys were conducted in which two streets in Vienna – one with and one without greenery - were compared according to criteria such as 'attractiveness' and

'subjective feeling of safety'. The questionnaires for these surveys were developed in an iterative process, on the basis of the expert and focus group interviews, where a relationship between subjective safety and attractiveness was postulated. The interviewers were trained before questioning people on the road.

For the 414 interviews quota sampling was used according to age, gender and the place of living. The participants were between 14 and 92 years of age (mean = 41,19 & standard deviation = 19,15 years). In total, 212 female and 202 male persons took part in the interviews. Different types of road users were represented in the sample: 39% regular walkers, 33% regular public transport users, 10 % regular cyclists and 18% regular car drivers ("regular" = those who use the transport mode at least three times a week). The interviews took place in November 2015 under good weather conditions.

Comparison study: Road side interviews

The goal of this working step was to get a first impression of how attractiveness and subjective safety of pedestrians may be affected by one important traffic characteristic, namely car speed, and by greenery. The comparison study took place in two inner city streets of Vienna:

- Lerchenfelder Straße (LS): an arterial street running through the 7th district of Vienna, traversable in both directions; parking lanes on both sides and tram tracks in the middle of the street in both directions, maximum speed 50km/h, numerous shops, pubs and restaurants, pavements appr. 2,5 m wide, greenery (trees/some shrubs) on one side of the street (figure 1).

Figure 1: Lerchenfelderstraße *©Factum*

- Neustiftgasse (NG): an arterial street in the 7th district, parallel to Lerchenfelderstraße; it is a one-way street, parking lanes on both sides, one lane for cars and one for buses, maximum speed 30km/h, a few shops, pubs and restaurants, pavement appr. 2m wide, no greenery (figure 2).

Figure 2: Neustiftgasse *©Factum*

In each of these two streets 100 personal roadside interviews were carried out between June and July 2016. The interviews took place in July 2016 under good weather conditions. Quota sampling was used according to gender and age. In the questionnaire, statements concerning subjective safety and attractiveness of the two roads were presented and the questioned persons should answer on 5-step Likert-scales whether they agreed with these statements or not. 47% female and 53% male filled in the questionnaire. The interviewees were aged between 13 and 90 (mean = 41,3 years, SD = 15,82). 40% were regular walkers, 35% regular public transport users, 13% regular cyclists, 12% regular car drivers. All participants lived in Vienna and the majority of the respondents were familiar with the street/s.

In the following the main results of the standardised surveys (Quantitative verbal data and Comparative study) will be outlined, with references to the preparative qualitative steps where suitable or necessary:

RESULTS

Link between active mobility and greenery

The experts considered the interrelation between mobility and greenery undisputable. Greening would have a lot of advantages according to them. The fol-

lowing aspects were mentioned which have a reference to literature, as well:

- Greening makes areas "human": Greening creates a distance to car traffic: *„Within a 30-40m of cross section of the street a human being without a tree feels lost"* (expert interview, traffic planner); greening makes people feel comfortable.
- Noise protection: Objectively greening has only a low noise-protection potential but in a subjective way it influences the feeling of noise protection.
- Shadowing: Greening protects against sun and gives shade to pedestrians and cyclists.
- Perception of seasons: Greening enables to register seasons more consciously. Thus, the contact to nature does not vanish. *"There is also room for insects and small crawlers"* (expert interview, traffic planner).
- Physical and psychological well-being: According to the experts, greenery helps to relax, makes the public space livelier, and has a positive effect for well-being. It stimulates the wish for staying outside.

The results of the first survey (n = 414) underlined the importance of greenery for active mobility, as well (see table 1).

- 75% of all respondents consider urban greenery as (very) important for their daily walks. Only 7% do not value greenery and 18% are indifferent. People who already walk and cycle a lot and elderly people appreciate urban greenery more than others.
- 64% would like to have more trees and plants in Vienna.
- 46% consider additional green areas more important than car parks. People who are used to walk a lot (significantly more than the average) often approve this statement, unlike those who use the car every day.
- 46% would walk more often if the city was greener. These data support the finding of the focus group interviews that greenery is possibly the most important incentive for walking.
- 31% would cycle more often if the city was greener.

Even though greenery motivates people to walk, the interviewees are less willing to make detours just to reach a "green-route" (35% would make a detour). Elderly people, women and those who walk often are more likely to make detours.

Experiences in the public space

In the focus group interviews the participants were asked to describe an attractive pedestrian route. The main characteristics of an attractive pedestrian route were: low car traffic; trees that provide shade and separate the pavement from the roadway; benches where you can sit and rest and watch the street or the surroundings. In the survey we asked what traffic characteristics are experienced as "usual" in public spac-

Table 1: Opinions with respect to greenery; Question: How much to you agree to the following statements? Agree – Agree mostly – neither nor – do not agree mostly – do not agree; the categories "agree" and "mostly agree", and "do mostly not agree" and "do not agree" are summarised.

Statement	Agree (mostly)	Neither nor	Do not agree (mostly)
For me greenery is important on all my ways in my everyday mobility	75%	18%	7%
There should be more trees in Vienna	64%	27%	9%
Additional greenery is more important than car parks	46%	27%	27%
I will walk more often, if the city is greener	46%	17%	37%
I will cycle more often, if the city is greener	31%	14%	55%
On my everyday routes I choose mainly green routes	49%	21%	44%
On my everyday routes I walk mainly in traffic calmed areas	57%	17%	26%
On my everyday routes I choose green routes even if it means to make a detour	35%	21%	44%

es: 71% (very) often experience that there was heavy car traffic, 56% (very) often walk in roads without green but with many parked cars, and 39% in roads where there are no seats/benches to rest on (see table 2). These experiences do certainly not reflect the expectations of an attractive route.

Comparison – subjective safety vs. attractiveness

The survey results indicated that greenery is important for active mobility. But does it really influence the attractiveness of streets? What kind of effect does it have on the subjective feeling of safety?

Attractiveness

In general, both roads did not get high scores for attractiveness. Only 6% of the respondents consider these streets 'attractive'. Some stated that these streets are 'rather attractive' which makes 20% for NG and 25% for LS (see figure 3).

LS with greenery, however, scored significantly better than NG ($\chi^2(4) = 19.76$, $p = .001$). More than 50% consider NG an 'unattractive' street. 'Unattractiveness' in both streets includes: heavy car traffic, noise and the lack of greenery.

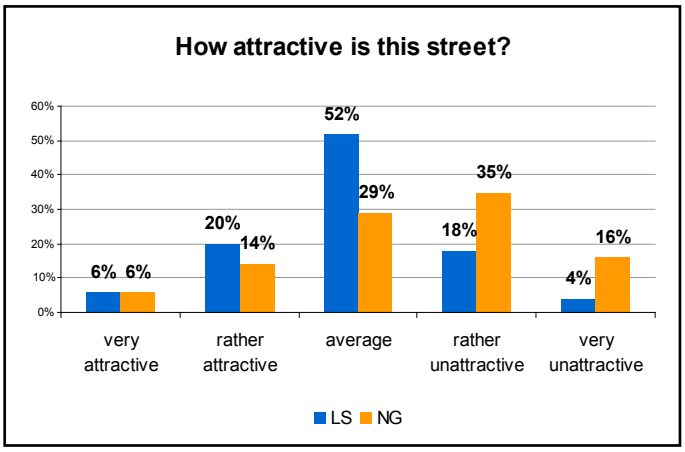
One third of the interviewee does not like walking in NG. In LS the share is significantly lower (13%; $\chi^2(4) = 10.30$, $p = .036$). Those who liked to walk in LS liked the many shops, the architecture and the greenery. In NG interviewees liked mainly the shops and restaurants.

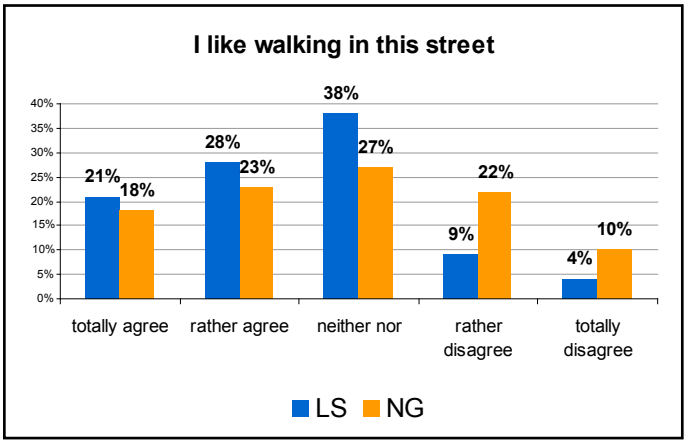
64% wouldn't like to 'sit on a bench' in NG. In LS significantly more people consider it likely to sit down on a bench (41%; $\chi^2(4) = 16.72$, $p = .002$).

Safety

With respect to the subjective feeling of safety the results turned out to be the opposite way (see figure 4).

NG was rated significantly better than LS with respect to safety ($\chi^2(4) = 22.88$, $p = .000$); 50% feel





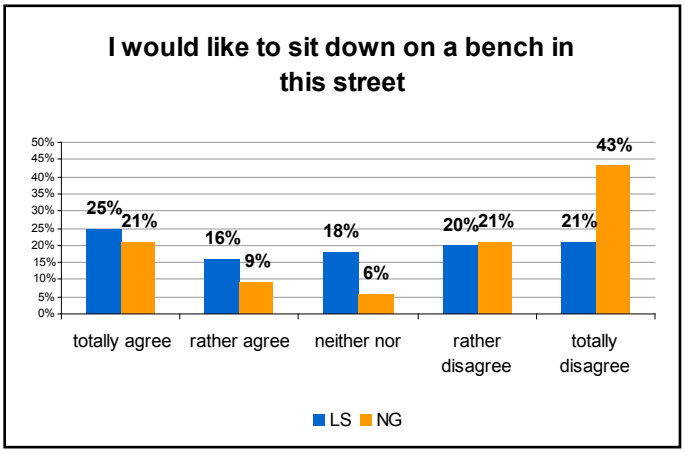


Figure 3: *Attractiveness scores in LS and NG (n = 200)*

Table 2: Experiences in public space - Question: How often do you experience the following situations on your everyday walks? (very often – often – sometimes – rarely – never)

Statement	Very often/often	Sometimes	Rarely/never
Roads with heavy car traffic	71%	19%	10%
Roads without green, but with many parked cars	56%	27%	17%
Roads where there are no seats/benches to rest on	39%	25%	26%

safe (as pedestrians) in NG. The share in LS is 24%. 21 % would let children walk on their own in NG and 11% in LS ($\chi^2(4) = 7.66$, $p = .105$). Car speeds are considered lower in NG than in LG ($\chi^2(4) = 12.00$, $p = .017$) but 'too fast' in both streets by less than 50 % in NG and 56 % in.

These results indicate that subjective feelings of safety seem not to correspond with greenery but rather with vehicle speed, which is lower in NG than in LS. 'Attractiveness' on the other hand seems to rather be linked to greenery and other infrastructural elements.

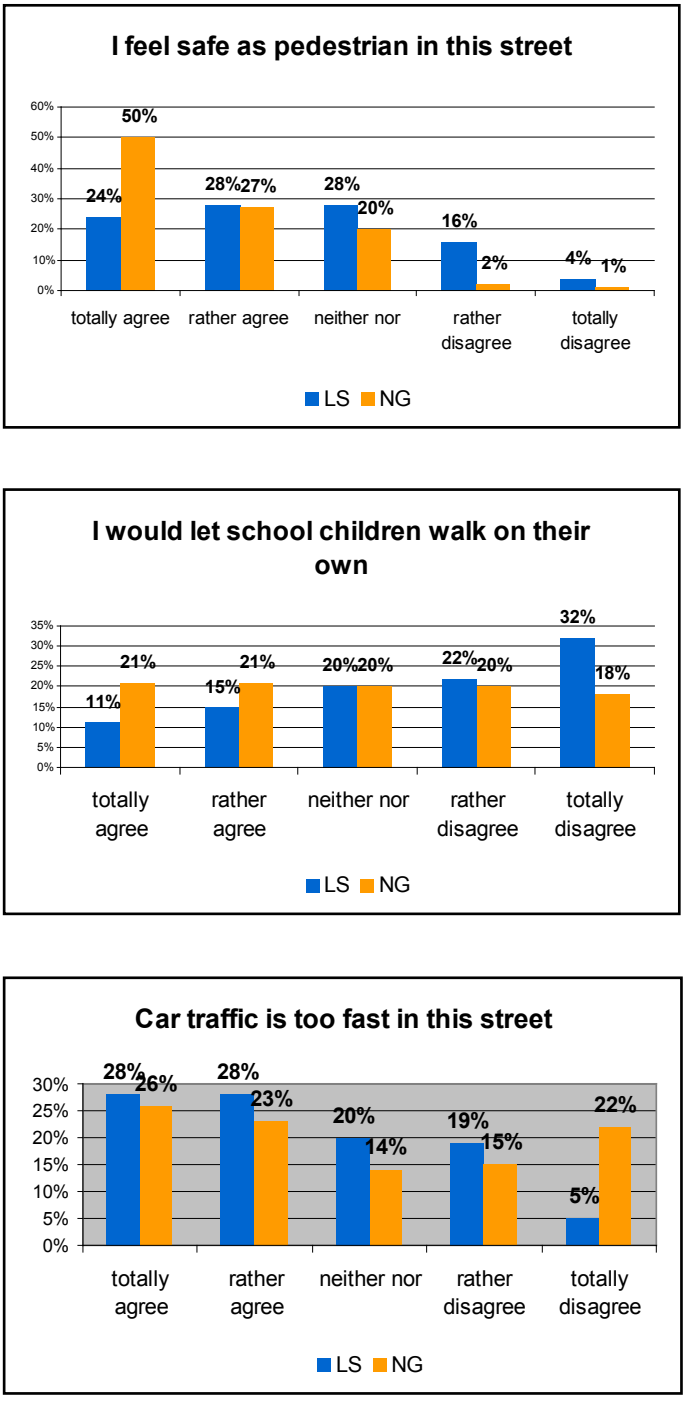


Figure 4: Safety scores in LS and NG (n = 200)

The results with respect to safety and attractiveness are also underlined when comparing the results of those people who consider the roads as attractive. They significantly enjoy walking more than those who do not evaluate the roads as attractive ($\chi^2(16) = 140.05$, $p = .000$). However, there is no significant result with respect to safety ($\chi^2(16)$ 24.12 = , $p = .087$). People considering the roads as attractive do not feel safer than those people who assess the roads as unattractive (see table 3).

Table 3: Attractiveness– Enjoyment of walking and feeling of safety

Evaluation	Enjoy walking	Feel safe
Road is attractive	47%	30%
neutral	41%	36%
Road is unattractive	12%	34%

DISCUSSION AND CONCLUSION

Greenery is considered as important aspect when walking and cycling. Especially elderly people, women and those who walk a lot value urban greenery. These target groups benefit the most if you make the city greener. You might not persuade car drivers by promoting attractive walking routes but if car drivers start walking because of other reasons greenery is an important aspect to make walking an enjoyable mode.

The readiness to make detours to reach a green route is low, especially among the car drivers. Green space planning and route planning should take this into consideration, when designing streets or planning routes. For instance, in navigation apps there should always be the option/suggestion of a possible detour of max 15% to choose a route with more green.

The survey underlined the necessity for a better cooperation between those responsible for city greenery (in Vienna "Stadtgartenamt) and the traffic planning departments. While traffic calming measures have the potential to increase the subjective feeling of safety, they do not automatically improve the attractiveness of the street. When it comes to greenery it is the other way around: attractiveness does not necessarily mean improved safety, for instance when one has to cross streets. If safe and attractive pedestrian routes are the goal, measures to both improve

Figure 5: Krongasse in Vienna, 1050 and the Krongarden
http://www.krongarten.at/d7141_8xw/krongarten/

attractiveness – e.g. with the help of greenery – and subjective safety (lower vehicle speeds) need to be combined.

There are some nice examples of a successful combination of these two elements in the city of Vienna. One of them is the so called Krongarten (see fig. 5). The Krongarten is located in a traffic calmed area (Krongasse; 30 km/h zone) in the inner city of Vienna. There used to be no green in this lane. A group of local artists decided to make the lane greener. In a long process they were allowed to make use of two parking spots for creating a green oasis. Since 2012 these two designated spots are designed and arranged by local residents during the summer time.

Such a procedure could make use of existing quality criteria. For instance, there are several national

Table 4: Quality criteria active mobility & greenery

Quality criteria according to WALCYNG/ HOTEL	Contribution of greenery
Safety (subjective and objective)	separation to cars – protection against accidents; protection against weather conditions (against sun, rain, wind); protection against harassment, lively streets prevent harassments
Comfort	Reduction of stress; traffic calming; broad sidewalks - accessibility
Aesthetic	Increase of sojourning; eye catcher; experiences of nature perception of seasons; cleanliness and maintenance of walking infrastructure; noise and air pollution reduction
Accessibility	Barrier free; Design for all to attract different kind of target groups
Sustainability	Climate stabilising function; Prevention of large scale sealing
Social Communication	Inducement of activities and communication
Participation	"Community gardening" - promotion of communication and social contact Identification with the neighbourhood and the district Prevention of vandalism by creating a sense of togetherness

and international research projects that deal with quality criteria for walking (see e.g. Cost action 358, Methorst et al. 2010). In the Eu-Project Hotel (Bein et al. 2004) quality criteria were set up on basis of the EU-Project Walcyng (Hyden et al. 1997). These criteria could be applied for green space planning, too. The following table (4) gives an overview of these criteria and the relation to green space planning

In summary, the results of empirical work in the project GoGreen indicate that there is a clear relation between urban greenery and the share of active mobility. The trend to more urban green is noticeable not only in Vienna, but it is a worldwide phenomenon, as greenery has the potential to improve quality of life (see eg. Müller 2008, Acebillo 2012, Grün Stadt Zürich 2006). The changes in awareness can be identified in residents' interests and attitudes, and in the planning and administration. The idea of a car-dominated city is being gradually replaced by a human-centred planning approach. Experts stress the importance of more intersectoral exchange and cooperation between traffic planning and green planning departments on a macro-, meso- and micro level as the coordination between traffic departments and green space planning is scarce. There is, therefore, room for improvement. Moreover, interdisciplinary research on this topic is necessary.

A professional handling of urban greenery with respect to planting, care and maintenance is important for a lasting success. Urban greenery has a stimulating and enlivening effect if it is well-kept and a visible part of a holistic city concept.

SHORT COMINGS OF THE STUDY

It is obvious that the two streets that were chosen for a comparison are very different in many respects that all could have an impact on how attractiveness and subjective safety are perceived. Thus, a statistically thorough calculation of such impacts is out of the question. However, both places differ distinctly in two aspects that are important for our study: In one road there is nice greenery, while the speed limit is at 50 km/h, while in the other street there is no greenery, but a 30 km/h limit leading to lower car speeds. In our opinion this makes it possible to at least attribute exploratory character to the study presented here. Considering the results, we conclude that it would make sense to carry out more research in order to compare the effects of car speeds and greenery, with more resources than those available to the authors of this study.

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