

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

Veerle Ross<sup>a</sup>, Ellen Jongen<sup>b</sup>, Karin Van Vlierden<sup>a</sup>, Kris Brijs<sup>a</sup>, Tom Brijs<sup>a</sup>, Ruben Hens<sup>a</sup>, Geert Wets<sup>a</sup>, Marleen Vanvuchelen<sup>c</sup>

<sup>a</sup>Hasselt University, School for Transportation Sciences, Transportation Research Institute (IMOB), Agoralaan gebouw D, 3590 Diepenbeek, Belgium

<sup>b</sup>Open University, Faculty of Psychology and Educational Sciences, Valkenburgerweg 177, Heerlen, The Netherlands

<sup>c</sup>Hasselt University, Rehabilitation Research Center (REVAL), Agoralaan gebouw D, 3590 Diepenbeek, Belgium

**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)<sup>1</sup> 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 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 Institute, 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.

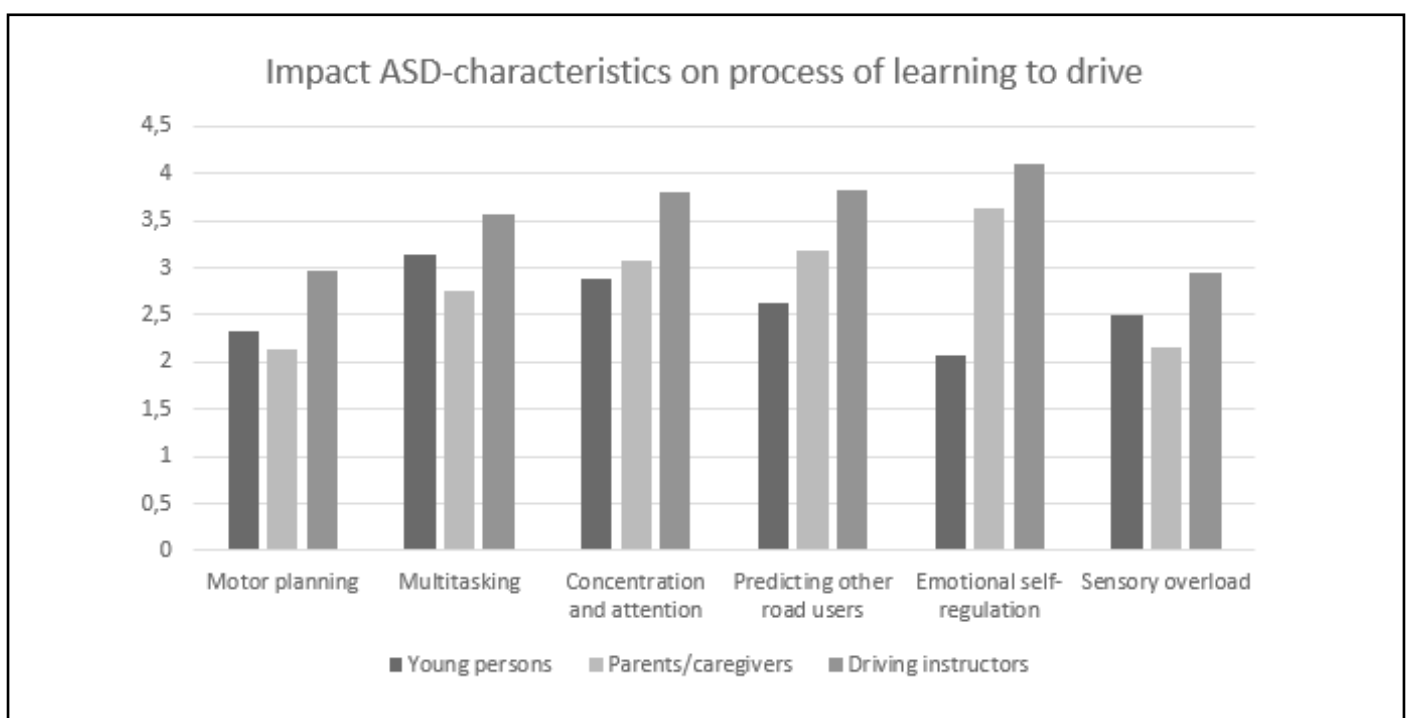
Because of the lack of interrelationship between the different groups of respondents and the differ-

ences 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**

Characteristic	Young persons			Parents/caregivers			Driving instructors		
	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>
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 benefits 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 per-

sons 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 meta-cognitive 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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