Smartphone Use While Driving: An Investigation of Young Novice Driver (YND) Behaviour

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A B S T R A C T

Road traffic collisions are the leading cause of death for those between the ages of 15–29, according to the World Health Organisation. This study investigates one of the primary reasons for the high fatality rate amongst Young Novice Drivers (YNDs) – their use of smartphones while driving. We gathered responses from a representative sample of YNDs on their behaviour while driving using an updated version of the ‘Behaviour of Young Novice Drivers Scale’. Survey responses totalled 700 YNDs situated throughout Germany. From these responses, we examined the prevalence of certain driving behaviours that are described as ‘distracting’ and compared these driving behaviours to the respondents’ use of specific smartphone features. The responses report that music-related activities (e.g. changing music on a smartphone) are most common amongst YNDs. Speaking on the phone is seldom-reported, although more males than females indicated engagement in this behaviour. We further carried out a correlation analysis and correspondence analysis. On that basis we found that those who report speaking on a smartphone are significantly more likely to engage in driving behaviours with potentially fatal consequences, such as speeding and driving while impaired by prohibited substances (drugs, alcohol). We propose that the results could be used by policymakers for public information implications and to tailor financial penalties for those engaging in smartphone behaviours that are linked to harmful driving behaviours. In addition, our findings can also be used in a Usage-based Insurance (UBI) context to financially incentivise safer driving.

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1. Introduction

Vehicles are not just a space where driving takes place. They are also important sites of social interaction where conversations are had and music is experienced in group settings (Merriman, 2009). Driver distraction has become an increasing concern among policy-makers. It is reported to be responsible for an estimated 28% of crashes in the United States (NCSA, 2018), with similar figures seen in other regions such as Australia and Spain (WHO, 2011). Distracted driving is typically referred to as engaging in competing non-driving related activities that individually or in any combination require visual,
cognitive, physical, auditory, and other resources (Young, Regan, & Hammer, 2007). The issue has been exacerbated by the rise in popularity of smartphones in the last decade (Dingus et al., 2016; Ortiz, Ortiz-Peregrina, Castro, Casares-López, & Salas, 2018).

Talking on hand-held phones can significantly increase the cognitive, physical and auditory workloads of drivers, and subsequently lead to reductions in the ability to perceive and appropriately react to unexpected crash events (Cazzulino, Burke, Muller, Arbogast, & Upperman, 2014; Haque & Washington, 2015; Mack & Rock, 1998). Klauer, Dingus, Neude, Sudweeks, and Ramsey (2006) found that the collision-risk for texting while driving is five times higher than driving under the influence of alcohol. Accordingly, Caird, Simmons, Wiley, Johnston, and Horrey (2018) found that sending a text negatively influences nearly all aspects of driving. That means that behaviours related to both texting and talking on hand-held phones are the most dangerous secondary activities within the car (Lansdown, 2012; Prat, Gras, Planes, Font-Mayolas, & Sullman, 2017). However, given the social interaction and information flow utility of smartphones (Park & Lee, 2014; Rosen, Whaling, Carrier, Cheever, & Rokkum, 2013), they are nevertheless used an average of 150 times a day, making them a focal point of drivers’ lives even throughout the driving task (Meeker & Wu, 2013).

Today’s Young Novice Drivers (YNDs)1, for the most part, have lived through their formative years with smartphones. As a result, those aged 18–25 years are more likely than any other age group to use a smartphone while driving (AAMI, 2012). These behaviours do not only include texting and talking on a hand-held phone. Due to the smartphone’s application-variability, a variety of new smartphone-related secondary activities (such as music-related smartphone use) is reported to be on the rise (George, Brown, Scholz, Scott-Parker, & Rickwood, 2018). That said, Luria (2018) found that young learners touch their smartphone 1.7 times per minute when driving a car. Hosking, Young, and Regan (2006) further found that YNDs spend up to 400 more time with their eyes off the road than other drivers. Klauer et al. (2014) calculated that phone use is associated with an eight-fold increase in crash risk for young drivers. Those results point to an alternative reasoning for crash risk that is associated with distracted driving, in that YNDs are not well-equipped with appropriate ‘safety-critical’ skills (i.e. attention maintenance, hazard anticipation, hazard mitigation) when handling adverse events (Cassarino & Murphy, 2018; Crundall et al., 2012; McKnight & McKnight, 2003; Muttart, 2013; Pradhan & Crundall, 2016). That makes YNDs one of the most vulnerable groups to smartphone use while situated in road traffic. That said, smartphone use is not only dangerous in and of itself, but may also be an effective proxy for an elevated risk appetite of YNDs (Beck, Yan, & Wang, 2007; Scott-Parker, Watson, King, & Hyde, 2013).

There have been multiple approaches in safety research to allow for a profound understanding of the complex problem of YNDs’ smartphone use (Gauld, Lewis, White, & Watson, 2016; George et al., 2018; Hassani et al., 2017; Montag et al., 2015). In Germany almost 99% of young drivers aged 18–25 years own a smartphone (mpfs, 2020). Nevertheless, information about their specific smartphone use while driving is limited. Police reports, for instance, collect information about driver distraction but do not systematically gather information about granular smartphone-related activities (e.g. texting, talking etc.). Also, drivers are inherently unlikely to report smartphone use after a collision given that it is a prohibited action that can lead to significant penalties (§23 StVO, German Traffic Law). Vollrath, Huemer, Teller, Likhacheva, and Fricke (2016) performed an observational study to gather information about the smartphone use of (young) German drivers, allowing them to overcome ‘false testimony’ issues. However, even if observational studies can overcome some of the aforementioned limitations, observers will find it difficult to distinguish between specific smartphone-related activities; for example, whether a driver is texting or searching for music. Therefore, this research adds to extant road safety and driving behaviour literature by considering smartphone use behaviours from the perspective of German YNDs. In addition to providing an insight into YNDs’ self-reported smartphone use behaviour, we contextualise their smartphone related activities against other risky driving behaviours. Based on these research objectives, we formulate three research questions:

1. Which smartphone use behaviours are most prominent amongst German YNDs?
2. Which smartphone use behaviours are most prominent amongst males and females?
3. Are YNDs who engage in smartphone use behaviours while driving also more likely to engage in other risky driving behaviours?

To answer these questions, we revert to the Behaviour of Young Novice Drivers Scale (BYNDS). This tool was originally developed by Scott-Parker, Watson, and King (2010) and since then validated in further YND studies (Jannusch, Völler, Murphy, & Mullins, 2020; Oviedo-Trespalacios & Scott-Parker, 2017; Scott-Parker & Proffitt, 2015; Šeibokaite et al., 2020). In the last decade, however, the smartphone has become a prominent feature of YNDs’ lives. Therefore, this nation-wide study is based on the latest, updated German version of the BYNDS, which seeks to overcome some of the temporal and cultural limitation of the original (Jannusch et al., 2020). In terms of the temporal limitations, the inclusion of multiple modes of

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1 In this study YNDs include those aged 18–24 years who drive at least an average of 1,000 km per year.
smartphone interaction is a particularly notable update since the development of the BYNDS in 2010, which enables the present analysis.

2. Methodology, data collection and description

As the original version of the BYNDS (Scott-Parker, Watson, & King, 2010) does not capture the increased diversity of YNDs behaviours, we use an updated version of the BYNDS provided by Jannusch et al. (2020). This version is timely commensurate and allows us to gather a broader picture on young drivers’ perceived smartphone use while driving.

Validation of the German version of the BYNDS using Exploratory Factor Analysis (EFA) resulted in a five-factor solution which is consistent with the original Australian version of the BYNDS proposed by Scott-Parker et al. (2010). The German version was found to explain a variance of about 52%. That outcome is not as good as the Australian version of the BYNDS, but is slightly better than for example the New Zealand version of the BYNDS with 49.30% of variance explained (Scott-Parker & Proffitt, 2015; Scott-Parker, Watson, King, & Hyde, 2012). Cronbach’s alpha ($\alpha$) was used to evaluate the internal consistency of the resulting composite scale and subscales (Table 1).

The internal consistency within each subscale of the updated BYNDS is high and ranges from 0.85 (risk exposure) to 0.92 (deliberative endangerment). Overall, the results provided by (Jannusch et al., 2020) indicate that the updated version of the BYNDS is a reliable and valid measurement tool upon which to base our conclusions on YNDs’ driving behaviour in Germany. Further details on the assessment for reliability and validity can be found in (Jannusch et al., 2020).

A stratified sample of 350 female and 350 male YNDs participated in the survey (N = 700). With a Kaiser-Meyer-Olkin measure (KMO) of 0.95 this sample size is suitable for further evaluation (Hutcheson & Sofroniou, 1999). The average age of the sample was 21.41 years (SD = 1.93). To ensure that all YNDs in our survey drive a vehicle on a regular basis, participants who reported to drive less than 1,000 km per year were excluded from the survey. That led to an average driving exposure between 5,000 – 10,000 km per year. Table 2 outlines the response distribution for the full set of items with smartphone related responses highlighted at the top.

In order to obtain a more nuanced view on the gender-specific smartphone-related activities, we aggregate and analyse the response distribution in three modes in Section 3. These include regular smartphone use (participants who indicated usage as ‘almost always’ and ‘often’), occasional smartphone use, and seldom (‘sometimes’) smartphone use. Further analyses on the relationship between smartphone-related activities and other risky driving behaviours, using a correlation analysis and correspondence analysis, are provided in Section 3.2.

The relationships between responses to the German BYNDS were measured by non-parametric Kendall’s tau-b ($\tau$) correlations. Correspondence analysis has previously been applied in research fields such as sociology and psychology (Beh and Lombardo, 2014). It was developed by Escofier-Cordier (1969) with the aim to explore the relative relationship between and within two groups of variables through the use of factor scores. Factor scores represent the similarity in the structures within a set of rows and columns (Abdi & Béra, 2014). The factor scores can be plotted as maps in which rows and columns of a contingency table constitute the coordinates of the factor scores. That allows for a graphical illustration of the most important relationships among the variables’ response categories. This relationship is calculated in terms of the distance between individual row and column profiles, and the distance to the average row and column profile, in a low-dimensional space (Abdi & Béra, 2014; Benzécri, 1992; Nagpaul, 1999). The total variance of the factor scores is proportional to the independence chi-square statistics ($\chi^2$) of the contingency table. On that basis, in a correspondence analysis, the factor scores dissemble this $\chi^2$ statistic into orthogonal components (Abdi & Béra, 2014; Benzécri, 1992). Section 3.2.2 further explains the merits of correspondence analysis for the purposes of our analysis. Data analysis was performed in RStudio version 1.2.1335. For correspondence analysis we used the R packages FactoMineR and factoextra.

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Table 1

| Variance explained (%) | DE  | UD  | SP  | RE  | SMP |
|-----------------------|-----|-----|-----|-----|-----|
| Cronbach's alpha ($\alpha$) | 14.36 | 11.63 | 9.81 | 8.05 | 7.68 |

DE = deliberative endangerment; UD = unfocused driving; SP = speed; RE = risky exposure; SMP = smartphone distraction.

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Cronbach’s alpha indicates the reliability of responses to a survey. Values over 0.9 indicate that the responses were not, as a whole, falsely reported and are reliable indicators of the sample’s true beliefs.
Table 2
YNDs’ responses to the German BYNDS (N = 700), 2019, Germany.

| Item                                                                 | Never % | Sometimes % | Occasionally % | Often % | Almost Always % |
|----------------------------------------------------------------------|---------|-------------|----------------|---------|-----------------|
| Smartphone related behaviour                                        |         |             |                 |         |                 |
| You interact with your music application (e.g. Spotify)              | 255     | 35%         | 13%            | 21%     | 98%             |
| You change the music on your smartphone                              | 244     | 35%         | 12%            | 20%     | 111%            |
| You search for music on your smartphone                              | 399     | 43%         | 24%            | 16%     | 74%             |
| You send a voice message on your smartphone                          | 542     | 49%         | 23%            | 16%     | 55%             |
| You send test messages on your smartphone                            | 379     | 54%         | 22%            | 13%     | 39%             |
| You read messages on your smartphone                                | 268     | 38%         | 24%            | 11%     | 58%             |
| You speak on a mobile that you hold in your hands                    | 435     | 63%         | 12%            | 8%      | 26%             |
| You use your phone while texting                                     | 792     | 56%         | 24%            | 11%     | 13%             |
| Average smartphone use                                               | 220     | 46%         | 16%            | 12%     | 66%             |
| Other risky driving behaviour                                        |         |             |                 |         |                 |
| You wear your seatbelt                                               | 19%     | 3%          | 4%             | 2%      | 23%             |
| Your passengers wear seatbelts                                       | 17%     | 2%          | 4%             | 3%      | 64%             |
| You indicate when you are changing lanes                            | 17%     | 2%          | 1%             | 2%      | 11%             |
| You drive after taking an illicit drug such as marijuana or ecstasy  | 589     | 61%         | 13%            | 6%      | 2%              |
| You search for music on your smartphone                              | 593     | 85%         | 6%             | 5%      | 3%              |
| You carry more passengers than there are seatbelts for in your car   | 519     | 74%         | 5%             | 6%      | 29%             |
| You wear a seatbelt if it is only for a short trip                   | 56%     | 5%          | 4%             | 6%      | 17%             |
| You carry more passengers than can legally fit in your car          | 522     | 75%         | 3%             | 2%      | 4%              |
| If there is no red light camera, you drive through intersections on a red light | 533     | 76%         | 1%             | 6%      | 16%             |
| You drive when you think you may have been over the legal alcohol limit | 547     | 76%         | 11%            | 7%      | 33%             |
| You overtake a car on the right out of town (e.g. highway)          | 581     | 54%         | 24%            | 11%     | 25%             |
| You go more than 20 km/h over the speed limit in town (e.g. 70 km/h) | 428     | 61%         | 27%            | 11%     | 24%             |
| You actively take part in a conversation with your passengers       | 21%     | 3%          | 8%             | 6%      | 24%             |
| You see a red light camera, you drive through intersections on a red light | 415     | 59%         | 13%            | 6%      | 13%             |
| You travel in the left lane on multilane highways                    | 581     | 54%         | 24%            | 11%     | 25%             |
| You do an illegal U-turn (A U-turn is a 180 degree change of direction.) | 592     | 54%         | 24%            | 11%     | 25%             |
| You misjudge the speed of an oncoming vehicle                       | 598     | 48%         | 30%            | 5%      | 13%             |
| You miss your exit or turn                                          | 63%     | 3%          | 21%            | 6%      | 9%              |
| You misjudge the gap when you are turning left                      | 318     | 45%         | 35%            | 14%     | 8%              |
| You misjudge the gap when you are overtaking another vehicle        | 291     | 42%         | 35%            | 14%     | 8%              |
| You misjudge the distance you need                                   | 242     | 55%         | 26%            | 14%     | 8%              |
| You misjudge the speed when you are exiting a main road             | 227     | 32%         | 40%            | 21%     | 6%              |
| You turn right, into the path of another vehicle                    | 398     | 57%         | 30%            | 6%      | 8%              |
| You enter the road in front of another vehicle, without leaving them much space | 600     | 41%         | 39%            | 4%      | 7%              |
| Your driving is affected by music                                    | 191     | 27%         | 30%            | 25%     | 77%             |
| Your driving is affected by noise                                    | 89%     | 11%         | 37%            | 25%     | 77%             |
| You drive when you are tired                                        | 152     | 22%         | 41%            | 19%     | 27%             |
| You allow your driving style to be influenced by what mood you are in | 135     | 19%         | 22%            | 32%     | 21%             |
| Your driving is affected by negative emotions like anger or frustration | 180     | 26%         | 20%            | 33%     | 23%             |
| You go for a drive with your mates giving directions to where they want to go | 68%     | 10%         | 16%            | 24%     | 42%             |
| You overdrive at an intersection when the light goes green          | 102      | 15%        | 24%            | 13%     | 50%             |
| You go over the speed limit in areas where it is unlikely that there is a radar or speed camera | 154     | 22%         | 30%            | 18%     | 27%             |
| You go up to 10 km/h over the speed limit out of town (e.g. 105 km/h) | 96       | 14%         | 18%            | 20%     | 50%             |
| You go up to 20 km/h over the speed limit out of town (e.g. 112 km/h) | 154     | 22%         | 18%            | 19%     | 28%             |
| You go up to 10 km/h over the speed limit in town (e.g. 55 km/h)      | 111     | 16%         | 19%            | 17%     | 26%             |
| You go up to 20 km/h over the speed limit in town (e.g. 62 km/h)     | 247     | 35%         | 20%            | 30%     | 60%             |
| You delay or do not change when overtaking                           | 163     | 23%         | 20%            | 16%     | 27%             |
| You go more than 20 km/h over the speed limit out of town (e.g. 125 km/h) | 291     | 42%         | 21%            | 13%     | 4%              |
| You go too fast around a corner                                      | 502     | 43%         | 31%            | 10%     | 16%             |
| You speed at night on roads that are not well lit                   | 401     | 43%         | 31%            | 11%     | 7%              |
| You drive faster if you are in a bad mood                           | 259     | 57%         | 20%            | 30%     | 60%             |
| Your driving is affected by noise                                    | 136     | 18%         | 36%            | 26%     | 77%             |
| You speed up when the light goes yellow to get across the crossroads before the red light | 76       | 14%         | 23%            | 27%     | 37%             |
| You drive in the snow                                               | 40%     | 6%          | 28%            | 12%     | 26%             |
| You drive in the rain                                               | 12%     | 6%          | 3%             | 1%      | 2%              |
| You drive at night                                                  | 20%     | 9%          | 25%            | 19%     | 66%             |
| You drive at dusk or dawn                                           | 26%     | 4%          | 15%            | 34%     | 22%             |
| You drive on icy roads                                              | 106     | 10%         | 28%            | 21%     | 25%             |
| You drive at peak times in the morning and afternoon                | 27%     | 4%          | 16%            | 21%     | 31%             |
| You drive on the weekend                                            | 12%     | 6%          | 3%             | 1%      | 2%              |
| You carry your friends as passengers at night                       | 60%     | 9%          | 22%            | 23%     | 36%             |
| Your car is full of friends as passengers                           | 29%     | 6%          | 15%            | 34%     | 22%             |
| You interact with your navigation system while driving              | 125     | 18%         | 26%            | 12%     | 22%             |
| You try to reach an object unrelated to the driving task            | 161     | 23%         | 26%            | 12%     | 22%             |
| You eat or drink while driving                                      | 110     | 16%         | 22%            | 32%     | 36%             |
3. Results

3.1. Analysis of the response distribution overall, and on three classes of interaction

The following subsection provides a breakdown of the gender-specific smartphone use based on three classes of interaction: those who regularly use their smartphone while driving, those who occasionally use their smartphone while driving, and those who seldom use their smartphone while driving. Fig. 1 presents an overview of the smartphone use associated with YNDs in Germany, based on the specific applications used. From a total of 700 YNDs, 65% indicated they have changed the music on their smartphone while driving. Some 63% of the participants reported to generally interact with a music application.

Responses suggest that more males (32%) than females (29%) read notifications on their smartphones. More than half of YNDs indicated that they have searched for music (57%) or sent voice messages (51%) while driving. Some 46% of YNDs report sending text messages while driving and hiding their phone while texting (M: 46% vs. F: 22%). However, more males than females reported hiding their smartphone while texting (M: 21% vs. F: 14%) and speaking on hand-held phones (M: 21% vs. F: 14%).

Overall, both genders generally display similar patterns of smartphone use, although slight deviations are found between genders for behaviours such as reading notifications, hiding their smartphone while texting, and speaking on hand-held phones.

3.1.1. Regular smartphone use

Some 14% of the sample reported to regularly use their smartphone while driving, on average (Table 2). Males are more likely to regularly use their smartphone while driving than females (Fig. 2). Some 11% of male YNDs, compared to 10% of female YNDs, usually read notifications. Likewise, more males (11%) than females (7%) send text messages while driving and hide their phone while texting (M: 13% vs. F: 12%). Some 11% of female and male participants reported using their smartphone to send voice messages. In comparison, almost one-quarter of male and female YNDs use their smartphone regularly to interact with a music application or to change the music while driving. However, female YNDs report using a music application (F: 24% vs. M: 21%) more frequently than male YNDs. By contrast, more male than female YNDs indicated that they change the music on their smartphone while driving (M: 23% vs. F: 21%). Fewer respondents report searching for music however (M: 15% vs. F: 11%). Moreover, only 4% of female YNDs reported engaging on a hand-held phone-call. In comparison, almost twice as many male YNDs reported to do so regularly (7%).

3.1.2. Occasional smartphone use

Some 17% of the sample reported ‘occasionally’ using their smartphone while driving, on average. As with ‘regular’ smartphone users, more male YNDs occasionally use their smartphones while driving than females (Fig. 2). This includes using their smartphones to read text notifications while driving (M: 20% vs. F: 14%), writing texts (M: 14% vs. F: 10%) while driving and hiding their phone while texting (M: 15% vs. F: 11%). Some 11% of female and male participants report using a hand-held phone (M: 11% vs. F: 5%), operating a music app (M: 25% vs. F: 19%), and searching for music on the app (M: 20% vs. F: 19%). The same proportion of females and males occasionally use

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3 Interacting with a music application refers to the general use of a specific applications like Spotify or Apple music while driving. In contrast, changing individual songs can also be performed without entering into the application, for instance via lock screen.
their smartphones to send voice messages while driving (18%). However, a higher percentage of females change music while driving (F: 22% vs. M: 19%).

3.1.3. Seldom smartphone use

Some 24% of the sample reported only ‘sometimes’ to use their smartphone while driving. Amongst those who seldom use their smartphone while driving, the distribution or behaviours amongst genders are very similar (Fig. 2). Some 35% of female and 34% of male YNDs rarely read notifications on their smartphone. In comparison, more female than male YNDs report using their smartphones to send text messages (F: 26% vs. M: 23%). Around 18% of YNDs report hiding their phone while texting on rare occasions, while 23% of YNDs seldom send a voice message while driving. Slightly more females than males (F: 20% vs. M: 19%) interacted with a music application and searched for music (F: 24% vs. M: 23%). More male than female YNDs change the music while driving (M: 24% vs. F: 21%), however, more males than females engage with hand-held phone calls (M: 24% vs. F: 19%). This percentage of use is much higher than in other dimensions (i.e. in comparison to those who ‘regularly’ or ‘occasionally’ use smartphones) and is a surprising observation given plethora of road safety efforts of the German Road Safety Council (DVR) together with the European Transport Safety Council (ETSC) and law enforcements (§23 StVO, German Traffic Law) that have sought ban this action in Germany.
3.2. Exploratory analysis of the relation of smartphone use and other risky driving actions

3.2.1. Correlation analysis

Table 3 displays correlations between smartphone use and other risky driving behaviour reported by YNDs. Only risky driving behaviours that showed at least a ‘small’ but substantive correlation with smartphone use (>0.2) are extracted. The abbreviations introduced in Table 3 are also used in the subsequent correspondence analysis.

Table 3
Correlations between smartphone use and other risky driving behaviour among YNDs in Germany, 2019 (N = 700). Results presented indicate driving behaviours that showed at least a ‘small’ but substantive correlation with smartphone use (>0.2).

| Items               | Abbreviation | Speak | Read | Text | Hide | Voice | Music_app | Search | Change |
|---------------------|--------------|-------|------|------|------|-------|-----------|--------|--------|
| Accidents           | Accidents    | 0.13  | 0.20 | 0.20 | 0.20 | 0.13  | 0.08      | 0.07   | 0.09   |
| Medical             | Medical      | 0.29  | 0.19 | 0.28 | 0.25 | 0.29  | 0.15      | 0.18   | 0.19   |
| Speeding no radar   | Sp_radar     | 0.15  | 0.23 | 0.23 | 0.26 | 0.19  | 0.22      | 0.19   | 0.17   |
| 10km/h in town      | iT_10kmh     | 0.14  | 0.23 | 0.16 | 0.21 | 0.14  | 0.14      | 0.11   | 0.15   |
| 10-20 km/h in town  | iT_10-20kmh  | 0.30  | 0.29 | 0.29 | 0.32 | 0.31  | 0.24      | 0.24   | 0.22   |
| + 20 km/h in town   | iT_over20kmh | 0.49  | 0.35 | 0.40 | 0.38 | 0.38  | 0.24      | 0.29   | 0.29   |
| + 20 km/h out of town | iT_over20kmh | 0.39  | 0.26 | 0.29 | 0.36 | 0.29  | 0.20      | 0.19   | 0.21   |
| Speeding not well lit | Sp_blight    | 0.42  | 0.35 | 0.31 | 0.35 | 0.31  | 0.23      | 0.15   |        |
| Speeding curve      | Curve        | 0.37  | 0.37 | 0.28 | 0.32 | 0.31  | 0.16      | 0.16   | 0.18   |
| Speeding overtaking | Sp_overt     | 0.21  | 0.26 | 0.25 | 0.33 | 0.25  | 0.24      | 0.24   | 0.25   |
| Overturning left    | Left_driving | 0.50  | 0.37 | 0.46 | 0.38 | 0.38  | 0.19      | 0.35   | 0.22   |
| U-Turn              | U_Turn       | 0.33  | 0.28 | 0.30 | 0.31 | 0.36  | 0.20      | 0.25   | 0.20   |
| Drug use            | Drug         | 0.58  | 0.36 | 0.42 | 0.39 | 0.37  | 0.19      | 0.24   | 0.18   |
| Drunk driving       | Drunk        | 0.43  | 0.39 | 0.40 | 0.39 | 0.34  | 0.19      | 0.27   | 0.21   |
| Drivers licence     | No_licence   | 0.54  | 0.37 | 0.36 | 0.35 | 0.37  | 0.18      | 0.21   | 0.17   |
| Red light crossing  | Red_light    | 0.50  | 0.30 | 0.36 | 0.36 | 0.32  | 0.19      | 0.22   | 0.18   |
| Passengers legally fit | P_legal     | 0.55  | 0.40 | 0.39 | 0.32 | 0.39  | 0.25      | 0.23   | 0.28   |
| Passengers seatbelt | P_seatbelt   | 0.58  | 0.40 | 0.44 | 0.35 | 0.41  | 0.25      | 0.25   | 0.31   |
| Left driving        | Left_driving | 0.47  | 0.33 | 0.34 | 0.29 | 0.30  | 0.21      | 0.28   | 0.23   |
| Speak on hand-held phone | Speak     | 1.00  | 0.50 | 0.54 | 0.83 | 0.47  | 0.29      | 0.36   | 0.29   |
| Read notifications  | Read         | 1.00  | 0.57 | 0.52 | 0.52 | 0.42  | 0.44      | 0.44   | 0.43   |
| Send texts          | Text         | 0.10  | 0.62 | 0.60 | 0.39 | 0.47  | 0.43      |        |        |
| Hide while texting  | Hide         | 1.00  | 0.53 | 0.53 | 0.34 | 0.44  | 0.33      |        |        |
| Voice message       | Voice        | 1.00  | 0.38 | 0.42 | 0.43 | 0.42  | 0.44      |        |        |
| Music application   | Music_app    | 0.2-0.29 | small effect | 1.00 | 0.61 | 0.64 |        |        |
| Search for music    | Search       | 0.3-0.49 | medium effect | 1.00 | 0.60 | 0.60 |        |        |
| Change music        | Change       | 0.5-1.0 | strong effect | 1.00 | 0.60 | 0.60 |        |        |

Overall the data suggests that YNDs who reported to speak on a hand-held phone, read texts, send texts, hide their phone while texting and send voice messages are more often engaged in other risky driving behaviour than YNDs who only indicated music related behaviour. However, there exist two exceptions; a moderately-strong correlation effect between ‘searching for music’ and overtaking on the right side (0.35) as well as ‘changing music’ and taking more passengers than seatbelts available in a car (0.31). The data suggests that those who reported talking on a hand-held phone are associated with the riskiest behaviours. Speaking on a hand-held phone is strongly correlated with behaviours such as overtaking on the right (0.50), red light crossing (0.50), driving without a valid licence (0.54) and driving while intoxicated (0.58). Moreover, the data indicates a moderately-strong effect between talking on a hand-held phone and speeding more than 20 km/h faster than allowed in an urban area (0.49). Speeding in urban areas is also moderately correlated with behaviours like reading notifications (0.35), sending texts (0.40) or sending voice messages (0.38). Drivers who read texts while driving also seem to be likely to take more passengers than legally fit (0.40) or than there are seatbelts in the car (0.40). Taking more passengers than seatbelts in the car is also moderately correlated with texting while driving (0.44). In addition, there exists a moderately-strong correlation of 0.46 and 0.42 between texting while driving and driving while intoxicated and while overtaking a car on the right side. The moderately-strong correlation effect is slightly smaller (0.39) between hiding a phone and drunk driving. In addition, hiding a phone is moderately associated with drug use (0.39). For YNDs who send voice messages, the correlation analysis reveals the strongest effects are found with those who choose to take more passengers than seatbelts available (0.41) and more passengers that can be legally allowed to travel in the vehicle (0.39).

3.2.2. Correspondence analysis

Correspondence analysis constitutes an extension of principal component analysis (Abdi & Béra, 2018). It is a geometric statistical approach to graphical analysis the association between rows and columns of a contingency table in a two-dimensional plot (Glynn, 2014). Correspondence analysis does not, however, graphically represent which rows or columns...
have the highest response numbers compared to the frequency analysis in Section 3.1. Instead, it indicates the latent relationships between these reported behaviours by measuring their relative ‘above-average’ association. The average association between behaviours is located at the origin, where the x- and y-axis meet. The further the row or column label is located from the origin, the stronger the independence of the row or column label from its row-wise or column-wise average. Furthermore, column points (red) with similar profiles are close on the factor map. On that basis, Fig. 3 shows a distinct separation between those who use their smartphones regularly while driving (often), those who use their smartphones occasionally while driving (occasional), and those who rarely use their smartphones while driving (seldom). However, there is little distinction between the genders within each subclass indicating a similar profile. For instance, females who often (Females_often) use their smartphones are located close to (closely associated) males who often (Males_often) use their smartphones.

3.2.2.1. Correspondence analysis on smartphone use against gender.

Fig. 3 displays a correspondence analysis of smartphone use (blue) against gender (red) to see which smartphone behaviours are more aligned with each gender. Thereby it also takes into account the interaction frequency reported by the YNDs. Together, both dimensions explain 99.51% of the variance within the data. That suggests that the map represents almost all information in the residuals. For better orientation, the abbreviations introduced in Table 3 are consistent with the abbreviations used in Figs. 3 and 4. When considering the effect of smartphone use frequency with specific smartphone behaviours, the distance from the origin indicates the strength of the relationship between row and column labels in the same graphical region. The longer a ‘line’ can be drawn from the origin, the higher the association. In addition, the smaller the angle that can be formed by drawing lines from the origin for row and column labels, the stronger the association between smartphone use frequency and smartphone use behaviour. We have added two arrows to Fig. 3 to better highlight this manner of association.

These two arrows, for instance, highlight a significant association between females who often use their smartphone while driving, and those who change the music on their smartphones while driving. An angle of 90 or 180 degrees between these two labels would indicate no association or a negative association, respectively (Greenacre, 2017). According to Fig. 3, males and females often hide the fact they are using their smartphones during their driving tasks. Fig. 3 also reveals a strong association between Music_app and Females_occasional, indicating that females are more likely to occasionally interact with music applications while driving. The data also reveals that respondents rarely engage in smartphone behaviours that have previously identified as the most distracting behaviours in UK drivers (Lansdown, 2012), such as reading and writing messages, and talking on a hand-held phone. However, around a quarter still ‘sometimes’ engage in these actions (Table 2), and Fig. 3 reveals that females are more associated with speaking on their smartphones, while males are more associated with sending text messages.

3.2.2.2. Correspondence analysis on smartphone use against other risky driving behaviours.

In addition to a gender-level view on smartphone use behaviours, we seek to analyse the association between smartphone use behaviours and more traditionally-recognised ‘dangerous’ driving behaviours. Fig. 4 displays the correspondence analysis of smartphone use (blue) against risky driving behaviours identified in Table 3 (red). Only the more prominent relationships are included to allow for a better specification of the associations between smartphone use and dangerous driving behaviours. Overall, Fig. 4 explains 71.64% of the variance in the residuals.
Speaking on a smartphone while driving is a highly discriminating variable and is largely associated with more egregious driving behaviours. *Speak* is strongly associated with high-risk driving behaviours such as *No_licence* (driving without a licence), *Drug* (driving while under the influence of drugs) and *Red_light* (driving through red traffic lights). This is confirmed by the correlation analysis in Table 3. On that basis our data suggests that there are likely to be groups of ‘problem young drivers’ within the young driver cohort who commit a variety of high-risk driving behaviours. The correspondence map also shows a strong association between *Search* (searching for music) and *U_Turn*, followed by *Hide* (hiding their smartphone while texting) and *Drunk* (driving while under the influence of alcohol). *Music_app* (use of the music applications on smartphones) is likely to be associated with speeding actions, although these associations are not highly discriminatory. These include actions such as *Sp_overt* (speeding while overtaking), *iT_10_20kmh* (speeding 10–20 km/h over the speed limit in urban areas), *iT_over20kmh*, and *oT_over20kmh* (speeding over 20 km/h over the speed limit in both urban and rural areas). Those who change the music on their smartphones while driving are most-associated with risky actions such as *P_seatbelt* (allowing more passengers in their vehicle than seatbelts available) and *P_legal* (fitting more passengers in their vehicle than legally allowed), although this is a variance that is shared with those who speak on a hand-held phone while driving.

4. Discussion

Today’s young drivers use their smartphones in such a high frequency that it’s use while driving may seem natural even if their behaviour endangers lives. There have been different approaches in safety research including self-report measures and observational studies to allow a profound understanding of the complex problem of YNDs’ smartphone use (Gauld et al., 2016; George et al., 2018; Hassani et al., 2017; Montag et al., 2015). For German YNDs, however, there exists little peer-reviewed information. This study aims to fill this lacuna by adding to the discussion about YNDs’ smartphone use. We carry this out by elaborating on the specific smartphone use behaviour, and identify more granular activities (e.g. music related activities) than the ‘texting and talking on hand-held phone’ behaviours that have been identified as the most dangerous secondary activities (Lansdown, 2012; Prat et al., 2017). In addition, the contextualisation of smartphone related activities with other risky driving behaviour reveals new insights about German YNDs risky driving characteristics.

Based on the distribution of responses, male YNDs seem to be more prone to smartphone use while driving than female YNDs. That outcome is not surprising as a sizeable body of research has found that male YNDs tend to be more risk-seeking than female YNDs (Constantinou, Panayiotou, Konstantinou, Loutsiou-Ladd, & Kapardis, 2011; Evans & Hampson, 2014; Prato, Toledo, Lotan, & Taubman-Ben-Ari, 2010; Smart, Stoduto, Mann, & Adlaf, 2004).

Music-related activities are most widespread and perceived as the most regular smartphone use whereby almost 65% of participants reported searching for music while driving at least from time-to-time. The prominence of music-related smartphone use is also reported by George et al. (2018) who, nevertheless suggest that there appears to be a greater justification for changing music compared to search for music. Our data supports that finding; indicating that YNDs are less engaged in searching for music than changing music while driving. Due to the overall high percentage of YNDs using their phone for music-related activities, it is conceivable that YNDs perceive music-related activities as less dangerous. This could be attributed to the fact that drivers are allowed to use the car stereo while driving, which implies that changing or searching for music is safe. Nevertheless, changing music while driving, like reading or writing text messages, can cause cognitive, visual and physical distraction and significantly increase the risk for road traffic collisions (Oviedo-Trespalacios, Haque, King, & Washington, 2016).

Reading text messages was reported by 62% of YNDs, although the majority of female and male YNDs indicated that they do so infrequently. YNDs’ strong engagement in texting while driving was also reported in other young driver populations (Atchley, Atwood, & Boulton, 2011; Bazargan-Hejazi et al., 2017; George et al., 2018; Young & Lenné, 2010). In 2015, a US national survey reported that 59% of drivers aged 19–24 years engaged in reading a text message at least once in the past 30 days. In contrast to
reading, Atchley et al. (2011) reported that a majority of YNDs also send text messages while driving. In the case of German YNDs, the amount of participants who reported texting while driving is with 46% lower and only some 11% of male and 7% of female YNDs reported sending text messages while driving regularly. Murphy, Gauld, and Lewis (2020) provide a possible explanation for the high difference between YNDs who read and send text messages respectively. One of the researchers’ main argument is that reading can be carried out quickly, with little effort. As a result, YNDs might perceive reading as less dangerous or distracting than sending a text. However, the percentage of German YNDs who at least ‘sometimes’ send text messages is still concerning at 46%.

Caird et al. (2018) find that sending a text had a negative impact on nearly all aspects of driving performance. The WHO stated that texting can reduce the reaction time among YNDs by 35%. In addition, Klauer, Dingus, Neale, Sudweeks, and Ramsey (2006) calculated that the risk for a collision caused by texting is 5 times higher than driving under the influence of alcohol.

Talking on a hand-held phone is another highly-discussed hazardous driving action (Cazzullo et al., 2014; Haque & Washington, 2015). For German YNDs, talking on a hand-held phone is a less common action with 24% of male and 19% of female YNDs only ‘sometimes’ engaging in the behaviour. As taking a call seems less distracting than reading a text, one could presume that the amount of YNDs talking on a hand-held phone should be higher in the German sample. However, user behaviour changes and McDonald and Sommers (2015) emphasised that teens have moved to using less phone calling and texting in everyday life. A representative study of YouGov (2016) in Germany surveyed that instead of making phone calls, 80% of 18 to 24 year olds prefer to communicate by e-mail, SMS, or WhatsApp. Hence, we assume the incoming number of phone calls while driving is much lower compared to incoming text messages, which might explain the higher number of YNDs reporting to read texts compared to speaking on a hand-held phone. An alternative explanation for the low number of hand-held phone calls can be the high number of participants who reported to send voice messages while driving. Since their introduction, voice messages present an attractive and comfortable alternative for making a call or even texting. That said, a slight majority (51%) of female and male YNDs indicated that they send voice messages at least ‘sometimes’, which is much higher compared to texting and speaking on a hand-held phone.

Recent studies suggest that laws banning smartphone use while driving are not as effective as desired in different YNDs populations (George et al., 2018; Kim, 2018; WHO, 2011). The German legislation seems to be no exception. In particular, our data shows YNDs continue to text, but in a more dangerous, concealed manner, with 16% of male and 12% of female drivers reporting that they hide their phone while texting on a regular basis. Hiding a phone while texting involves a conscious effort (Gauld, Lewis, and White, 2013). In combination with the cognitive (e.g. reading and understanding), visual (e.g. looking at the screen), and physical distraction (e.g. typing, holding the phone), YNDs are ‘flying blind’. Hosking, Young, and Regan (2006) found that YNDs aged between 18 and 21 years spend 400% more time looking away from the road when they were texting. That number could be even higher compared to texting on a concealed smartphone. As deterrence based measures such as high penalties for YNDs smartphone use (§23 StVO, German Traffic Law) do not seem to be sufficient to prevent smartphone use among YNDs, we urge policy makers to focus on alternative measures. With an anchor to the studies of Gauld, Lewis, White, Fleiter, and Watson (2017) and Pivetta, Harkin, Billieux, Kanjo, and Kuss (2019) more effort should be spent on the creation of social norms that appeal to YNDs ‘inner sense’ and thereby make smartphone use while driving socially unacceptable. In terms of public policy and safety information campaigns we especially see a combination of extrinsic and intrinsic motivation as most effective to decrease YNDs smartphone use in future.

Beck and colleagues (2007) found drivers who report using their phone while driving are more likely to be engaged in other risky driving behaviour. This study can further differentiate this outcome with regard to German YNDs. According to the correlation analysis, German YNDs who use their smartphone’s music-related applications are less likely to be engaged in other risky driving behaviour. It is possible that a great amount of risk-averse YNDs who mostly self-reported as safe drivers do not perceive music-related activities as dangerous. In contrast, YNDs who indicated that they speak on a hand-held phone seem to be most likely to drive intoxicated, drunk, drive through red lights or perform other high risk behaviours. The correspondence analysis confirmed this findings, indicating a strong association between those who speak on their phone and those who engage in other behaviours with potentially fatal consequences, such as intoxicated driving, disregarding red traffic lights, and driving with more passengers than available seatbelts. Hence, in accordance with Scott-Parker et al. (2013), our data suggest that within the young driver cohort there is likely to be a group of ‘problem young drivers’ who commit a variety of high-risk driving behaviours.

We propose that this result could be used by policy makers to tailor financial penalties for those problem young drivers. However, to deter all young drivers from engaging in risky driving actions policy makers should design countermeasures that increase the perception of certainty, swiftness and severity of punishment as suggested by Bates, Anderson, Rodwell, and Blais (2020), and follow ‘deterrence theory’. That said, we also see the need to better understand the influence of personal and environmental factors, such as the latent influence of perceived social norms, in order to address the issue of high-risk driving (Freeman, Armstrong, Tuelove, and Szogi, 2015; Piquero, Paternoster, Pogarsky, & Loughran, 2011). An additional solution could be the mandatory use of UBI schemes for YNDs already applied in motor insurance. Thereby, consistent use of applications that are related to risky driving behaviours (i.e. the use of the ‘phone call’ app would suggest ‘speaking’, which is significantly related to speeding and substance use) will be reflected in the risk premium being charged to the user. Peer, Muermann, and Sallinger (2020) highlight the positive reinforcement effects of financial incentives, which may lead to a reduction in adverse or risk driving habits.

5. Conclusion

For YNDs, smartphones have become a focal point of their lives even throughout the driving task. Due to young drivers’ limited driving experience, the use of smartphones is concerning as it causes cognitive, visual and physical distraction, and
thereby adversely affects their ability to react appropriately when facing a hazardous event. We find that even with a strong legislation in place, smartphone use among German YNDs is common. Music-related smartphone use is most widespread with almost a quarter reporting to interact with a music application or changing their music on a regular basis while driving.

Other risky behaviours such as talking on a hand-held phone are reported less often. This could be explained by a change in smartphone use behaviour. Younger generations tend to text more often than to talk on a phone and also use alternative ways of making phone calls such as voice messages. That said, our data shows that the amount of YNDs who indicate that they send voice messages while driving is much higher than those who send text messages or to talk on a hand-held phone. An interesting finding of this study is that German YNDs who reported talking on a hand-held phone are more likely to also report high-risk behaviours such as driving through red traffic lights or driving while intoxicated. As a result, we associate those who engage in this behaviour to be the most risk-seeking group of YNDs in Germany, to which special attention should be paid by researchers and policy makers.

However, policy makers should not ignore YNDs who solely use their smartphone for music-related activities. Rather than being seen as ‘safer drivers’, a confounding effect may be in place. They may seem more risk-averse than their risk-seeking counterparts only because they may perceive changing music as a safe behaviour that is not too distracting. Targeted campaigns should increase awareness of the fact that all smartphone-related activities can significantly increase the risk of a crash or near-crash event. However, we do not solely see policy makers as responsible. Vehicle manufacturers, who have recently turned to making their car seem like a place of entertainment, may have induced a false perception that behaviours like changing the music while driving are perceived as safe, and should instead engage in efforts to reduce this behaviour. Lastly, we find that a sizeable number of German YNDs deliberately disobey laws by hiding their phone while driving. We encourage policy makers to think about the design of countermeasures that not only strongly extrinsically, but also intrinsically, motivate YNDs to avoid using their smartphone while driving. Possible solutions are already discussed in safety research such as establishing social norms in the cohort of young drivers that make smartphone use while driving like changing the music while driving are perceived as safe, and should instead engage in efforts to reduce this behaviour.

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CRediT authorship contribution statement

**Tim Jannusch:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Visualization, Validation. **Darren Shannon:** Formal analysis, Writing - review & editing, Visualization, Validation. **Michaëlle Völler:** Methodology, Writing - review & editing, Supervision, Visualization, Validation. **Finbarr Murphy:** Writing - review & editing, Resources. **Martin Mullins:** Writing - review & editing, Supervision, Resources, Funding acquisition.

References

AAMI. (2012). Young Drivers Index.

Abdi, H., and Béa, M. (2014). Correspondence Analysis. Abdi, H., & Béa, M. (2018). Correspondence Analysis. In R. Alhajj & J. Rokne (Eds.), Encyclopedia of Social Network Analysis and Mining (pp. 429–439). New York, NY: Springer, New York.

Atchley, P., Atwood, S., & Boulton, A. (2011). The choice to text and drive in younger drivers: Behavior may shape attitude. Accident Analysis and Prevention, 43(1), 134–142.

Bates, L., Anderson, L., Rodwell, D., & Blais, E. (2020). A qualitative study of young drivers and deterrence based road policing. Transportation Research Part F: Traffic Psychology and Behaviour, 71, 110–118.

Bazargan-Hejazi, S., Teruya, S., Pan, D., Lin, J., Gordon, D., Krochak, P. C., & Bazargan, M. (2017). The theory of planned behavior (TPB) and texting while driving behavior in college students. Traffic injury prevention, 18(1), 56–62.

Beck, K. H., Yan, F., & Wang, M. Q. (2007). Cell phone users, reported crash risk, unsafe driving behaviors and dispositions: A survey of motorists in Maryland. Journal of safety research, 38(6), 683–688.

Benzécri, J.-P. (1992). Correspondence analysis handbook. CRC Press LLC.

Caird, J. K., Simmons, S. M., Wiley, K., Johnston, K. A., & Horrey, W. J. (2018). Does talking on a cell phone, with a passenger, or dialing affect driving performance? An updated systematic review and meta-analysis of experimental studies. Human factors, 60(1), 101–133.

Cassarino, M., & Murphy, G. (2018). Reducing young drivers' crash risk: Are we there yet? An ecological systems-based review of the last decade of research. Transportation Research Part F: Traffic Psychology and Behaviour, 56, 54–73.

Cazzulino, F., Burke, R. V., Muller, V., Arbogast, H., & Upperman, J. S. (2014). Cell phones and young drivers: A systematic review regarding the association between psychological factors and prevention. Traffic injury prevention, 15(3), 234–242.

Constantinou, E., Panayiotou, G., Constantinou, N., Louitiou-Ladd, A., & Kapardis, A. (2011). Risky and aggressive driving in young adults: Personality matters. Accident Analysis and Prevention, 43(4), 1323–1331.

Crundall, D., Chapman, P., Trawley, S., Collins, I., Van Loon, E., Andrews, B., & Underwood, G. (2012). Some hazards are more attractive than others: Drivers of varying experience respond differently to different types of hazard. Accident Analysis and Prevention, 45, 600–609.

Dingus, T. A., Guo, F., Lee, S., Antin, J. F., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. Proceedings of the National Academy of Sciences, 113(10), 2636–2641.

Evans, K. L., & Hampson, E. (2014). Does risk-taking mediate the relationship between testosterone and decision-making on the Iowa Gambling Task?. Personality and Individual Differences, 61, 57–62.

Freeman, J., Armstrong, K., Truelove, V., and Szogi, E. (2015). Left on the side of the road? A review of deterrence-based theoretical developments in road safety.
T. Jannusch, D. Shannon, M. Völler et al. Transportation Research Part F 77 (2021) 209–220

Gauld, C., Lewis, I., and White, K. M. (2013). Identifying the determinants of concealed and obvious texting while driving: Are they distinct behaviours?. Transportation Research Part F: Traffic Psychology and Behaviour, 96, 208–218.

Gauld, C. S., Lewis, I. M., White, K. M., & Watson, B. (2016). Young drivers’ engagement with social interactive technology on their smartphone: Critical beliefs to target in public education messages. Accident Analysis & Prevention, 96, 208–218.

Gauld, C. S., Lewis, I. M., White, K. M., Feitler, J. J., & Watson, B. (2017). Smartphone use while driving: What factors predict young drivers’ intentions to initiate use, and respond to social interactive technology?. Computers in Human Behavior, 76, 174–183.

George, A. M., Brown, P. M., Scholz, B., Scott-Parker, B., & Rickwood, D. (2018). “I need to skip a song because it sucks”: Exploring mobile phone use while driving among young adults. Transportation Research Part F: Traffic Psychology and Behaviour, 58, 382–391.

Glynn, D. (2014). Correspondence analysis. Exploring data and identifying patterns. Teoksessa Gunn, Dylan and Robinson, Justyna (toim.) Corpus Methods for Semantics. Quantitative studies in polysemy and synonymy, 443–486.

Greenacre, M. (2017). Correspondence analysis in practice. CRC Press.

Haque, M. M., & Washington, S. (2015). The impact of mobile phone distraction on the braking behaviour of young drivers: A hazard-based duration model. Transportation Research Part F: Traffic Psychology and Behaviour, 50, 13–27.

Hassani, S., Kelly, E. H., Smith, J., Thorpe, S., Sozzer, F. H., Aitchley, P., ... Vogel, L. C. (2017). Preventing distracted driving among college students: Addressing the mismatch between student and parent perspectives. Accident Analysis and Prevention, 99, 297–309.

Hongkong, S., Young, K., and Regan, M. (2006). The effects of text messaging on young novice driver performance. Retrieved from..

Hutcheson, G. D., & Sofroniou, N. (1999). The multivariate social scientists: Introductory statistics using generalized linear models. Sage.

Jannusch, T., Völker, M., Murphy, F., & Mullins, M. (2020). A new version of the Behaviour of Young Novice Drivers Scale (BYNDS) Insights from a randomised sample of 700 German young novice drivers. Accident Analysis & Prevention, 145 105622.

Kim, H. S. (2018). The role of legal and moral norms to regulate the behavior of texting while driving. Transportation Research Part F: Traffic Psychology and Behaviour, 52, 21–31.

Klauser, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., and Ramsey, D. J. (2006). The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data.

Klauser, S. G., Guo, F., Simons-Morton, B. G., Ouiemt, M. C., Lee, S. E., and Dingus, T. A. (2014). Distracted driving and risk of road crashes among novice and experienced drivers. New England Journal of Medicine, 370(1), 54–59.

Lansdown, T. C. (2012). Individual differences and propensity to engage with in-vehicle distractions–A self-report survey. Transportation Research Part F: Traffic Psychology and Behaviour, 15(1), 1–8.

Luria, G. (2018). The mediating role of smartphone addiction on the relationship between personality and young drivers’ smartphone use while driving. Transportation Research Part F: Traffic Psychology and Behaviour, 59, 203–211.

Mack, A., & Pecht, I. (1998). Inattentional blindness: Perception without attention. Visual attention, 8, 55–76.

McDonald, C. C., & Sommers, M. S. (2015). Teen drivers’ perceptions of inattention and cell phone use while driving. Traffic injury prevention, 16(sup2), S52–S58.

McKnight, A. J., & McKnight, A. S. (2003). Young novice drivers: Careless or clueless?. Accident Analysis and Prevention, 35(6), 921–925.

Meeker, M., and Wu, L. (2013). Internet trends. Paper presented at the Proc D11 Conference. Rancho Palos Verdes.

Menon, R. (2018). Mobile phone addiction and the geographies of the car. Geography Compass, 12(2), 586–598.

Montag, C., Blasskiewicz, K., Sariyska, R., Lachmann, B., Andone, I., Trendafov, B., ... Markowitz, A. (2015). Smartphone usage in the 21st century: Who is active on WhatsApp?. BMC research notes, 8(1), 331.

mpfs. (2020). JIM-STUDIE 2019 - Jugend, Information, (Multi-) Media..

Murphy, C., Gauld, C., and Lewis, I. (2020). Predicting the monitoring/reading of communications on a smartphone among young drivers using an extended theory of planned behaviour. Accident Analysis and Prevention, 136 105403.

Muttart, J. W. (2013). Identifying hazard mitigation behaviors that lead to differences in the crash risk between experienced and novice drivers. University of Massachusetts Amherst Mass.

Nagpaul, P. (1999). Guide to advanced data analysis using IDAMS software. New Delhi: United Nations Educational, Scientific and Cultural Organization.

NCSA, N. C. f. S. A. (2018). Distracted driving 2016 Traffic Safety Facts Research..

Ortiz, C., Ortiz-Peregrina, S., Castro, J., Casas-Castro, C., & Salas, C. (2018). Driver distraction by smartphone use (WhatsApp) in different age groups. Accident Analysis and Prevention, 117, 239–249.

Oviedo-Trespalacios, O., Haque, M. M., King, M., and Washington, S. (2016). Understanding the impacts of mobile phone distraction on driving performance: A systematic review. Transportation Research Part C: Emerging Technologies, 72, 360–380.

Oviedo-Trespalacios, O., & Scott-Parker, B. (2017). Transcultural validation and reliability of the Spanish version of the behaviour of young novice drivers scales (BYNDS) in a Gambian young driver population. Transportation Research Part F: Traffic Psychology and Behaviour, 49, 188–204.

Park, N., & Lee, H. (2014). Nature of youth smartphone addiction in Korea 언론정보학회. Journal of Communication Research.

Peer, S., Muermann, A., and Sallinger, K. (2020). App-based feedback on safety to novice drivers: Learning and monetary incentives. Transportation Research Part F: Traffic Psychology and Behaviour, 71, 198–219.

Piqué, A. R., Paternoster, R., Pogarsky, G., and Loughran, T. (2011). Elaborating the individual difference component in deterrence theory. Annual Review of Law and Social Science, 7, 235–380.

Pivetta, E., Harkin, L., Billieux, J., Kanjo, E., and Kuss, D. J. (2019). Problematic smartphone use: An empirically validated model. Computers in Human Behavior, 100, 105–117.

Pradhan, A. K., and Crudall, D. (2016). Hazard avoidance in young novice drivers: Definitions and a framework Handbook of Teen and Novice Drivers. CRC Press.

Prat, F., Gras, M., Planes, M., Font-Mayolas, S., and Sullivan, M. (2017). Driving distractions: An insight gained from roadside interviews on their prevalence and factors associated with driver distraction. Transportation Research Part F: Traffic Psychology and Behaviour, 45, 194–207.

Prato, C. G., Toledo, T., Lotan, T., and Taubman-Ben-Ari, O. (2010). Modeling the behavior of young novice drivers during the first year after licensure. Accident Analysis and Prevention, 42(2), 480–486.

Rodriguez, R. A., and Scott-Parker, B. (2013). The role of legal and moral norms to regulate the behavior of texting while driving. Transportation Research Part F: Traffic Psychology and Behaviour, 52, 21–31.

Scott-Parker, B., and Piff, C. (2015). Validation of the Behaviour of Young Novice Drivers Scale (BYNDS) in a New Zealand young driver population. Accident analysis and prevention, 77, 62–71. https://doi.org/10.1016/j.apt.2015.01.019.

Scott-Parker, B., Watson, B., King, M. J., and Hyde, M. K. (2013). Revisiting the concept of the ‘problem young driver’within the context of the ‘young driver problem’: Who are they?. Accident Analysis and Prevention, 59, 144–152.

Scott-Parker, B., Watson, B. C., and King, M. J. (2010). The risky behaviour of young drivers: Developing a measurement tool..

Seibokaitė, L., Endriulaitienė, A., Žardceitė-Matulaitienė, K., Oviedo-Trespalacios, O., Watson-Brown, N., and Scott-Parker, B. (2020). The self-reported driving behaviour of young drivers in Lithuania: An application of the behaviour of young novice drivers scale–Lithuania (BYNDS-Li). Transportation Research Part F: Traffic Psychology and Behaviour, 59, 311–323.

Smart, R., Stoduto, G., Mann, R. E., and Adalf, E. M. (2004). Road rage experience and behavior: Vehicle, exposure, and driver factors. Traffic injury prevention, 5(4), 345–354.

Vollrath, M., Huemer, A. K., Teller, C., Likhacheva, A., and Fricke, J. (2016). Do German drivers use their smartphones safely?—Not really!. Accident Analysis and Prevention, 96, 29–38.

WHO. (2011). Mobile phone use: a growing problem of driver distraction..

YouGov. (2016). Junge Deutsche texten lieber statt zu telefonieren.

Young, K., Regan, M., and Hammer, M. (2007). Driver distraction: A review of the literature. Distracted driving, 2007, 379–405.

Young, K. L., and Lenné, M. G. (2010). Driver engagement in distracting activities and the strategies used to minimise risk. Safety science, 48(3), 326–332.