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Young Pedestrians' Mobile Phone Use While Crossing the Road

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ABSTRACT: In Austria, distraction and carelessness are the number one cause of accidents. This affects all types of travel modes. The use of smartphones makes a significant contribution to distraction in road traffic. While the issue of car drivers and adult pedestrians has already been investigated in numerous publications, the extent of the problem and its impact on children and adolescents walking on foot is hardly known. Within the framework of an explorative study, almost 2,800 crossing events of school children in front of an educational center in the city of Vienna (Austria) were observed and analyzed. The results show that 44% of the pupils observed were engaged in some kind of use or were visibly holding a mobile phone in their hands when crossing the street at the unsignalized intersection. The results underline the need for training to educate children and adolescents about safe behavior in road traffic.

1. INTRODUCTION

Pedestrian traffic plays a central role in mobility for all age groups. Especially children show high shares of walking trips. The last Austrian national household survey in 2013/2014 showed that 26.9% of all trips by 6 to 14-year-olds are made on foot (weekdays) (Tomschy et al., 2017). In the city of Vienna, the share of walking trips of up to 14-year-old children is even 36% (Omnitrend GmbH, 2020). However, in this age group, between 1995 and 2013/14 in Austria the share of walking has decreased by 15 percentage points for the benefit of car-passenger trips (increase of 12 percentage points) (Tomschy et al., 2017). At the same time, very low activity rates can be observed for children and adolescents all over Europe: For example, in the age group of 11 to 17-year-old pupils in Austria, less than 18% fulfil the WHOs´ recommendations of one-hour physical activity per day (Strong et al., 2005; Cavill et al., 2006). The older the children get, the less activity they show (Ramelow et al., 2015). This is a dramatic development, correlating with decreasing health and increasing obesity levels (Pucher et al., 2010).

Given the negative developments in terms of decreasing physical activity and increasing car-passenger trips, especially young age groups should be in the focus of interventions promoting non-motorized modes for everyday mobility. At the same time one must take into account that children and adolescents are a very vulnerable group in road traffic for several reasons (Stark, 2019). Thus, walking young people are particularly at risk of being involved in road traffic accidents. As distraction is a frequent cause of accidents, it can be assumed that the use of mobile devices represents an increased hazard in road traffic. Indeed, smartphones as a source of distraction are becoming a growing problem affecting road users. To what extent the problem applies to children and young people, however, has hardly been researched.

The purpose of this paper is to explore the extent of the problem of the use of mobile devices by young pedestrians while crossing the road. In doing so, the results of in-site observations at an intersection in the city of Vienna are presented.

The paper is structured as follows: Section 2 contains a brief literature review on the use of smartphones in road traffic and the description of multiple resources model as starting point for the study. Section 3 presents details about the study's method. The results of the descriptive-explorative data analysis are presented in Section 4. In Sections 5, the paper closes with a discussion of key findings, study limitations, and opportunities for future work.

2. BACKGROUND

2.1 Use of smartphones in road traffic

In 2015, about 38% of all traffic accidents involving personal injury in Austria could be attributed to overnight driving or distraction (Statistics Austria, 2017). For accidents involving personal injury and pedestrian involvement, the proportion is as high as 44% (Kuratorium für Verkehrssicherheit, 2015). Walking children and young people are particularly at risk of being injured in road traffic accidents. Together with senior citizens, they belong to the age groups most frequently injured in pedestrian accidents in Austria (Statistics Austria, 2018). This can be attributed to the fact that (i) children and adolescents in Vienna are primarily on foot and (ii) to the developmental psychological and physiological characteristics of young pedestrians (chapter 2), which lead to a generally increased risk of road traffic accidents. The use of mobile devices and the associated distraction poses an additional hazard in road traffic (Education Group GmbH, 2017).

Studies show, that during the last years the smartphone ownership increased, especially among young age groups. For example, whereas in 2008 only 4% of all young people in Upper Austria between the ages of 11 and 18 owned a mobile phone, a study by the Education Group GmbH (2017) showed that 85% of them already had one. A strong correlation with the age of the young users is evident. A German study from 2017 analyzed that around 6% of 6 to 7-year-olds own a smartphone, 67% of 10 to 11-year-olds and 94% of 16 to 18-year-olds.

According to their high prevalence in the population, the presence of mobile phones in road traffic has increased. Many studies deal with the effects of distraction while driving. For example, a German study surveyed the problem of distraction caused by mobile phones among car drivers in 2016, with up to 65% of respondents stating that they used their mobile phone while driving, depending on the type of use (Kubitzki and Fastenmeier, 2016). In addition, a significant correlation between the activities “making phone calls”, “reading text messages” and the occurrence of accidents was proven.

There is also research on the distraction of pedestrians by smartphones. According to this, it is estimated that between 17% and 33% of pedestrians use smartphones while crossing the road (Kuratorium für Verkehrssicherheit, 2017). A German study among 15 to 19 years old adolescents found that a quarter of all observed pedestrians were distracted (e.g. by phone conversations, looking at the phone, typing, listening to music) while crossing a street (Vollrath et al., 2019). According to a study in UK, this corresponds to one third of the observed school students (Baswail et al., 2019). A study in China recorded a rate of 16% of pedestrians using mobile phones while crossing unsignalized intersections - 64.1% of them were young pedestrians under 30 years (Zhang et al., 2018). This usage rate is similar to the results of a study by students of the German Wiesbaden Rhein-Main University reporting that 16% of pedestrians use their mobile phones in traffic (Niewöhner et al., 2016). In a subsequent survey, 64% of the respondents stated that they used the smartphone for communication purposes, while the remaining 36% watched videos or listened to music. This study did, however, not focus on young age groups. This is also the case for a study in the USA, in which more than 1,100 pedestrians at high-risk intersections were observed (Thompson et al., 2013). Nearly one-third of all pedestrians performed a distracting activity such as talking on the phone, text messaging, or listening to music while crossing. Further sources of distraction for pedestrians across all age groups are for example conversations. An observation in Austria showed that 32% of pedestrians were distracted by an intensive conversation (Kuratorium für Verkehrssicherheit, 2017). This was followed by 17% with headphones and 17% with a mobile phone at the ear. 10% of the sample were observed typing on their smartphones during the crossing. The results show that apart from intensive conversations, smartphone use makes a significant contribution to the distraction of pedestrians in road traffic (ibid). This is supported by an observation in Malaysia which showed that 85% of all distracted pedestrians had their attention focused on their mobile phone (Syazwan et al., 2017). A study of Schwebel et al. (2012) among 138 students was conducted to assess the distraction by talking on the phone, texting, or listening to music while crossing a virtual street. The results show that participants distracted by music or texting were more likely to be hit by a vehicle than were undistracted participants as they were more likely to look away from the street environment. The use of smartphones while crossing a road has a particular effect on walking speed. For example, Lamberg and Muratori (2012) found that walking speed is significantly reduced both when making phone calls and when typing messages (Lamberg and Muratori, 2012). They also observed that typing text messages leads to a deviation from the ideal walking line. The longer crossing time when using smartphones can be attributed on the one hand to slower walking speed and on the other hand to a more careful strategy when overcoming obstacles. Furthermore, with the help of eye-tracking it was observed that obstacles were looked at less often and much shorter while using a mobile device (Timmis et al., 2017). Stavrinos et al. (2009) conclude in their study that cell phones distract preadolescent children while crossing streets. Results indicate, while distracted, children were, for example, less attentive to traffic, left less safe time between their crossing and the next arriving vehicle, and experienced more collisions in the virtual environment.

Overall, it can be stated that there are relatively few studies on children and young people in the context of distraction and pedestrian road crossing behavior. Given the fact that distraction is the main cause of accidents in Austria and the general vulnerability of young age groups in road traffic, the result of an online survey carried out in 2013 by the Austrian Road Safety Board and Herry Consult GmbH (2015) is alarming, according to which 9 out of 10 young people use the mobile phone in everyday life while walking. To get more information on the use of mobile phones, it seems very useful to observe children and adolescents when they are pedestrians on their daily routes in real life traffic situation. Studies in the area of pedestrian road crossing behavior and distraction often make use of virtual pedestrian environments (e.g. Neider et al., 2010; Stavrinos et al., 2009; Meir et al., 2015; Stavrinos et al., 2011; Schwebel et al., 2012; Tapiro et al., 2016). Virtual settings help (i) to have full information on the participants (e.g. in terms of age, travel habits, attitudes), (ii) to have control of the experiment's conditions, and (iii) they offer safe situations which makes them effective to be used for trainings to improve pedestrian skills (e.g. Tolmie et al., 2002). At the same time simulated environments may lead to a bias, as participants might be aware of the experiment. Other studies conduct observations in real environments to identify distracting activities (e.g. Thomson et al., 2013; Hatfield and Murphy, 2007; Ferenchak, 2016). In this context, video recordings or eye-tracking devices are often used to analyze the pedestrians' behavior (e.g. Zhang et al., 2018; Timmis et al., 2017).

2.2 Children's participation in traffic and the multiple resources model

Although participation in traffic is sometimes perceived as a complex situation by adults as well, there are other challenges in road traffic that are specific to childhood. These include, among other things, (i) difficult visual relationships due to smaller body size, (ii) not yet fully developed abilities to anticipate the dangers or actions of other people, (iii) difficulties in assessing the speed of approaching vehicles, (iv) lower concentration spans or also (v) not yet internalized rules and regulations for participation in road traffic (Schützhofer et al., 2015; Kuratorium für Verkehrssicherheit and HERRY Consult GmbH, 2015). Of course, the perception of the traffic environment is strongly dependent on the child's stage of development (Schützhofer et al., 2018). In this context, one should not only think about very young children, but also adolescents. Empirical evidence shows that specific traffic competences are not fully developed until the age of 14 such as for example speed perception (ibid). This clearly reflects the vulnerability of young road users, especially when they are travelling alone. As outlined above, the use of mobile devices may present an additional hazard in road traffic.

The assumption that the use of mobile phones is additionally detrimental to the lower level of attention of children in road traffic is based on the multiple resources model according to Wickens (1980, 2002). According to this model, visual, auditory, cognitive and motor resources are available to humans for information processing, by means of which tasks can be performed. If these are carried out simultaneously, one speaks of multitasking. The multiple resource theory assumes that two tasks to be performed simultaneously are affected by the level of capacity and the specific structures, processes and capacities they require. In more detail, according to Wickens (2002), each of the above-mentioned resources is only available to a limited extent, which means that when certain activities are carried out in parallel, the total capacity can be reached or exceeded, which leads to a lower attention potential in each of the parallel activities.

The multiple resource model tries to explain how well two tasks can be performed competitively and divides the capacity of attention resources into different dimensions respectively contingents. Based on the model of Wickens, three processing stages (encoding, central processing, response), two response codes (manual vs. vocal), two modes of perception (visual vs. auditory), and two input codes (spatial vs. verbal) are distinguished (Figure 1). In terms of visual perception, Wickens distinguishes between focused vision and ambient vision. According to this, we can look at something in focus (e.g. a vehicle in front) and at the same time perceive peripheral visual information in the environment (e.g. the edge of the road).

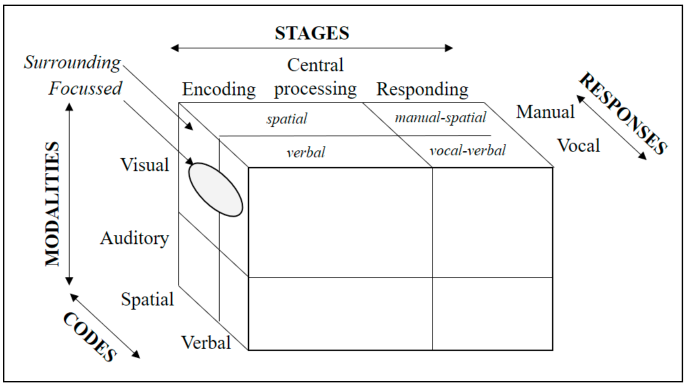


Figure 1. Model of multiple resources according to Wickens (Wickens, 2002; Ollermann, 2018).

It is assumed that activities that access different contingents can be better performed simultaneously than those that are fed by the same resource contingent. Based on this assumption, it should be easier to perform verbal processes and spatial processes simultaneously than to perform two verbal processes. For example, it is difficult to write a text when people are talking on the side. This is because both of these activities have to be processed verbally. Likewise, a vehicle cannot be steered safely and a destination cannot be typed manually into a navigation device, because both of these tasks access the spatial processing quota. However, the simultaneous performance of activities using different attention contingents only works if the tasks do not exceed a certain degree of complexity. This means that two demanding tasks can no longer be performed simultaneously even if they serve different contingents (Ollermann, 2018).

Within the processing stage, encoding is of utmost importance for the investigation of the behavior of children and adolescents in road traffic. It can be assumed that any kind of smartphone use has a negative impact on the overall availability of resources. However, the visual-spatial perception - that is primarily relevant in road traffic - is still more compatible with auditory activities such as "listening to music" or "making phone calls". In contrast, it is less compatible with activities such as "writing text messages", "surfing the Internet" or "gaming". However, this hypothesis is only valid as long as none of the activities exceeds a certain degree of complexity, which could be assumed when a child crosses a street.

2.3 Objectives

The overall aim of this research is to determine the extent to which children and adolescents aged 6-18 years use mobile devices while crossing the road and to analyze the effect of the use on crossing behavior to shed more light on the smart phone-related activities that might distract young pedestrians. On-site observations near a school site in the city of Vienna were conducted to explore the different types of smartphone use.

3. APPROACH

3.1 Study design

The exploratory study was designed as a field observation; the use of a camera was waived for legal reasons. In a pre-test not described here in detail the suitability of the location[1], survey period (time of day) and two different survey designs of the observation sheet were tested.

The observation was conducted to determine how many children and adolescents use their mobile phones while crossing the road and what types of use have been pursued. It was ascertained whether people made phone calls, looked at the device, wore or held headphones or held the device in their hands without interacting with it at the time of observation. For this purpose, a paper-and-pencil data entry form was used, on which defined characteristics were documented for each crossing procedure respectively person observed, including the approximate age of the persons divided into three age groups from 6 to 18 years (estimated by the observer). Due to the number of factors being recorded, only one pedestrian was observed at a time. With regard to the selection procedure, the first person to step off the curb with the intent to cross the selected road was recorded. This procedure was repeated as soon as the documentation procedure was completed. In cases that more than one individual step off the curb completely simultaneously, the person on the far left respectively the person on the far right was selected alternately. The observations were conducted by one single data collector, who observed the people from the site inconspicuously, but close enough to make an age estimation, in order to ensure as far as possible that the individual being observed should not be aware of the observation process. The observer was a female master student who was trained to collect the data following the same procedure throughout the whole observation process. She was involved in the development of the survey design herself (observation procedure and development and testing observation sheets). After a theoretical introduction, the training took place on-site in the course of a pre-test under supervision of a senior scientist.

3.2 Observation site

As observation site an unsignalized intersection near an education center was chosen (Kenyongasse/Stollgasse, Vienna, 7th district, Figure 2). The education center is attended by pupils of all school levels of different school types; in total, the education center is visited by about 1,900 pupils (Medienbüro der Ordensgemeinschaften Österreich, 2018). The selected intersection is a T-junction. Kenyongasse is a north-south single-lane road with parking strips and sidewalks on both sides. The speed limit is 30 km/h. In the crossing area there are sidewalks on both sides; due to trees and a garbage island, as well as parking cars, visibility can be blocked. The Stollgasse is also a one-way street with a speed limit of 30 km/h, which runs from east to west. The road up to Kenyongasse is

1 Due to budget reasons only one observation site was chosen, where a high frequency of young pedestrians can be expected. Of course, this aspect as well as the characteristics of the intersection lead to limitations of the study (see chapter 5).

single-lane and divided into two lanes after the intersection. There are no data on traffic volume. A tram line is guided as a side track in this section. On the northern side of Stollgasse there is a parking strip up to Kenyongasse, which can also lead to visual shadows due to parked cars. There are sidewalks on both sides of the street. At the northeast corner of the intersection there is a sidewalk overhang. The length of observed crossing is 4 to 6 meter. Overall, it can be estimated that the crossing situation is not very complex.

At this site the first step of the survey was carried out on five different working days at the end of May and beginning of June 2018 at school start and end times between 07:15 and 08:15 a.m. and between 12:45 and 02:15 p.m. Since the observation was carried out on several days at the same location, it cannot be excluded that some students were observed several times. However, this was not considered further in the course of the analysis.

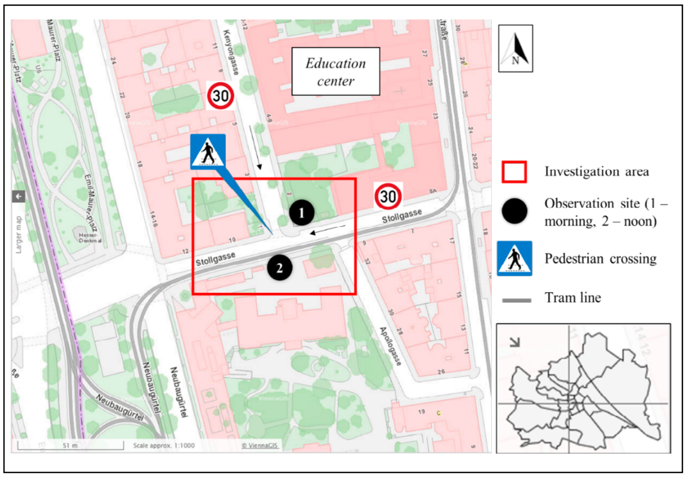


Figure 2. Observation site, Kenyongasse/Stollgasse, Vienna, 7th district.

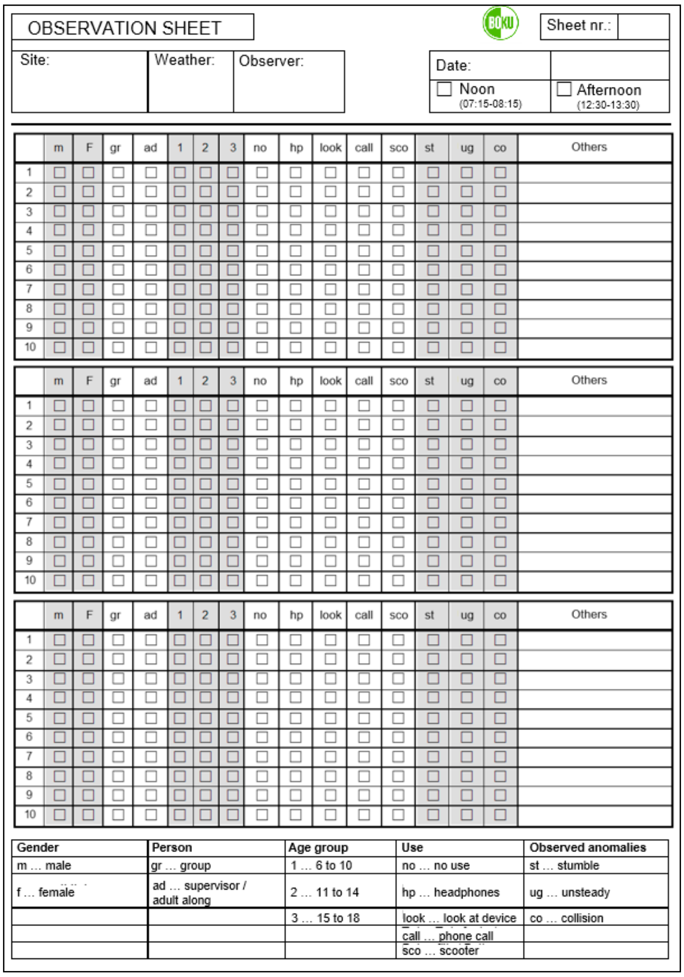
3.3 Observation sheet

For the quantification of the use of mobile phones on-site, a paper-and-pencil observation sheet in list form was developed. There is a separate line for each person (respectively crossing) observed, in which all applicable attributes could be ticked (Figure 2). This design proved to be suitable, as the list form allows quick orientation on the sheet.

Based on the findings of the pre-test, it was observed that many persons hold a mobile phone in their hands. This was, therefore, cited as an additional category of use. It was also found that some observed persons held headphones in their hands during the crossing and disentangled them. Since it can be assumed that these people will use headphones soon and presumably also next time they cross, the category 'headphones in hand' was added. Further, only a few students were observed to be on the scooter, so this attribute was removed from the pre-test version of the observation sheet. In the survey, this information was noted in the column 'Other'.

The following variables were collected: Time of day *[morning, noon]*, gender *[male, female]*, grouping *[alone, group, with a supervisor]*, approximate age *[6–10, 11–14, 15–18]*, type of smartphone usage *[no use, smartphone in the hand (without use), headphones in the hand, headphones in ear, look at the smartphone during the crossing, telephoning with a smartphone on the ear]* (multiple answers possible), effect *[stumbles, unsteady gait, collision]* (multiple answers possible), Other *[other observed anomalies, comments]*. It should be noted, that the categories of smartphone usage include the assumption that wearing headphones means listening to music which need not to be the case. It might also be that those persons, for example, are having a call with a headset or do not use smartphone function at all. The smartphone use observed when entering the roadway was recorded (multiple usage possible); a change during the crossing was not considered. It should also be noted, that the age of the persons could only be estimated by the observer.

The observation sheet also contains form fields to write down the sheet number, date, weather, location, and observer. The explanation of the abbreviations used can be found at the bottom of the form.



OBSERVATION SHEET — Sheet nr.:

Site: | Weather: | Observer: | Date: | ☐ Noon (07:15-08:15) | ☐ Afternoon (12:30-13:30)

	m	F	gr	ad	1	2	3	no	hp	look	call	sco	st	ug	co	Others
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

	m	F	gr	ad	1	2	3	no	hp	look	call	sco	st	ug	co	Others
1																
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	m	F	gr	ad	1	2	3	no	hp	look	call	sco	st	ug	co	Others
1																
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10																

Gender	Person	Age group	Use	Observed anomalies
m ... male	gr ... group	1 ... 6 to 10	no ... no use	st ... stumble
f ... female	ad ... supervisor / adult along	2 ... 11 to 14	hp ... headphones	ug ... unsteady
		3 ... 15 to 18	look ... look at device	co ... collision
			call ... phone call	
			sco ... scooter	

Figure 2. Observation sheet (translated from German).

3.4 Data analysis

The collected data of the PAPI-questionnaires of the quantitative observation were encoded and entered in IBM SPSS. In order to check the significance of the results, Pearson Chi-square tests were carried out for the generated crosstabs. The data must be at least nominally scaled and the sample must be larger than N=50 (University Zurich, 2019). Both requirements are met by the data collected. The strength of the correlations was determined using Cramer's V-tests. The Cramer's V-test is a symmetrical measure and is based on the test statistics Chi-square; a classification by Regber (2019) was used for interpretation of effect strength.

4. RESULTS

4.1 Sample

A total of 2,796 crossing events were recorded (51.7% in the morning, 48.3% at noon). With 63.1% girls in the sample, the gender distribution is skewed, which could be due to the fact that a training institution for elementary education is located near the observation point, which is mainly attended by girls. Concrete data on the age and gender distribution of the educational institutions in the center were not available.

Of the age groups surveyed, 6-10 year olds account for around 20%, the other two age groups each account for around 40% (*Table 1*). It should also be mentioned that younger persons in the sample tended to be boys, older persons tended to be girls. The children or adolescents observed in the morning tended to be alone (55.6%), whereas at midday they were usually in groups of at least two (65.3%). While 11.1% were accompanied by supervisors at the beginning of school, the proportion fell to 5.5% at noon, presumably due to working hours of many parents. Supervisors were almost exclusively observed in the group of 6-10 year-olds.

	Age group			
	All	6-10 (*n*=536)	11-14 (*n*=1,107)	15-18 (*n*=1,153)
gender				
female	63.1%	41.6%	60.3%	75.7%
male	36.9%	58.4%	39.7%	24.3%
Accompaniment				
alone	42.9%	32.2%	41.6%	49.0%
group	48.7%	27.0%	57.0%	50.9%
with supervisor	8.4%	40.7%	1.4%	0.1%

Table 1. Percentage distribution of the sample in the quantitative survey by age, gender, and accompaniment (N=2,796).

4.2 Use of mobile phones

It was observed that 44.1% of all school children used the mobile phone in some way during the crossing process ("users") (Figure 1). If it is assumed that simply holding the mobile device does not lead to distraction, the variable 'device in hand only' needs to be excluded from the group of users. However, it is assumed that the probability of looking at the mobile device while crossing is higher when it is already in the hand than when the smartphone has to be taken out of the pocket first. For this reason, the variable 'device in hand only' is considered a separate category (15.5% of users). The other types of usage (looking at the device, making a phone call, headphones in ear and headphones in hand) are summarized in the category 'Active usage' in the following chapters. Active usage accounts for 28.6% of all observations.

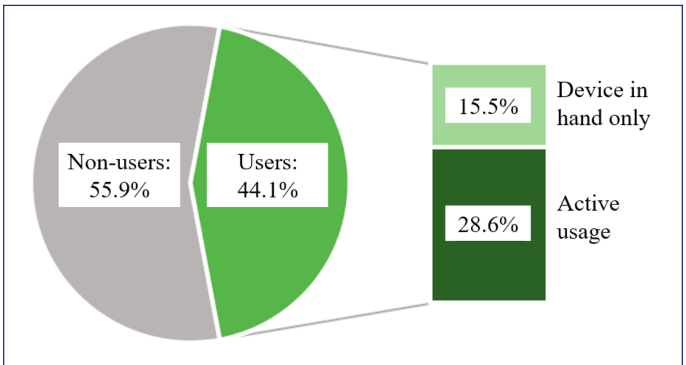

Figure 1. Proportion of non-users and users (active usage and people with the device in their hands only) (N=2,796).

By far the most frequently identified use of the smartphone while crossing the road is 'wearing headphones in the ear' (38.7%), followed by the categories 'looking at the device' (20.4%) and 'making a phone call' (8.1%) (multiple answers possible).

It was also analyzed that girls use the phone more often than boys (54.6% users versus 26.0%; $\chi^2(2, N=2{,}796) = 244.210$, $p = .000$; Cramer's V = .296) (Figure 1); this can be observed especially in the two older age groups (Table 2). The share of girls having the device in their hand only is much higher than among boys.

Correlating with the above-mentioned fact that the age group of 6-10 year-olds has a lower proportion of smartphone owners, it was observed that older people used the phone more often. It should be noted that also the type of use differed among age groups: the younger the users were, the higher is the share of making a phone call or looking at the screen, with increasing age 'wearing headphones in the ear'[2] became the primary type of use. However, it must be taken into account that the age group was only estimated (see also Discussion).

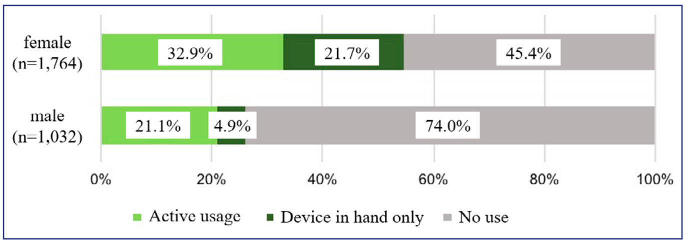

Figure 1. Proportion of non-users and users (active usage and people with the device in their hands only), by gender (N=2,796).

Age group	6-10		11-14		15-18	
gender	female	male	female	male	female	male
Non-users	88.8%	86.9%	43.9%	70.2%	35.5%	65.4%
Device in hand only	5.8%	4.5%	21.4%	5.9%	26.0%	3.9%
Active usage	5.4%	8.6%	34.7%	23.9%	38.5%	30.7%

Table 2. Percentage distribution of non-users and users by age and gender (N=2,796).

Looking at the frequency of use depending on whether the persons observed were travelling alone, in a group or with a supervisor, it can be stated that the share of active mobile phone users is highest among those who walk alone (44.2%); for groups this proportion is 19.5% ($\chi^2(4, N=2{,}796) = 367.859$, $p = .000$). Thus, it might be assumed, that groups are likely to be safer on the road, not only because they are more likely to be noticed by other road users, but also because the distraction caused by using a phone is less than for individuals. At the same time, however, it is known that children in groups are more likely to distract each other. Smartphones are least frequently used in the presence of a supervisor (1.3%). However, it should be noted that almost exclusively children in the youngest age group were on the move with supervisors, who also have the least number of smartphones statistically speaking.

In order to determine whether the time of day has an influence on user behavior, it was analyzed whether different distributions can be identified before school starts (early) and after school finishes (midday). The share of active users decreases from 30.5% to 26.4% during the day ($\chi^2(2, N=2{,}796) = 48.295$, $p = .000$). Further differences were found in the way the phones were used depending on the time of day: While in the morning most children and youths who actively use a phone listen to music (78.0%), the proportion is reduced to about 37.3% at midday. In contrast,

2 As mentioned in chapter 3.3, we followed the assumption that 'wearing headphones in ear' implies a use of the smartphone although the observations did not allow to draw the conclusion that children listen to music or similar.

the proportion of those who have their eyes on the device increases from 24.0% in the morning to about 40.6% at the end of school, and the proportion of those making a call increases from 5.0% to 21.8%.

5. DISCUSSION

This study was aimed to explore the use of mobile devices and effects on crossing behavior. Although the subject matter is relatively well documented among adults, which is why some places are already using targeted campaigns and penalties for distracted behavior, the same problem is not sufficiently explored among children and adolescents, especially with regard to the still incomplete development of traffic skills among young age groups. From the point of view of child development, it can be assumed that theoretically all abilities for safe participation in road traffic are developed by the age of 14 (Limbourg, 1995), but the pedestrian behavior observed shows that further awareness raising might be advisable. This can be concluded from the study findings showing that 29% of the children and adolescents observed were engaged in some kind of active usage. This share is 44%, if also 'visibly holding a mobile phone in their hands' is considered as an interaction with the smartphone. As there is no comparable observational study in Austria, these results can only be put into relation with a survey of the Austrian Road Safety Fund, in which 34% of young people questioned stated that they listen to music while walking (Kühnelt-Leddihn et al, 2013). Other studies in Europe on young pedestrians showing rates of 25% (Vollrath et al., 2019) and 32% (Baswail et al., 2019) of holding and interacting with devices such as mobile phones or music players while crossing. It should be noted that the comparison with other studies is sometimes only possible to a limited extent due to the different characteristics of the study sites (e.g. with/without traffic lights), a different target group or because other survey methods were used.

In our study, the probability of using the phone depended on approximate age, gender and companionship, revealing higher rates of interactions with mobile devices among older children, girls and children traveling alone. Similar differences were found in previous studies on adolescents in terms of gender (Stavrinos et al., 2009) and in terms of companionship (Vollrath et al., 2019; Baswail et al., 2019).

One explanation for the higher share of girls having the device in their hand only may be that girls typically have smaller trouser pockets. Since the temperatures during the observation were well above 20°C, it was not necessary to wear jackets that might have sufficiently large pockets for smartphones. Consequently, it can be assumed that the students hold the mobile devices in their hands instead of putting them into a backpack or handbag.

The time of day had also an influence on smartphone usage: After school, students generally showed lower rates of interactions with their phone, but - if an interaction was observed - they used it more frequently to make phone calls. It can be assumed that the pupils tended to be alone in the morning on their way to school and interacted with peers in the afternoon, which, in the latter case, probably makes listening to music less attractive. We also assume that more calls are made at noon, because children want to make appointments with friends or parents. A German study found a similar result reporting a higher probability of using the phone after school compared to the morning (Vollrath et al., 2019). In UK, the time of day affected the pedestrian behavior in that way that failing to look left and right was more frequent on the way home from school which might be explained by increased tiredness (Stavrinos et al., 2009). However, this also applied to adolescents in the morning who were late to school.

When interpreting the results, some limitations have to be considered: It must be taken into account that the relatively simple design of the unsignalized intersection together with a speed limit of 30 km/h may have had an increasing effect on the frequency of use of smartphones. As mentioned before, it cannot be excluded that the same individuals are observed in the sample multiple times. The age was estimated only by observation. As this is difficult with young age groups, this must be taken into account when interpreting the results. However, at least a comparison of our youngest and oldest age group should also be possible based on the estimated age providing an impression of tendential differences. For future surveys in this context the use of video material or eye-tracking tools could be help to get more information. Both methods were not used due to their complex application and legal requirements. The observation sheet used by the observer, however, has proven to be an efficient tool to collect relevant information. A larger sample size and other intersections or street sections (especially linked to accident locations with a high number of pedestrian-vehicle crashes) could reveal further facets of the distraction problem and concretize existing findings. In addition, several observers could be used at the same site to check the interrater reliability of the assessment of age etc.

The findings from this study should sensitize city respectively traffic planners for pedestrian behaviors of young age groups. The findings underline once again the importance of parents' educational work to protect children in road traffic as well as preventive traffic education measures that point out the risks of distraction. In that regard, school's safety education should intensively treat this topic. On the one hand, specific attention should be drawn to danger spots where increased attention is required, and on the other hand, information should be provided on the risks of distraction in order to encourage more careful use of the smartphone during road participation or voluntary abstention from its use.

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