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The effectiveness of an intervention to promote active travel modes in early adolescence

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ABSTRACT

This study investigates the changeability of transport-related attitudes and mode choice of early adolescents. Data on attitudes and travel behavior were collected in Austria and Germany in two consecutive survey waves with an interval of one year. The approach is based on a before-after control group experiment with an intervention promoting active travel modes. Based on the Theory of Planned Behavior we used structural equation modeling analyzing effects of the intervention; the potential for behavioral changes was modelled as moderator variable between intention and behavior. Findings suggest that the intervention was effective in changing attitudes, perceived behavioral control (PBC) and intentions to use non-motorized travel modes more, and car less. Difference models show that changes of attitude, subjective norm, and PBC accounted for 29% (car passenger) to 92% (walking) of the variance in changes in intention. The changes in intentions are however weak predictors of changes in reported behavior.

1. Introduction

Recent developments show that children levels in physical activity decrease to alarming rates. In Austria, only 57% of young people fulfil the recommendations of the World Health Organization (WHO) on health-enhancing physical activity (HEPA); adults show even lower rates (BMFJ, 2016). At the same time, the independent mobility is declining with significant consequences for the physical, social and mental development of children (e.g. Frauendienst & Redecker, 2011; Shaw et al., 2013, 2015). Although there are some promising tendencies among Germans young adults in terms of declining car ownership rates and car travel (Kuhnimhof, Wirtz, & Manz, 2012), the car is still seen as a symbol of freedom: Accordingly, 72% of pre-license teenagers residing in the city of Vienna with a high quality supply of public transport (strongly) agreed on the question, whether they would like to obtain a driving license as soon as possible and drive a car on their own (Bartana, Stark, & Fritz, 2015). Against the background of these developments and the pressure of current European emission reduction targets, many awareness campaigns and policies promoting walking and cycling have been conducted in recent years. Most of them target adults, although the willingness of teenagers to accept habitual changes is higher than for adults (Scholl & Sydow, 2002). Some authors state that the changeability of personality traits ends in early adulthood (Bloom, 1964; Costa & McCrae, 1985). According to Scholl and Sydow (2002) the car gains a symbolic value for adolescents long before they obtain a driving license. In addition, Flade and Limbourg (1997) state that a pro-car orientation seems to be acquired from

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the age of 12; it increases with rising age. Therefore, it can be assumed that behavioral interventions for young adolescents in the age group of 12–14 – representing a "transition phase" between childhood and adulthood – may be relevant and, presumably, even more effective compared to older target groups. Of course, this age group does not act totally autonomously and their travel behavior is still influenced by their parents' travel decisions. However, some positive impacts on travel behavior may become evident only after teenagers reach adulthood and exercise their preference for a certain mode of transport. The current study will therefore focus on early adolescents in this developmentally important phase.

Travel behavior of children is a widely discussed topic, especially primary school children and mode choice on their school trips are often subject of programs. However, there is a scarcity of empirical information about well-tested complex interventions to influence the everyday mobility, especially, of young people in the transition period from children to teenagers. Some evaluations exist for Safe Routes to School (SRTS) programs promoting active school travel (AST) which started in 2005 in the U.S. (Stewart, 2011): The objective of SRTS is to increase the rate and safety of AST through both infrastructure improvements and non-infrastructure activities. Particularly, SRTS programs support walking or biking safely on school trips through some combination of (i) engineering measures (e.g. infrastructure improvements), (ii) education (e.g. safety courses), (iii) enforcement (e.g. increased police patrols near schools), (iv) encouragement (e.g. events or media campaigns), and (v) evaluation (e.g. data collection and analysis). In existing evaluations, none of the changes in AST-rates could be directly attributed to the effects of SRTS programs because they were not compared to changes in rates at control schools. In conclusion Stewart (2011) states that evaluations using more rigorous experimental designs are necessary.

Mendoza, Levinger, and Johnston (2009) evaluated the implementation of a walking school bus (WSB) at one school in Washington within a controlled, quasi-experimental trial with consecutive cross-sectional assessments. They found that WSB is a promising intervention in the short and long term among urban, low-income elementary school students. More studies can be found in the area of health research: A systematic review on the effectiveness of interventions to promote physical activity in early adolescence was conducted by Van Sluijs, McMinn, and Griffin (2007). The authors identified 33 studies aimed at children and 24 at adolescents. Twenty-four studies were of high methodological quality, including 13 studies in children. Although some evidence was found for potentially effective strategies to increase the levels of physical activity, as stated by the authors, a lack of high quality evaluations hampers conclusions concerning effectiveness, especially among children.

This article contributes to the literature by presenting a before-after control group experiment with intervention on young adolescents (12–14 years), which enjoy relatively little research attention in comparison with adults, early-license teens and primary school children. The paper provides an insight into their everyday mobility and in better understanding of the effectiveness of campaigns using a robust experimental design. Our intervention focused on a reduction of car passenger use and promoting walking and cycling as environmentally friendly and healthy modes of transport. In contrast to other studies, this study examines the impacts on travel behavior <u>and</u> attitudes in this age group. Our approach is based on the Theory of Planned Behavior (TPB), which is a widespread socio-psychological model for the prediction respectively explanation of planned behavior. Furthermore, Steinmetz, Knappstein, Ajzen, Schmidt, and Kabst (2016, p225) highlight "the utility of the TPB for designing and evaluating the effectiveness of interventions across different behaviors". The theory was developed by Icek Ajzen in 1980s based on the Theory of Reasoned Action (TRA). According to the theory, intentions and behaviors can be influenced if significant effects are caused on one or more of the following predictors: (i) attitudes toward the behavior, (ii) the expectations on how others will evaluate the behavior (subjective norm) and (iii) the expectation on how easy it is to perform a certain behavior (perceived behavioral control) (e.g. Ajzen, 1991, 2011). These three dispositions guide the intention which is assumed to be the immediate antecedent of behavior: The more favorable the attitude and subjective norm, and the greater the perceived behavioral control, the stronger should be the person's intention to perform the behavior. The stronger the intention, the more likely an individual will perform the behavior. This relation can be moderated by the degree of control over the performance of a questioned behavior (Ajzen, 2011). If there are factors outside an individual's control, PBC can also contribute directly to prediction of behavior. PBC may also have a moderating effect of the intention-behavior relationship (Fishbein & Ajzen, 2010). In this context, higher PBC is associated with better intention-behavior consistency. There could be also other moderating effects (e.g. habit), which are not discussed in detail here.

The theory is very often applied in the field of health studies. The TPB is also applied in research on travel behavior in different contexts (e.g. Abrahamse, Steg, Vlek, & Gifford, 2009; Bamberg, 1995; Bamberg, Ajzen, & Schmidt, 2003; Bamberg & Schmidt, 1998, 2003; Forward, 2014; Heath & Gifford, 2002). However, no application can be found in this study area on 12–14 years old adolescents, except for one study on bicycle use in New Zealand (Frater, Kuijer, & Kingham, 2017). Main focus of the study of Frater et al. (2017) was to assess how variables from the prototype/willingness model contribute to TPB to predict intention to cycle to school. In other research subjects, TPB is a well-supported theoretical framework applied to analyze attitudes and behavior of children and youth; most of them refer to health-related decision making and sports-psychology (e.g. Fila & Smith, 2006; Lien, Lytle, & Komro, 2002; Wigginton, 2011). In this context, findings indicate that TPB is useful for predicting factors directly related to behavior, but not for predicting the indirect effect of intention (e.g. Fila & Smith, 2006). They summarize that older samples (26 or older) are more likely to act on their intentions, and thus more likely to perform the intended behaviors, than are younger samples (25 or less) (Wigginton, 2011). In the field of exercise behavior "intention-behavior gaps" were confirmed for young age groups by several studies (e.g. Martin, Kulinna, McCaughtry, Cothran, & Dake, 2005; Martin, Oliver, & McCaughtry, 2007; Motl et al., 2002; Trost, Saunders, & Ward, 2002). Researchers suggest that intentions are not stable in young age groups, and that other factors besides intention are driving exercise behavior or healthy eating behavior (e.g. habit, socioeconomic status). Further, children have difficulties in translating intention into behavior as a result of unforeseen barriers, limited self-regulation skills and a lack of behavioral control (Motl et al., 2002).

Transferring these results to the subject of mobility behavior, we assume some similarities because children are presumably not totally free in their travel decisions and have behavioral routines. On the other hand, early teenagers tend to emphasize their autonomy and begin to individuate themselves from their parents (Schilder, Brusselaers, & Bogaerts, 2016). In this context, we considered the individual freedom of mode choice being a potential variable in our model development, but not habit.

Our study examines the effect of an intervention on children's changes in attitudes, intentions and behavior. Therefore, we assume that the TPB is a useful instrument in making effects visible. Understanding the effectiveness of awareness campaigns may provide important answers for policy-makers on if this age group can be addressed, and on how well planned and resolutely pursued campaigns might contribute to the overall development of active and sustainable mobility. It is hoped that the present analysis will also encourage researchers to find new pathways to understand travel behavior in this age group in general.

2. Approach

2.1. Study design and participants

We used a before-after control group experiment which is a widely used approach in intervention research (e.g. Langweg, 2009). Mobility and attitude surveys were conducted with a one-year interval between waves. In between, we conducted an awareness campaign for the promotion of active travel modes. The net effect of the intervention results from the before-after comparison of the test group after the deduction of the before-after effect in the control group. This ensues from the principle according to which external impacts (such as increase in age, weather conditions) can be eliminated. The first set of data was collected in April 2013 and started with an attitude questionnaire (Section 2.2). The questionnaires were handed out in class. Instructions on the scales and supervision were offered for the completion of the questionnaires. Over a period of seven days students filled in the paper-and-pencil travel diary for reporting their detailed travel behavior – mainly as part of their lessons (Stark, Bartana, & Fritz, 2015). The second phase of data collection took place in April 2014, following the same procedure. The intervention phase started about four months after the first wave and was finished two weeks before the second wave.

This study was conducted at four secondary schools in Austria and Germany. The school locations differed in terms of geographical setting and public transport supply (Table 1): We selected two schools from Vienna (A in the densely built city center, B at the edge of Vienna, both with good public transport supply), one from a small town in Lower Austria (C, less accessible with public transport), and one school from Itzehoe, Germany (D, comparable with school C in regard to the location and public transport supply). School D was included as "outside group" from Northern European, which is characterized by a high affinity to bicycle.

According to a most similar case design, two classes per school took part in the surveys and were arbitrarily assigned to the intervention or control group. However, we were not able to randomly assign the adolescents within the classes to the intervention or control group, because the intervention consisted of group events with the whole class; the momentum in the group was indeed an important factor of motivation. In total 169 persons (90 in test group, 79 in control group) took part in both waves and all surveys. Participants in the final sample were 54% female.

2.2. Questionnaires

For the attitude survey, we developed a one-page *attitude questionnaire*. The items were designed to assess the constructs in the Theory of Planned Behavior (TPB). The travel mode alternatives considered were car-passenger, public transport, riding a bicycle, and walking. With respect to each travel mode, respondents answered two questions designed to measure each of the predictors in the TPB: attitude (ATT), subjective norm (SN), perceived behavioral control (PBC), and intention (INT). Responses were provided on 5-point graphic scales which were explained to the adolescents. The two items for each TPB-construct were separated by other items, but all items for a given travel mode were kept together. As outlined above, there are no comparable TPB-applications in the transport context for children at this age. Therefore, the questions were designed in part following the questionnaire Bamberg et al. (2003) used in their study on the effects of the introduction of a pre-paid bus ticket on increased bus use among college students and modified to keep the questions as simple as possible for our age group. Travel-mode attitudes were assessed using the following two items: "For me, to take public transport (use the bicycle/to walk/going by car as a passenger) is (i) "good–bad" and (ii) "pleasant–unpleasant". The two subjective norms items were formulated as follows: (i) "Most people who are important to me think that I should take public transport (use the bicycle/walk/go by car as a passenger)" and (ii) "Most people who are important to me would support me taking public transport (using the bicycle/walking/going by car as a passenger)". These items were followed by a 5-point scale with endpoints labelled "likely and unlikely". Perceived behavioral control was assessed using the following two items: (i) "For me to take public transport (use the bicycle/walk/go by car as a passenger) is easy – difficult" and (ii) "My freedom to take

Table 1
Characteristics of the studied schools (changed after Stark, Beyer Bartana, Fritz, Unbehaun, & Hössinger, 2018).

School	A	B	C	D
General plan of school location				
Location	Center of town (Vienna)	Edge of town (Vienna)	Small town in rural area (Tulln)	Small town in rural area rural area (Itzehoe)
Country	Austria	Austria	Austria	Germany
Density [inhabitants/km^2]	5458[a] (urban district)	1437[a] (urban district)	139[a] (district)	125[b] (district)
Accessibility with transit	Very good connections (metro, tram, bus)	Good connections (metro, tram)	Very few connections (busses)	Very few connections (busses)

[a] Year 2017.
[b] Year 2016.

public transport (use the bicycle/walk/go by car as a passenger) is high–low". Intention was surveyed using the items (i) "My intention to take public transport (use the bicycle/walk/go by car as a passenger) in the near future is strong–weak" and (ii) "I intend to take public transport (use the bicycle/walk/go by car as a passenger) in the near future" (likely–unlikely).

Data on the travel behavior were collected by means of an one-week *travel diary*, where each trip was self-reported along with the following attributes: used travel modes and duration on trip stages (trip sections traveled with a uniform mode), origin and destination, weather conditions and accompanying persons (Stark et al., 2015). To find out more about the freedom of mode choice, we collected information on the decision makers per travel mode ["I chose the mode by myself; together with others; it was chosen by someone else"]; the answers would help ascertain possible changes in mode choice and attitudes that could be brought about through our intervention. With the help of the travel diaries we were able to calculate different variables on mode use on the level of trip stages, trips and persons (Section 3.3.1). Further, *household information* were collected. Due to lack of space, a description of this questionnaire is not included.

The second wave of the survey used the same questionnaires.

2.3. Intervention

Our intervention for the test-group mainly consisted of three elements: (i) information, (ii) reflection and (iii) action (Fig. 1). The activities are briefly described below. All campaign materials, presentations and activities were designed and conducted by researchers. We attached importance to design all materials to the age of our target group. Key characteristic of the intervention program was an individualized treatment of the children. This means that their actual travel behavior served as starting point for most of the materials, discussions etc. Although the preparation of a tailor-made intervention is more complex, this does not mean that the concept is not transferable to other groups. As outlined above, the control group received no intervention.

The *information phase* aimed at the transfer of knowledge. We addressed the following topics with the help of presentations in the classroom: (i) Environmental impacts of traffic and infrastructure (including energy consumption, noise and pollutants, fragmentation of natural habitats, consumption of space, and urban sprawl), (ii) negative impacts of lack of physical activities were discussed and (iii) traffic safety with the focus on traffic accident risk of young adults. The presentations included videos, games and questions of estimation. The information events took about five school lessons à 50 min (per class in the test group) in total. Besides presentations, we designed worksheets in the field of mobility. Some of these worksheets were individualized based on the data of the first travel survey. For example, children calculated the costs and emissions of their own trips and compared the results to the class.

The *reflection elements* in the intervention served to promote alternatives to car use and arouse young people's interest in current barriers of using active travel modes. Each student received a one-page individual certificate named 'mobility passport', which summarized the individual travel behavior collected in wave 1: The mobility passport contained amongst others information on trip lengths (school-home), number of trips, and mode choice (e.g. for school trips, other trips, trips shorter than three kilometers). One chart visualized the individual mode choice in comparison to the school class. All contents of the mobility passport were designed in a child-friendly manner. Based on this sheet we discussed the individual mode choices. With the help of questionnaires, we also collected subjective reasons why children do not use active travel modes more often. We conducted workshops where the students examined individual alternatives to their car use and the potential to increase the level of activity and sustainability of their mobility.

To put these ideas into practice the students conducted 'active days' and reflected on their experiences in testing the alternatives on their school and leisure trips. These discussions included feedback from researchers and classmates. These

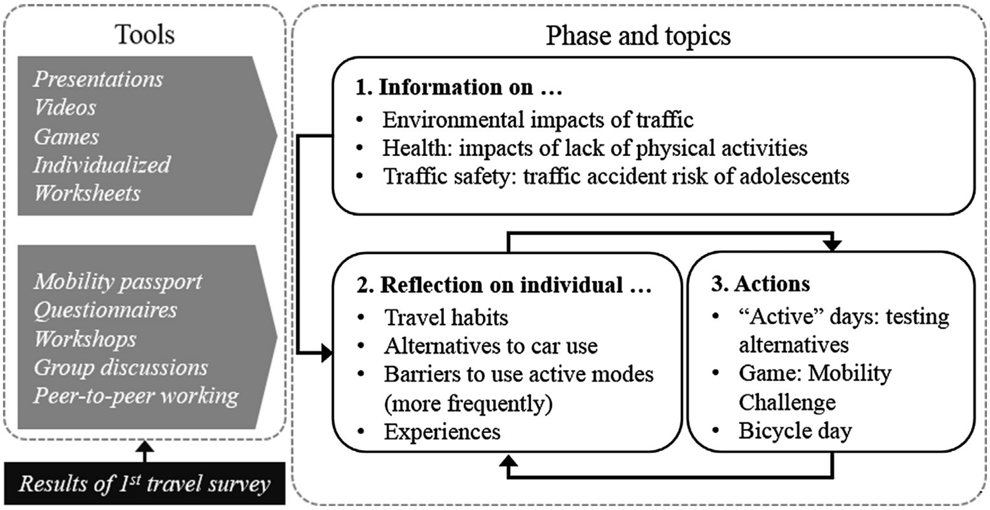

Fig. 1. Overview of topics and tools of the intervention.

activities served also as a preparation for a one-week 'mobility challenge'. The objective of this game was the collection of points by reducing the individual car use and increasing the use of active travel modes compared to their results based on mobility data of survey 1. Within five days children competed individually, in teams within the class and between the schools. There were also prizes to be won. The current score was updated daily to encourage a maximum performance. This intervention phase also included an outdoor "bicycle day" and a reflection workshop after the mobility challenge.

Overall, the intervention activities took about twelve school lessons à 50 min (per class in the test group) – excluding the all-day activities and the one-week 'mobility challenge'.

3. Results: Effectiveness of the intervention

To assess the overall impact of the intervention, we analyzed the indicators of the TPB and the reported behavior before and after the intervention. Because most of our information and activities in our campaign were designed to decrease car use as a passenger and to increase walking and cycling we expected the strongest effects on these modes; we did not expect our intervention to have a strong effect on the use of public transport.

3.1. Attitudinal variables

The changes of attitudes were analyzed by using pairwise t-tests between wave 2 and 1 and a two-sample *t*-test for the differences between control and test group (Table 2). All underlying variables on attitude, subjective norm, perceived behavioral control (PBC), and intention range from 0 to 1, with higher scores indicating favorable dispositions.

Table 2 shows some significant effects on attitudes, intentions and PBC in the intended direction: The test group shows a significantly stronger positive change of walking-related variables than the control group (applies to attitudes, perceived behavioral control, and intention). For the cycling variables we found no significant difference between test group and control group, but a positive change of all corresponding variable in both groups. The effect on public transport is ambivalent: the attitudes toward this mode became more positive (but in the test group less than in the control group); the PBC and intention changed negatively in the test group but positively in the control group. This counter-intuitive pattern may result from the competitive relationship between the modes: an increase of the intention to use a particular mode (e.g. walking in the test group) will ceteris paribus decrease the intention to use other modes (e.g. public transport). In the intervention we explicitly recommended to increase the level of active mobility by not taking the nearest public transport station but walking to the next one. For car passenger use the detrended attitudes, control beliefs and intentions of the test group became significantly more negative after the intervention – as intended.

The subjective norm variables (SN) show little differences between control group and test group. This is plausible because the intervention did not target to change the children's perceived expectations. The increase in the SN-level between wave 1 and 2 (for both groups in all modes) may indicate that the children perceived an increasing social pressure (e.g. from environmental and health awareness) or a greater willingness to comply with the normative requirements.

3.2. Mode choice

The impact of the intervention on the travel behavior of the young adolescents was measured by comparing the reported mode choice before and after the intervention. We generated three different indicators of mode choice on trip level: (a) a

Table 2
Two-sample *t*-test of differences between test group (T) and control group (C) with respect to changes from wave 1 (0) to wave 2 (1); (***p < 0.001, **p < 0.05, *p < 0.10), N = 169 persons.

Travel mode	Variable	$\Delta M_{1\text{-}0,T}$	$\Delta M_{1\text{-}0,C}$	$\Delta M_{1\text{-}0,T}-\Delta M_{1\text{-}0,C}$	t	p
Walking	ATT_1	0.889	0.405	0.484	2.224	0.028**
	ATT_2	0.822	0.418	0.405	1.749	0.082*
	SN_1	0.344	0.456	−0.111	−0.448	0.654
	SN_2	0.633	0.329	0.304	1.264	0.208
	PBC_1	0.922	0.468	0.454	1.946	0.053*
	PBC_2	1.000	0.430	0.570	2.471	0.015**
	INT_1	0.622	0.165	0.458	1.876	0.062*
	INT_2	0.611	0.304	0.307	1.300	0.195
Bicycle	ATT_1	0.522	0.203	0.320	1.536	0.126
	ATT_2	0.356	0.215	0.140	0.625	0.533
	SN_1	0.344	0.380	−0.035	−0.153	0.879
	SN_2	0.489	0.595	−0.106	−0.515	0.607
	PBC_1	0.311	0.658	−0.347	−1.550	0.123
	PBC_2	0.611	0.595	0.016	0.071	0.944
	INT_1	0.367	0.101	0.265	1.138	0.257
	INT_2	0.389	0.329	0.060	0.279	0.780
Public transport	ATT_1	0.178	0.342	−0.164	−0.725	0.470
	ATT_2	0.200	0.203	−0.003	−0.012	0.991
	SN_1	0.389	0.418	−0.029	−0.122	0.903
	SN_2	0.644	0.544	0.100	0.399	0.691
	PBC_1	−0.011	0.101	−0.112	−0.679	0.498
	PBC_2	−0.100	0.089	−0.189	−0.926	0.356
	INT_1	−0.333	0.127	−0.460	−2.022	0.045**
	INT_2	−0.033	0.430	−0.464	−1.911	0.058
Car passenger	ATT_1	−0.267	0.241	−0.507	−2.517	0.013**
	ATT_2	0.156	0.013	0.143	0.643	0.521
	SN_1	0.167	0.342	−0.175	−0.797	0.427
	SN_2	0.156	0.152	0.004	0.016	0.987
	PBC_1	−0.756	−0.228	−0.528	−2.543	0.012**
	PBC_2	−0.533	−0.215	−0.318	−1.362	0.175
	INT_1	−0.644	−0.291	−0.353	−1.513	0.132
	INT_2	−0.778	−0.114	−0.664	−2.970	0.003**

nominal variable indicating a single "main mode" for each trip; (b) a dummy variable for each mode indicating if the mode was used on at least one stage of the trip; and (c) a metric variable for each mode indicating the time share of this mode on the trip. Table A-1 in the Appendix shows the result for these indicators, if all reported trips in both waves are taken into account. The table shows the changes in mode choice from wave 1 to wave 2 in the test group and control group along with a significance test of differences between the changes in both groups. The largest effect is a significant increase of public transport use in the control group, which is balanced by insignificant reductions of car use and bicycle use. This inconclusive pattern may be caused by different characteristics of the trips in both waves. Since we had no mode choice model to account for possible changes in distance, availability of modes etc., we took the following approach to control for the changes: We identified corresponding pairs of trips made by the same person from the same origin to the same destination in both waves. From a total of 5939 trips in both waves 46% meet this criterion, which account for 1360 trip pairs (602 in the control group, 758 in the test group) of 155 persons. We used only these 1360 comparable trip pairs for the subsequent analysis.

Table 3 shows the results for all three indicators: a two-sample *t*-test for the differences between test group and control group with respect to the changes in mode choice from wave 1 to wave 2. It should again be noted that the time shares of the modes are like communicating vessels (as mentioned for the intention): an increasing share of one mode causes ceteris paribus decreasing shares of other modes. Both groups show a similar decrease of 'car passenger use', but the results for the other modes are different. The control group shows also a strong decrease of cycling in favor of walking and public transport. The test group engaged particularly in cycling; this is the strongest deviation from the control group, which is highly significant across all indicators. The shares of walking and public transport increased not as much as in the control group (or not at all – depending on the indicator); these differences are only moderately significant.

The changes in mode choice are not fully in line with our expectations (we expected in particular a significant positive effect on walking) nor do they reflect the changes in attitudes as shown in Table 2. From this, it seems that the attitudinal changes did not manifest themselves in behavioral changes. In order to analyze the effect chain from our intervention on the attitudes and further down to the behavior we developed structural equation models. The person-based models in the

Table 3
Two-sample *t*-test of differences between test group (T) and control group (C) with respect to changes from wave 1 (0) to wave 2 (1); ($^{***}p < 0.001$, $^{**}p < 0.05$, $^{*}p < 0.10$), N = 1360 trip pairs.

Travel mode, definition	$\Delta M_{1\text{-}0,C}$	$\Delta M_{1\text{-}0,T}$	$\Delta M_{1\text{-}0,T}-\Delta M_{1\text{-}0,C}$	t	p
(a) "Main mode"					
Walking	0.033	0.015	−0.019	−1.363	0.173
Bicycle	−0.043	0.033	0.076	4.631	0.000***
Car passenger	−0.047	−0.045	0.002	0.080	0.936
Public transport	0.057	−0.003	−0.059	−2.719	0.007**
(b) "Mode used"					
Walking	0.012	0.024	0.012	0.458	0.647
Bicycle	−0.060	0.030	0.090	5.079	0.000***
Car passenger	−0.040	−0.054	−0.014	−0.675	0.500
Public transport	0.057	−0.003	−0.059	−2.719	0.007**
(c) "Time share"					
Walking	0.038	−0.001	−0.039	−2.577	0.010**
Bicycle	−0.046	0.030	0.076	4.573	0.000***
Car passenger	−0.043	−0.045	−0.002	−0.117	0.907
Public transport	0.049	0.016	−0.034	−1.827	0.068*

Note: We tested different definitions of mode choice on trip basis: (a) single "main mode" of the trip, (b) dummy if the mode was used on at least one trip stage, and (c) time share of the mode on the trip.

following section concentrate on walking, cycling and car use as a passenger, because our intervention focused on the promotion of non-motorized modes at the expense of car use.

3.3. Structural equation model

3.3.1. Input variables

Our intervention between the two survey waves aimed at changing attitudes and mode choice of the individuals in the test group. The main input variables are (i) a binary treatment variable, which is one if an individual belongs to the test group and zero otherwise, (ii) the changes in TPB-indicators, and (iii) the change of travel behavior, which is indicated as time share of travel modes on identical trips in wave 1 and 2 (indicator c from above). This indicator seems most appropriate, since our intervention not only aimed at switching to active travel modes but also at increasing the share of active modes. It should further be noted that the time shares on trip level (as shown in Table 3) were aggregated to person level by calculating the time share of travel modes on the total duration of all reported trips of a person.

As outlined above, modeling differences between a test group and a control group with respect to the changes of a before-after experiment is a quite rigorous test of an intervention; it removes almost all other possible influences on behavioral changes aside from the intervention (changes in age, road infrastructure etc.). Tables A-2–A-4 present the means, standard deviations, and correlations among the input variables regarding walking, bicycle use and car use as a passenger (Appendix).

Aside from the variables mentioned above, we took another aspect into consideration, which may interfere the relationship between intention and behavior (which seems to be low according to the descriptive results): A change of attitudes and intentions can only lead to a behavioral change if the children have the potential to use another travel mode on a particular trip. Besides situational factors such as trip length and availability of alternatives, our target group – young adolescents – comes along the characteristic not being completely free in their travel decisions. To consider this aspect we defined a binary potential variable for each travel mode, which is one if the mode had the potential of being used on a particular trip and zero otherwise. The potential variables were aggregated to person level by calculating the mean of all reported trips of a person. The potential is assumed to act as barrier only against a use of this mode, not against its non-use, that way moderating the effect from the intention to the behavior in the structural equation models.

The potential variables were defined as follows: The potential for walking is positive if the trip is shorter than 2.25 km and if the person made his/her mode choice at least partly independently. The potential for cycling is defined similarly, but with a trip length shorter than five kilometers and in consideration of the availability of a bicycle. The potential for car use is defined for a trip if the car option is faster than the public transport option, the trip is longer than one kilometer, the household owns a car and the decision on the use was not made completely externally. Infrastructural aspects were not considered in the potential variable, as we had no data about the built environment such as the existence of bicycle lanes in the residential areas or along the route.

According to the Theory of Planned Behavior, such barriers to perform a certain behavior should be reflected in the variable PBC. However, we assume that children have difficulties to aggregate their situational constraints to an overall estimation. In this context our approach can be seen as an "external objective monitoring" to control for individual situational constraints.

3.3.2. Model analysis

The person-level data for walking, bicycle use and car use as a passenger were subject to structural equation analyses, using IBM SPSS Amos (version 18.0). The model structure followed the TPB, however without a direct path from PBC to behavior, because path coefficients were insignificant.

The moderator effect of the potential on the path from intention to behavior was tested using the 'residual centered approach' (Little, Bovaird, & Widaman, 2006). Steinmetz, Davidov, and Schmidt (2011) recommend this approach based on a test of different approaches to detect interaction effects in the TPB. The uncentered indicators of the first-order effect variables (change of intention ΔINT and potential) are multiplied; the product is regressed on all first-order indicators; the residuals (of ΔINT1 ∗ Potential and of ΔINT2 ∗ Potential) are used as indicators of the 'pure' interaction effect (Int ∗ Pot), which is uncorrelated with the first-order effect variables.

The model fit was evaluated by means of the following indices: goodness-of-fit (GFI, Jöreskog & Sörbom, 1984), adjusted goodness-of-fit (AGFI; ibid.), root mean square error of approximation (RMSEA; e.g. Steiger, 1990), and the comparative fit index (CFI; Bentler, 1990). The GFI estimates the amount of variance explained by the model. AGFI adjusts the GFI by taking into account the degrees of freedom available for testing the model. Both are bounded above by one, which indicates a perfect fit, whereby a good fit is indicated by values above .95. The RMSEA indicates the discrepancy between implied covariance matrix (derived from the hypothesized model) and observed covariance matrix, with smaller values indicating a better fit. Usually, a value of .06 or less is indicative of an acceptable fit (Hu & Bentler, 1999). The CFI represents the ratio between the discrepancy of the target model to the discrepancy of the independence model and takes into account sample size. CFI values close to 1 indicate a very good fit. We provide the CFI for the default (index D) and saturated (index S) model.

The following figures show the parameters of the standardized solution. Due to the relatively low sample size of 155 participants, who took part in both survey waves and had identical trips in both waves, we set the significance level to $p \leq 0.10$; effects with a p-value above this level are put in brackets. It should be noted that several effects from the intervention to the PBC variables are just slightly above this level (Appendix Table A-5).

Fig. 2 displays the structural equation model for walking by means of the standardized parameters and the share of explained variance in the change of intentions and behavior. The goodness-of-fit indices reach satisfactory levels (GFI = .95, AGFI = .91, RMSEA = .03, CFI_D = .98, CFI_S = 1.00). The intervention had a positive effect on the change of attitudes and PBC as intended, although both are not significant. The change of attitudes and PBC had in turn a positive (and significant) effect on the change of intention. The change of intention is explained very well, but the realization into behavioral changes is weak (intention-behavior gap).[1] The first-order effect from the change of intention is positive as expected but not significant. There is an additional positive effect from the interaction term, which is even significant: if there was a potential to walk more due to a high share of walkable trips and a high freedom of choice, children with increasing intention walked more. Both effects from the change of intention and from the interaction term have however a low size, so that the share of explained variance in the change of behavior is low.

Fig. 3 displays the structural equation model for bicycle use by means of the standardized parameters and the share of explained variance in the change of intentions and behavior. The goodness-of-fit indices again reached satisfactory levels (GFI = .97, AGFI = .94, RMSEA = .00, CFI_D = 1.00, CFI_S = 1.00). The model shows similar tendencies like the walking model, but there are more serious problems with significance and a counter-intuitive (negative) parameter from the intervention to the change of PBC. The size of the effects from the change of attitudes and PBC on the change of intention is again very high, resulting in a high share of explained variance in the change of intention. In contrast to the walking model, the first-order effect from the change of intention to the change of behavior is significantly positive, whereas the interaction term with potential has no significant effect and is omitted from Fig. 3.

Fig. 4 displays the structural equation model for car use as a passenger by means of the standardized parameters and the share of explained variance in the change of intentions and behavior. There are two remarkable differences from the walking and cycling model: First, the intervention has a stronger and significant effect on the change of attitudes and PBC (with a negative sign following the intention of the intervention to reduce the share of car use as a passenger). Second, the effect of the change of attitudes and PBC on the change of intention is smaller and not significant, resulting in a relatively low share of explained variance in the change of intention. The effect from the change of intention to the change of behavior is similar like in the bicycle model: no significant interaction with the potential, but a positive first-order effect from the change of intention to the change of behavior, which is significant but at a low size, so that the share od explained variance in behavioral changes is also low. The goodness-of-fit indices reach again satisfactory levels (GFI = .97, AGFI = .93, RMSEA = .02, CFI_D =.99, CFI_S = 1.00).

Table 4 shows the result of a power analysis for the behavioral effect (i.e. the change in walking, bicycle use, and car use) caused by the intervention according to the three aforementioned models. The top row shows the probability (power) that the observed effect size (multiple squared correlation) leads to a rejection of the null hypothesis at the given sample size (N = 155) and a significance level ($1-\alpha$) of 0.95. Owing to the relatively small sample and the low effect size, all three models fail to reach a power of 0.8. The 2nd row shows the sample size that would be necessary to yield a power of 0.8, i.e. an 80%

[1] Meta-analyses show that intentions explain in general 28% of the variance in behavior (Sheeran, 2002); this result is however obtained from models with state variables, not from models of differences.

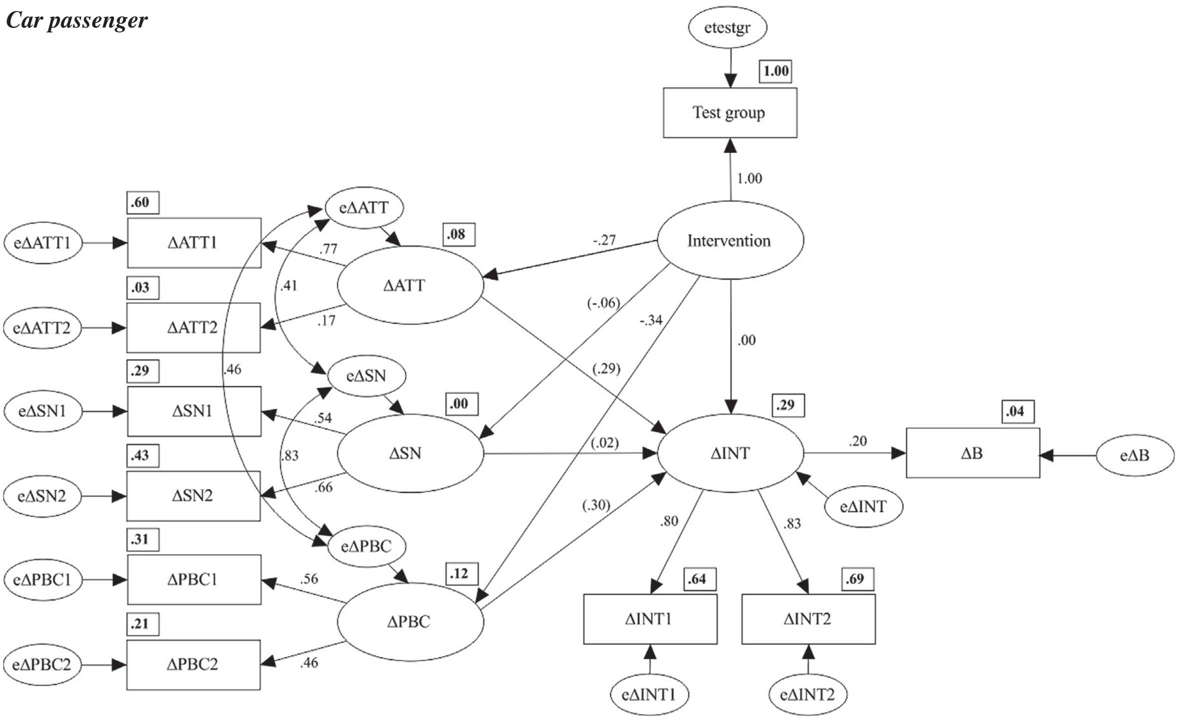

Fig. 4. Difference model of car use as a passenger: structural equation model with standardized path coefficients and explained variances in change of intentions and behavior. N = 155 persons. ATT = attitude; SN = subjective norm; PBC = perceived behavioral control; INT = intention; B = behavior; values in brackets are not significant on the 0.10-level.

Table 4
Power analysis of the change in mode choice caused by the intervention.

Indicator	Walking	Bicycle	Car passenger
Power of default model with sample size = 155	0.775	0.431	0.599
Required sample size for a power of 0.8	164	354	239

probability of rejecting the null hypothesis under the same conditions (same effect size and significance level). These sample sizes can serve as a benchmark, if the behavioral effect of this type of intervention is to be evaluated.

4. Discussion and conclusions

This study sheds light on a relatively unexplored field of research concerning the evaluation of an intervention on both awareness raising and travel behavior for early adolescents. There are many interventions that aim at a behavioral change toward more active and sustainable travel pattern of this target group. This underlines the need to know the effects of such campaigns. Some interventions were indeed accompanied by evaluation studies (e.g. Bamberg et al., 2003). However, for all we know this is the first before-after experiment with test group and a control group, in which the *pairwise differences* between the variable values before and after the intervention are directly used in the model (rather than using the variables of both waves separately). This is a quite rigorous test; it removes almost all other possible influences on the relationships, which may result from 'third variables' such as changes in age, changes in road infrastructure etc. We are able to interpret the effects straightforward as causal effects of the intervention. We used the data of those persons only, who took part in both waves and had identical trips in both waves – and we only used the attributes of these identical trips for the behavioral variable. This rigorous selection resulted in a limited sample size of 155 participants, what comes along with a limited significance even of effects of moderate size.

Nonetheless, the picture emerging from the analysis is quite clear: Our intervention described above proved to be an effective intervention to change the attitudes and perceived behavioral control of participants with respect to the use of different travel modes. The changed attitudes and control beliefs resulted in turn in a change of intentions: participants of the intervention intended to use non-motorized travel modes more, and car less. There is almost no direct effect from the intervention to the intention, confirming the assumption of the TPB that all external effects on the intention are mediated either through attitudes, subjective norms, or control beliefs. However, a change of behavior (which was an explicit aim of the intervention) was hard to achieve; the effect from the change of intention to the change of behavior accounts only for a few percent of explained variance in the change of mode choice for all three modes. Particularly for the walking mode it turned out that the translation from intention to behavior depends on the existence of short 'walkable' trips, what can be seen as an interaction effect between perceived behavioral control and intention on behavior (Fishbein & Ajzen, 2010). We achieved much less than the 28% reported by Sheeran (2002) for the variance in behavior, which is in general explained by intentions. There are probably several reasons for this. The first is that the 28% were obtained from models with state variables, whereas we used difference variables. Strictly speaking, we analyzed correlations between first derivatives of attitudinal variables, which are probably lower than the correlations between the original variables. Secondly, our model has a high level of aggregation: We asked for the general intention to use different travel modes for all trips during the next week, and the behavioral variables are the time-shares of these travel modes during the whole week. The aggregation level causes more situational variability, which brings more noise into the relationship between intention and behavior. It should further be noted that most studies do not use observed behavior and past behavior as proxy for present behavior.

This study only examined a sample of youth in four settings and findings may not be true for all youth in Austria and Germany. However, authors believe that findings are appropriate for basing future research and practice in persons of this age group. For future research, we recommend using larger, representative samples and objective data in addition, because our results solely relied on self-reports of the adolescents. In addition, the study is also limited by the non-randomized study design. From a methodological point of view, habit should be included to capture existing trade-offs between attitude and habit in the prediction of behavior (Bamberg et al., 2003; Verplanken, Aarts, & Knippenberg, 1994). A strong habit could lead to week attitude-behavior relationships.

Although the present study demonstrates the utility of the TPB as an effective conceptual framework for understanding the effects of an intervention on attitudes, in can be concluded that trip-specific situational relevancies cannot be adequately represented in person-based models. Applying the TPB within trip-based models, in which the situational variance of trip characteristics will fully come to fruition, could be a promising strategy (Stark & Hössinger, 2015). This creates a bridge between social-psychological approaches mainly acting on person level and transport planning approaches.

There is still research needed to derive effective interventions and to find appropriate designs for specific target groups. Which campaigns over what duration for which age groups are most successful? These questions require more systematic research and scientifically valuable evaluations of campaigns. We are aware that our study can only draw conclusions on short-term effects.[2] Future research should also investigate whether an effect in childhood persists in adulthood, when self-regulation increases. This may result in a higher consideration of alternative travel modes and may thus decrease the strength of habit, and increases the success in terms of behavioral changes toward active mobility modes. If no behavioral effects can be evoked by awareness raising campaigns – even not in the long term – policy makers should concentrate on the implementation of measures increasing the potential to exercise certain behaviors. This refers to the consideration of the family setting: future campaigns should involve important reference persons from adolescents' point of view such as parents or older siblings. As Giles-Corti and Salmon (2007) found out that school-based interventions promoting physical activity are more likely to be effective when families are involved than those that do not. It is worth mentioning that particularly for the age group of this study, also friends have a major influence (Frater et al., 2017; Stark & Hössinger, 2015). Creating environments that support local walking and cycling is a priority as a response to current transport needs of children and youth.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Appendix A

See Tables A-1–A-5.

[2] To assess long-term effects of our intervention we repeated the attitude and travel survey one more time. Overall, a comparison to the other two surveys is much more difficult as the sample size was much smaller and relevant circumstances changed: The ongoing analysis shows that 45% of the participants had changes in the school and/or residential location.