Motivation and active travel in adolescent girls and boys in Germany – Findings from the ARRIVE study

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Abstract

Active travel (using an active mode of transport such as walking or cycling) contributes to the accumulation of daily physical activity and thus holds potential for promoting health. To promote active travel among adolescents an in-depth understanding of determinants from a sex/gender perspective is needed. Within Self-Determination Theory (SDT), it is proposed that the quality of an individuals' motivation (i.e., the degree to which it is autonomous) determines the extent to which they engage in particular behaviors and perform them effectively. As part of the ARRIVE study, the aim of this research was to investigate the relationship between motivation and active travel in adolescent boys (N = 263, M_{age} = 12.92) and girls (N = 254, M_{age} = 13.21) from a nationwide German sample. Results showed significant group differences between male and female adolescents in the proportion of trips traveled actively, intrinsic motivation and amotivation. Logistic regression analyses demonstrated different relationships of the different types of motivation proposed within SDT on active travel behavior depending on sex/gender. In the total sample, integrated and identified regulation increased the odds of active travel (by 15.8%, and 20.3% respectively), whereas amotivation decreased the odds by 23.0%. Intrinsic motivation and controlled forms of extrinsic motivation (i.e. introjected and external regulation) did not significantly change the odds of active travel. Separate sex/gender-specific analyses were conducted. For boys, only identified regulation significantly increased the odds of active travel (by 40.2%) and amotivation significantly decreased the odds (by 18.8%). In girls, integrated (by 25.3%) and external (by 20.3%) regulation significantly increased the odds of active travel, while amotivation (26.6%) significantly decreased the odds. We conclude that disparities exist in the relationship among different regulation types with active travel behavior between adolescent boys and girls, and that findings contradictory to SDT might result from the specific context of traveling to a destination. Considering the regression analyses findings, future interventions to promote active travel among adolescents should incorporate

sex/gender-sensitive development, because some behavioral regulations might not be equally effective among girls and boys.

Keywords

Self-Determination Theory, behavioral regulation, youth, active transport, sex/gender analysis

1 Introduction

The majority of young people in Europe and around the globe fail to meet the recommended amount of physical activity (PA) (Guthold, Stevens, Riley, & Bull, 2020; Steene-Johannessen et al., 2020) of an average of at least 60 min/day across the week (Bull et al., 2020; WHO, 2020). This is concerning because the health benefits of PA in childhood and adolescence are evidenced (Janssen & LeBlanc, 2010; Poitras et al., 2016; WHO, 2020). Further, these PA-related health benefits as well as the PA behaviors can persist into adulthood (Corder et al., 2019; Telama et al., 2014). Recent research reinforces a PA gap between boys and girls, with girls being consistently less active across all age groups (Guthold et al., 2020; Steene-Johannessen et al., 2020). This is also evident in Germany with girls meeting the WHO guidelines less frequently than boys (Burchartz et al., 2021).

Past research has shown that active travel (AT) (e.g. walking or cycling to a destination) does not only contribute to adolescents' daily PA (Carlin, Murphy, & Gallagher, 2016; Larouche, Saunders, Faulkner, Colley, & Tremblay, 2014), but it can also enhance several markers of physical fitness, such as cardiorespiratory fitness, muscular strength or body composition (Henriques-Neto et al., 2020). Further, AT helped to reduce the prevalence of non-specific psychosomatic complaints (Kleszczewska et al., 2020).

However, recent research from several countries has demonstrated a declining or generally low prevalence of AT in adolescence (Haug et al., 2021; Larouche, 2018). Internationally, differences between boys and girls in the prevalence of AT or in travel mode have been identified, including Australia (Leslie, Kremer, Toumbourou, & Williams, 2010), Ireland (Costa, Adamakis, O'Brien, & Martins, 2020), Wales and Scotland (Haug et al., 2021), the Czech Republic (Pavelka et al., 2017), and New Zealand (Kek, García Bengoechea, Spence, & Mandic, 2019; Smith et al., 2019). In Germany, however, the MoMo Study did not find significant sex/gender[1] differences in AT to school. Nevertheless, the prevalence of walking (girls: 17.7%; boys: 20.2%) and cycling (girls: 21.5%; boys: 25.2%) to school was low among adolescents aged 11-17 years, which also indicated a tending difference in the choice of travel mode (Reimers et al., 2020). Additionally, a study in Southern Germany among 12 to

[1] The term sex/gender aims to recognize the entanglement of the socially induced gender-related factors and the sex-based biological / physiological attributes that interact to influence health behaviours. To recognize this, we follow the recommendations of the Cochrane Sex/Gender Methods Group by using the term sex/gender (Sex/Gender Methods Group; Springer, Mager Stellman, & Jordan-Young, 2012)

15 year-olds showed that girls were significantly less likely to cycle to school than boys (Schönbach, Brindley, Reimers, Marques, & Demetriou, 2020). Thus, there is still room for improvement for adolescent boys and girls. Apart from the benefit both boys and girls could gain from increased AT, promoting girls' AT might specifically contribute to reducing the sex/gender gap in PA, since girls generally demonstrate lower PA levels than boys (Guthold et al., 2020; Steene-Johannessen et al., 2020). The importance of taking a sex/gender-differentiated approach to health behaviors has been highlighted by recent research in the field of sex/gender (Schlund et al., 2021). Nevertheless, especially intervention studies concerning the promotion of AT in children and adolescents do not sufficiently consider sex/gender (Marzi et al., 2020). To facilitate the development of sex/gender-sensitive intervention programs, the determinants of adolescents' travel behavior should be examined from such a sex/gender perspective.

From a social-ecological standpoint, AT behavior is influenced by individual, interpersonal, community, built environment and policy determinants (Larouche & Ghekiere, 2018). On the individual level, motivation has the potential to positively influence health behaviors such as AT behavior (Ntoumanis et al., 2021; Ryan & Deci, 2017; Schönbach, Vondung, et al., 2020).

Among numerous psychological theories concerning motivation, Self-Determination Theory (SDT; Ryan & Deci, 2017) is an established framework to examine motivational processes for health-related behaviors and to design interventions (Ng et al., 2012). Research substantiates the applicability of SDT in PA settings (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). More specifically aligned with the current work, SDT has been applied in the context of children's and adolescents' PA participation (Owen, Smith, Lubans, Ng, & Lonsdale, 2014; Vasconcellos et al., 2020) as well as more recently to the context of AT to and from school (Burgueño et al., 2019; Burgueño et al., 2020; Marques et al., 2022; Marques et al., 2021).

In addressing motivation (i.e., why people are moved to act), SDT focuses not only on quantity but also on the quality of motivation. According to SDT, two general types of motivation (i.e., controlled motivation and autonomous motivation) as well as the construct of amotivation exist and are ordered along a continuum according to the degree of their autonomy (Ryan & Deci, 2017). At the one end of the continuum, amotivation represents a state in which a person lacks any autonomy or intention to engage in a behavior. Ascending according to the degree of relative autonomy, amotivation is followed by the controlled forms of motivation, which are regulated by external factors such as receiving rewards or avoiding punishments (external regulation), or by internal desires for example to avoid a feeling of guilt or maintain self-esteem (introjected regulation). Moving along the continuum, the autonomous forms of motivation are the result of the conscious value a person ascribes to

the behavior (identified regulation), the congruence with personal needs, values, and goals (integrated regulation), or the mere interest, enjoyment and satisfaction that a person obtains by performing the behavior (intrinsic motivation). In the literature, this dimensional structure results in different approaches to capture motivation (Howard et al., 2020; Kelso et al., 2020). Recent research emphasizes the value of differentiating the motivational types according to their behavioral regulation, as it can encourage meaningful intervention development, for example, by supporting decision-making on the conveying focus of activities (e.g. enjoyment, meaning, reward) (Howard et al., 2020). In terms of sex/gender differences in behavioral regulations, Teixeira et al. (2012) recommended that researchers acknowledge their potential existence and break down data across sex/gender accordingly. Their findings suggest a disparity between males and females in the strength and effect of each behavioral regulation on behavior. Specifically, they reported that certain behavioral regulations were more positively associated with exercise in females while showing no or negative associations in males and vice versa. Although their research focuses on an adult population and exercise, their findings and suggestions are still relevant to our investigation.

Research conducted in Spain provided initial evidence to support the relevance of the motivation types within SDT and AT to school. Specifically, Burgueño et al. (2019) reported that the autonomous forms of motivation (i.e. intrinsic motivation, integrated regulation, and identified regulation) positively predicted adolescents' AT behavior to school. However, this study did not investigate potential sex/gender differences in the six behavioral regulations or whether each regulatory style had equal influences on AT behavior in adolescent girls and boys. Further, the research conducted by Burgueño et al. (2019) was limited to the school domain. Generally, previous studies on AT predominantly focused on AT to/from school (Carlin et al., 2016; Schoeppe, Duncan, Badland, Oliver, & Curtis, 2013) although research suggests that school is just one among several destinations that adolescents frequently travel to in everyday life (Nobis & Kuhnimhof, 2018). Moreover, most studies focus on younger children rather than adolescents (Aranda-Balboa, Huertas-Delgado, Herrador-Colmenero, Cardon, & Chillón, 2020; Carlin et al., 2016; Schönbach, Altenburg, Marques, Chinapaw, & Demetriou, 2020), even though adolescence represents a critical life stage where changes in health behaviors (e.g. AT behavior) are likely to occur and to be carried over into adulthood (Mikkelsen et al., 2019).

Therefore, the present study aims to specifically address these lacks of knowledge by i) taking a sex/gender oriented approach to the motivational determinant of AT behavior; ii) focusing on AT in general by addressing more destinations of daily life than school; and iii) including adolescents aged 11-15 years. To the best of our knowledge, no previous study has examined the motivational mechanisms in general AT in adolescent boys and girls from a sex/gender-sensitive perspective.

Based on the reported importance to identify determinants of general AT behavior coupled with the outlined lack of knowledge, the purposes of this work were twofold. First, this study aimed to systematically investigate whether sex/gender differences exist in the different behavioral regulations for AT. Second, the aim was to examine whether there are disparities in the effects of different regulation types on AT behavior between adolescent boys and girls. Overall, we hypothesize that the six behavioral regulations will help to explain AT behavior in adolescent boys and girls. By investigating the relationships of the behavioral regulations with AT behavior, this study contributes to the overarching aim of the ARRIVE study, to empirically evaluate the theoretical relationships of diverse determinates with general AT behavior in adolescents (Reimers et al., 2022).

2 Methods

2.1 Study design

The present investigation is part of the ARRIVE (Active tRavel behavioR in the famIly enVironmEnt) study, a cross-sectional study to explore social and individual factors within the family environment that influence adolescents' AT behavior (Reimers et al., 2022). For this purpose, the 'Conceptual Framework for the Environmental Determinants of Active Travel in Children' by Panter, Jones, and van Sluijs (2008) was used. The proposed categories of this framework were supplied with several evidence based determinants of adolescents' travel behavior.

2.2 Procedure of data collection

The data collection was conducted in June 2021 by the means of computer-assisted web interviewing. Adolescents were recruited via their parents, by the use of an existing German-wide online panel (forsa.omninet), which is representative of the German population with regard to age, gender, education, and place of residence. The sample was drawn purposively, in order to achieve an approximately equal number of mothers and fathers with approximately equal number of daughters and sons aged 11-15 years. A minimum sample size of 500 parents and 500 adolescents was targeted (Bujang, Sa'at, Sidik, & Joo, 2018). The survey questionnaires were provided online using an online tool specifically developed by Forsa. Parents were recruited offline via telephone interviewing to ensure the representation of people who rarely use the internet within the sample. After parents provided informed consent for participation in the survey, they received a link to the questionnaire via e-mail. The survey was divided into two parts: parents completed the first part of the survey and adolescents responded to the second part. First, parents were informed about the purpose of the study and asked to answer the questions truthfully. After parents had completed the respective part of the questionnaire, they were asked to provide the link to the adolescent so as to let the adolescents fill in the questionnaire on their own.

Parents were advised to only be available for possible comprehension questions. Then, adolescents received the information on the study's purpose and how to answer questions. Adolescents also provided informed consent for participation before responding to the remaining questions. Before every new section of the questionnaire, adolescents were informed about the following content, reminded to answer the questions truthfully, and told that there were no right or wrong answers to the study items. To ensure full completion of the questionnaires, participants had to provide answers to every single item in order to move to the next page and to successfully complete the survey. In the case of more adolescents within the age of 11-15 years in the family, parents were instructed to choose the adolescent whose first name comes first in the alphabet. The current analyses are only based on the adolescent survey. In total, the adolescent survey took about 15 minutes to complete.

2.3 Study population

The study population consisted of 254 girls (M_{age} = 12.92 ± 1.35) and 263 boys (M_{age} = 13.21 ± 1.33) from cities with more than 100,000 inhabitants (29.2%), medium-sized towns consisting of 20,000–99,999 inhabitants (17.4%), small towns with 5,000–19,999 inhabitants (22.2%), and regions with less than 5,000 inhabitants (30.8%) across the whole of Germany. 87.2% of adolescents reported no migration background, 10.3% indicated a migration background from one parent and 2.5% reported a migration background from both parents. Details on characteristics of the study population are presented in Table 1. One adolescent was excluded prior to analyses because the adolescent indicated a diverse gender and the sample size of n=1 was too small to allow for a separate analysis.

Table 1

Characteristics of the study population.

	Total	Boys	Girls
N	517	263 (51%)	254 (49%)
Age			
11	81	31	50
12	113	60	53
13	109	52	57
14	119	64	55
15	95	56	39
Residence			
cities (> 100,000 inhabitants)	151	78	73
medium-sized towns (20,000–99,999 inhabitants)	90	45	45
small towns (5,000–19,999 inhabitants)	115	59	56
rural areas (< 5,000 inhabitants)	159	80	79
Missing	2		
Type of school			

Primary School	12	4	8
Secondary School (Mittelschule*)	24	13	11
Secondary School (Realschule*)	99	55	44
Secondary School (Gymnasium*)	294	140	154
Comprehensive secondary School*	74	43	31
Other	10	5	5
Missing	4		
Migration background			
Yes, from both parents	13	9	4
Yes, from one parent	53	27	26
No migration background	451	227	224
Perceived social support for AT from parents **	5.50 (1.01)	5.54 (0.06)	5.48 (0.06)

Note: * In Germany, students in secondary school are taught at different performance levels either in one school (comprehensive secondary school) or in separate schools (Hauptschule, Realschule or Gymnasium)
** measured on a 7-point Likert Scale and expressed as a mean value (standard deviation); for detailed information on measurement please see (Reimers et al., 2022)

2.4 Measures

2.4.1 Travel behavior

Adolescents indicated transport mode (e.g. by bike, by bus, by car, etc.) to several destinations, which have previously been identified as relevant in adolescent populations from Germany (Nobis & Kuhnimhof, 2018). Thus, the five ways assessed included the way to and from school, to friends/relatives, to shopping facilities and to destinations for leisure-time activities. For this purpose, the Mode and Frequency of Commuting To and From School Questionnaire (Segura-Diaz et al., 2020) was modified and translated to German. The responses on mode of transport were given based on a questionnaire from the Mobility in Germany survey (Mobilität in Deutschland, MiD) (Eggs et al., 2018). Responses to the mode of transport for each trip were later coded into either active (e.g. walking, cycling) or passive (e.g. being driven by car, using public transport). Subsequently, two sum scores for each participant were calculated, indicating the total number of ways traveled actively and passively (i.e. ranging from 0 – 5 ways traveled actively; 0 – 5 ways traveled passively). However, some adolescents indicated, that they did not travel to some of the destinations at all. Therefore, a second (additional) value was calculated for each adolescent: the proportion of ways traveled actively. For this purpose, we used the total number of ways that an adolescent reported to undertake actively and passively ($N_{\text{ways traveled actively}} + N_{\text{ways traveled passively}}$), resulting in a value ranging from 0 to 5) and the number of ways traveled actively ($N_{\text{ways traveled actively}}$). From this, we calculated the proportion of ways traveled actively for each participant:

$$Proportion\ of\ ways\ traveled\ actively = \frac{N_{ways\ traveled\ actively}}{N_{ways\ traveled\ actively} + N_{ways\ traveled\ passively}} \times 100$$

The same procedure was followed to calculate the proportion of ways traveled passively:

$$Proportion\ of\ ways\ traveled\ passively = \frac{N_{ways\ traveled\ passively}}{N_{ways\ traveled\ actively} + N_{ways\ traveled\ passively}} \times 100$$

2.4.2 Behavioral regulation in active travel

The Spanish Behavioural Regulation in Active Commuting to and from School (BR-ACS) Questionnaire (Burgueño et al., 2019) was translated to German and adapted to obtain information about behavioral regulation towards AT in general (with no exclusive focus on AT to/from school). For this purpose, two independent researchers translated the BR-ACS into German and adapted the focus from the original school setting (i.e. I walk or cycle to and from school because…) to general AT (i.e. I cover distances by foot or bike because…). After the resulting two versions of the questionnaire were discussed to reach a consensual first German version, three experts in the field of youth's activity behaviors and motivation reviewed the first German version in terms of semantic, idiomatic, conceptual, and cultural equivalences. The second version was then given to an independent translator to assess whether the German items reflected the content of the original items. The resulting version was tested for acceptability and understanding by two boys and two girls. Based on their feedback, the final German version of the BR-ACS questionnaire was established and used in the study. In total, 23 items on a 5-point Likert Scale assessed behavioral regulation in AT including intrinsic motivation (four items; e.g. I cover distances by foot or bike because it's fun), integrated (four items; e.g. I cover distances by foot or bike because it is consistent with my own values), identified (three items; e.g. I cover distances by foot or bike because I value the advantages), introjected (four items; e.g. I cover distances by foot or bike because I feel guilty when I don't do so) and external regulation (four items; e.g. I cover distances by foot or bike because other people say I should do so), and amotivation (four items; e.g. I don't see the sense of covering distances by foot or bike). For each subscale measuring the respective regulation, an average value was calculated. The adapted German questionnaire including an English translation is enclosed in the supplementary material (Supplementary 1).

2.5 Data analysis

Data analysis was performed in R (R Core Team, 2020) using the psych (Revelle, 2021) and car (Fox & Weisberg, 2019) packages. According to the recommendation from Flake, Pek, and Hehman (2017), the validity of the German version of the questionnaire for measuring behavioral regulation in AT was examined as it was translated and adapted from the original. The factor structure for the translated German version of the BR-ACS was assessed via AMOS (version 27.0; Armonk, NY, USA).

First, descriptive statistics for travel behavior and for each subscale of the questionnaire on behavioral regulation in AT was estimated for the whole sample, and separately for boys and girls.

Second, a confirmatory factor analysis (CFA) tested the six-factor structure of the questionnaire used for the present sample. Maximum likelihood method with Bollen-Stine bootstrap correction (5000 samples) was used since Mardia's test for normality indicated that the data might not be normally distributed (total sample: Mardia's coefficient = 128.756, critical ration (c.r.) = 43.165) (Kline, 2015). According to the recommendation to use a combination of diverse fit measures (Hu & Bentler, 1999), the following fit indices were considered to inform about model fit: chi-squared test (χ^2-test), chi-square and degrees of freedom ratio (χ^2/df), the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA) and the standardized root mean square residual (SRMR). Because the sensitivity of the χ^2-test increases with sample size, even small deviations from a perfect model lead to the rejection of the model (Hu & Bentler, 1999). Thus, we additionally included the χ^2/df, which is appropriate with values below 3 (Kline, 2015). CFI and TLI indicate good model fit with values around .95. However, CFI and TLI values lower or equal to .08 still indicate good model fit, if SRMR (< .11) and RMSEA (< .08) are also taken into account (Hu & Bentler, 1999). Additionally, the 90% confidence interval for the RMSEA should not include 0 and the upper border should not exceed .10 (Kline, 2015). The standardized regression weights values should be above 0.40 (Hair, Anderson, Babin, & Black, 2010) and correlations among latent variables should not exceed values greater than 0.85 so as to demonstrate an adequate conceptual discrimination (Kline, 2015). Next, to test whether the item characteristics can be compared between girls and boys, a multi-group factor analysis of invariance across sex/gender was performed according to Milfont and Fischer (2010). Whether the more restrictive model fits, was evaluated by means of χ^2-difference test. Additionally, both models are considered to reflect the data structure equally well, as long as differences in CFI and RMSEA remain below values of .010 and .015 respectively (Chen, 2007). For reliability analysis, internal consistency of the subscales was calculated through Cronbach's alpha with the respective values indicating excellent > .9, good > .8, acceptable > .7, questionable > .6, poor >.5, and unacceptable < .5 fit (Blanz, 2021). Additionally, composite reliability was assessed indicating good internal consistency with values greater or equal to .70 (Hair et al., 2010). Average Variance Extracted (AVE) indicates good convergent validity with values equal to or greater than .50 (Hair et al., 2010), yet, AVE values below 0.50 can still be accepted when composite reliability is greater than .60 (Fornell & Larcker, 1981).

Results of the CFA showed an appropriate fit of the data to the proposed model, sex/gender differences in behavioral regulations towards AT were investigated in a third step. To test for equality of variances across the sex/gender groups, Levene's test was carried out for the variables of intrinsic motivation, integrated, identified, introjected and external regulation, amotivation and travel behavior. If the resulting p-value indicated significance (< .05), homoscedasticity could not be assumed. Thus, to test sex/gender differences in those cases, the Welch's t-test was conducted. When the Levene's test did not reveal significant differences in variances, a two-sided t-test was used. Differences in travel behavior between adolescent girls and boys were analyzed using the proportion of ways traveled actively or passively, to account for the bias that some adolescents did not travel to all five destinations. A two-sided t-test was used with the level of significance set to $p < .05$.

Lastly, to assess the effect of the behavioral regulations on AT behavior, a logistic regression analysis was conducted including the behavioral regulations as predictor variables and travel behavior as the dependent variable. For this purpose, the sum scores of ways traveled actively and passively were supplied in the glm function in R to denote success (ways traveled actively) and failure (ways traveled passively). This procedure takes the different amount of ways taken into account by calculating the probability of success (traveling to a destination using an active mode of transport). In order to get a better understanding of how the six behavioral regulations operate within both sex/genders, the regression analysis was performed for the whole sample and separately for girls and boys. Regression analyses were controlled for age, social support and degree of urbanization. Regression coefficients (b) were then transformed to odds ratios (OR) via the exponential function of the regression coefficient (e^b) (Szumilas, 2010). To determine statistical significance, the obtained p-value from the Wald test was considered for each regression parameter and set to < .05 with a 95% confidence interval (95%CI).

3 Results

3.1 Descriptive statistics of travel behavior

Across the whole sample, adolescents reported to usually cover 3.05 of the ways actively and 1.87 ways passively. On average, girls used an active mode of transport for 2.83 trips whereas boys traveled actively 3.26 trips. A passive mode of transport was used on average for 1.66 ways by boys and for 2.09 ways by girls. Four adolescents reported not to travel to friends/relatives, 18 adolescents reported not traveling to leisure time facilities, and 18 adolescents reported not undertaking trips to shopping facilities. Including this information, adolescents reported active travel to 62% of ways on average and passive travel to 38% of the ways on average. On average, girls reported to actively travel 58% of the ways and 42% passively. Boys reported to actively travel 66% of the ways and 34% passively on average.

3.2 Confirmatory factor analyses of the questionnaire used to assess behavioral regulation in active travel

The CFA indicated acceptable model fit: χ^2 (215, N=517) = 739.59, p = .00; χ^2/df = 3.44; CFI = .92; TLI = .91; SRMR = .079; RMSEA[90%CI] = .069 [.063,.074]; p-close = .000. Standardized regression weights ranged from .55 (item 7) to .89 (item 10). The simplex structure proposed within SDT was supported, whereby the latent variables (i.e. the six behavioral regulations) were more strongly and positively correlated to those that are theoretically adjacent than to more distant ones. Details on latent correlations (ranging from -53 to .93) and factor loadings are provided in the supplementary material (Supplementary 2). In addition, and as shown in Table 2, Cronbach's alpha values ranged from .69 (introjected regulation) to .91 (intrinsic motivation), indicating acceptable internal consistently for all subscales except for introjected regulation, where consistency was marginally below .70. However, composite reliability values all remained equal or above .70 demonstrating good internal consistency. Average variance extracted values ranged from .37 (introjected regulation) to .72 (intrinsic motivation).

Table 2

Cronbach's alpha, composite reliability and average variance extracted for the six subscales from the questionnaire on behavioral regulation towards active travel.

	Cronbach's alpha	CR	AVE
Intrinsic motivation	.91	.91	.72
Integrated regulation	.89	.90	.68
Identified regulation	.72	.73	.48
Introjected regulation	.69	.70	.37
External regulation	.74	.73	.42
Amotivation	.87	.87	.62

CR = composite reliability, AVE = average value extracted

3.3 Invariance analysis

Table 3 shows model fit indices for the three constrained models. Differences in CFI and RMSEA remained below .010 and .015, respectively, supporting factor invariance across sex/gender.

Table 3

Factor invariance across sex/gender.

	χ^2	df	χ^2/df	CFI	TLI	SRMR	RMSEA [90%CI]	MC	$\Delta\chi^2$	ΔCFI	ΔRMSEA
Configural invariance	1020.983	430	2.374	.911	.895	.0809	.052 [0.048, 0.056]				

Metric invariance	1045.862	447	2.340	.910	.898	.0842	.051 [0.047, 0.055]	2 vs. 1	24.879	-0.001	-0.001
Scalar invariance	1099.543	470	2.339	.905	.898	.0840	.051 [0.047, 0.055]	3 vs. 2	40.155*	-0.005	0.000
Error variance invariance	1174.404	514	2.285	.901	.902	.0891	.050 [0.046, 0.054]	4 vs. 3	74.861*	-0.004	-0.001

MC = Model Comparison, 1 = Configural invariance model, 2 = Metric invariance model, 3 = Scalar invariance model, 4 = Error variance invariance model

*significant Chi-square difference with $p < .05$

3.4 Sex/gender differences

Compared to girls (M = 0.58; SD = 0.32), boys (M = 0.66; SD = 0.30) reported a significantly higher proportion of ways which they usually travel actively, $t(515) = 3.20$; $p = .001$; $d = 0.28$. For the behavioral regulations, significant differences between boys and girls were found in intrinsic motivation and amotivation (see Table 4 for means, standard deviations, p-values and effect sizes). Compared to girls, boys expressed significant higher levels in intrinsic motivation and significant lower levels in amotivation. However, Hedges' g shows only small effects. No differences between boys and girls were found in integrated, identified, introjected or external regulation. Descriptive statistics of the proportion of active and passive ways, and of the behavioral regulations are presented in Table 4 for the overall sample and with regard to sex/gender.

Table 4

Description of the six subscales from the questionnaire on behavioral regulation towards active travel and ways traveled actively and passively, for total sample, boys and girls.

		Mean, SD	Skew	Kurtosis	p-value[a, b]
Intrinsic motivation	Total	3.51, 1.05	-0.51	-0.41	
	Boys	3.62, 0.97	-0.51	-0.22	.01[a]*
	Girls	3.39, 1.12	-0.44	-0.68	g = 0.22
Integrated regulation	Total	3.01, 1.12	-0.01	-0.87	
	Boys	3.08, 1.07	0	-0.74	.12[a]
	Girls	2.93, 1.16	0.02	-1	
Identified regulation	Total	3.12, 1.03	-0.18	-0.65	
	Boys	3.14, 1.00	-0.16	-0.57	.62[b]
	Girls	3.10, 1.06	-0.19	-0.75	
Introjected regulation	Total	1.78, 0.76	1.02	0.72	
	Boys	1.80, 0.74	0.96	0.82	.63[b]
	Girls	1.77, 0.77	1.08	0.61	
External regulation	Total	2.12, 0.92	0.61	-0.45	
	Boys	2.06, 0.89	0.67	-0.19	.13[b]
	Girls	2.19, 0.94	0.54	-0.7	
	Total	1.78, 0.99	1.32	1.08	
	Boys	1.68, 0.95	1.58	2.08	.02[b]*

Amotivation					
	Girls	1.88, 1.02	1.09	0.35	g = 0.20
	Total	0.62, 0.31	-0.32	-0.99	
Proportion of ways traveled actively	Boys	0.66, 0.30	-0.47	-0.78	.001[b]* g = 0.26
	Girls	0.58, 0.32	-0.16	-1.13	
	Total	0.38, 0.31	0.32	-0.99	
Proportion of ways traveled passively	Boys	0.34, 0.30	0.47	-0.78	.001[b]* g = 0.26
	Girls	0.42, 0.32	0.16	-1.13	

SD = standard deviation

[a] Welch's test was performed when Levene's test ($p<.05$) indicated unequal variances of groups

[b] two-sided t-test was performed when Levene's test ($p>.05$) indicated equal variances of groups

* significant difference between girls and boys with $p < .05$; for significant differences effect sizes (Hedges' g) are presented below the p-value

3.5 Association of behavioral regulations and active travel behavior in adolescents

Logistic regressions were performed to determine the relationship between intrinsic motivation, integrated regulation, identified regulation, introjected regulation, external regulation, and amotivation on the likelihood of using an active mode of transport. Table 5 provides an overview of the regression parameters from the analysis for the total sample as well as for girls and boys separately.

In the overall sample, the model was significant (χ^2=273.92, $p < .001$) and explained 42.1% (Nagelkerke R^2) of the variance in AT behavior. Integrated and identified regulation as well as amotivation were significantly related to the likelihood of using an active mode of transport. While an increase in integrated and identified regulation increases the odds of using an active mode of transport, an increase in amotivation results in a decrease in the odds.

For boys, the model was significant (χ^2= 137.99, $p < .001$) and explained 41.9% (Nagelkerke R^2) of the variance in AT behavior. Intrinsic motivation, integrated regulation, introjected regulation and external regulation were not significantly associated with the odds of using an AT mode. Increasing identified regulation was significantly associated with an increase in the odds of using an AT mode, whereas increasing amotivation decreased the odds of using an AT mode.

For girls, the model was significant (χ^2=146.45, $p < .001$) and explained 44.8% (Nagelkerke R^2) of the variance in AT behavior. The analysis revealed no significant association of intrinsic motivation, identified and introjected regulation with the odds of using an AT mode. An increase in amotivation significantly decreased the odds of using an AT mode, whereas an increase in integrated or external regulation significantly increased the odds.

Table 5

Association between behavioral regulations and traveling active for total, male and female sample.

	Total			Boys			Girls		
	b	OR [95%CI]	%	b	OR [95%CI]	%	b	OR [95%CI]	%
Intrinsic Motivation	-.07	0.93 [0.82, 1.06]	-6.9	-.0.9	0.91 [0.75, 1.1]	-9.1	-.11	0.89 [0.74, 1.08]	-10.8
Integrated Regulation	**.15***	1.16 [1.01, 1.33]	15.8	.07	1.07 [0.88, 1.29]	6.9	**.23***	1.25 [1.03, 1.53]	25.3
Identified Regulation	**.18****	1.20 [1.05, 1.38]	20.3	**.34****	1.40 [1.15, 1.71]	40.2	.07	1.07 [0.88, 1.30]	7.2
Introjected Regulation	.04	1.04 [0.90, 1.21]	3.9	-.04	0.96 [0.77, 1.19]	-4.0	.12	1.12 [0.92, 1.39]	12.6
External Regulation	.09	1.09 [0.98, 1.22]	9.1	-.01	0.99 [0.84, 1.17]	-0.8	**.18***	1.20 [1.03, 1.41]	20.3
Amotivation	**-.26****	0.77 [0.69, 0.86]	-23.0	**-.21****	0.81 [0.70, 0.95]	-18.8	**-.31****	0.73 [0.63, 0.86]	-26.6

Note: Regression analyses were adjusted for age, social support and level of urbanization.

b = regression coefficient; OR = odds ratio, calculated by exp(b); % = percentage decrease or increase of the odds of using an active mode of transport, when the respective regression parameter increases by 1

* significant regression coefficient with $p < .05$; ** significant regression coefficient with $p < .01$

4 Discussion

The present work sought to gain a better understanding of the relationship between the motivational types proposed within SDT and travel behavior in adolescents with emphasis on the distinction between girls and boys. Thus, we investigated sex/gender differences in behavioral regulation towards AT. To allow a more individualized perspective, we examined the relationship between behavioral regulations and AT behavior in adolescent boys and girls separately.

Prior to proceeding to our main analyses, a CFA was conducted to evaluate the measurement model and to assess whether the responses to the questionnaire aligned with a simplex pattern of associations (i.e., reflective of the continuum of relative autonomy within SDT) (Flake et al., 2017). The obtained fit indices showed an acceptable model fit of the data to the model. Factor loadings were adequate with values ranging from .55 (item 7) to .89 (item 10). Correlation values among the latent variables were consistent with the theoretical assumptions of the autonomy continuum from SDT (Ryan & Deci, 2017), supported by the presence of the proposed simplex structure of association (Ryan & Connell, 1989). This simplex structure is also evident in the original questionnaire concerned with behavioral regulation in exercise (Markland & Tobin, 2004; Wilson, Rodgers, Loitz, & Scime, 2006). Even though our results suggest high correlations between the three autonomous

motivations, this is in line with the findings from the original BR-ACS by Burgueño et al. (2019) and with the Portuguese version of BR-ACS by Marques et al. (2022). Cronbach's alpha and composite reliability values provided support for acceptable internal consistency. Even though AVE values fall below .50, convergent validity of the construct is still adequate since composite reliability is higher than .60 (Fornell & Larcker, 1981). Invariance analysis across sex/gender for the six-factor structure supports the use of the questionnaire to evaluate sex/gender differences in the behavioral regulations towards AT. This is in line with the original Spanish questionnaire (Burgueño et al., 2019). We conclude that the questionnaire applied in this study is appropriate to assess behavioral regulations towards AT in the sample of German speaking adolescent boys and girls.

The examined sex/gender differences in behavioral regulation showed significantly higher levels of intrinsic motivation and significantly lower levels of amotivation in boys compared to girls. Additionally, boys reported significantly more trips for which they used an active mode of transport than girls. These results support the tenets within SDT that intrinsic motivation (or high quality motivation) is linked to the adoption and execution of the desired behavior whereas amotivation is rather detrimental (Ryan & Deci, 2017). To the best of our knowledge, no previous study has systematically examined sex/gender differences in the behavioral regulations towards the AT context. In the context of PA and exercise, some studies have investigated sex/gender differences (Gillison, Standage, & Skevington, 2006; Lauderdale, Yli-Piipari, Irwin, & Layne, 2015; Luque-Casado, Mayo, Lavín-Pérez, Jiménez, & Del Villar, 2021), however, evidence is rare. Similar to our results, a mixed-methods study based on SDT reported significantly lower levels of PA and autonomous forms of motivation in adolescent girls compared to boys (Luque-Casado et al., 2021). A study among British adolescents revealed that boys who reported significantly more leisure-time exercise than girls, also expressed more intrinsic goals for exercise participation while girls expressed more extrinsic goals (Gillison et al., 2006). In contrast, a study with college students found that, even though males reported more internal motives for PA engagement than females, PA levels were not significantly different between males and females (Lauderdale et al., 2015). This study not only demonstrated sex/gender differences in the behavioral regulations, but also builds on the findings reported by Teixeira et al. (2012) that, depending on sex/gender, the individual regulations may cause different effects on the respecting behavior. In this sense, a study from Germany showed that different behavioral regulation profiles were associated with different PA levels: girls with a specific combination of intrinsic and external regulations had the highest moderate-to-vigorous PA levels in physical education (Bachner, Sturm, García-Massó, Molina-García, & Demetriou, 2020).

Results from the regression analysis showed that intrinsic motivation had no significant association with AT in the total sample. Although somewhat contradictory to SDT, these

findings might originate from the AT context. Specifically, traveling a distance to a certain location is mostly not performed for the pure interest and enjoyment of traveling nor does it offer other attributes inherent to intrinsic motivation (e.g., optimal challenge), yet merely to reach a destination. Thus, extrinsic forms of motivation are highly relevant and applicable to the AT context (e.g., only method of travel, because of health benefits). This issue was also considered by Burgueño et al. (2019) who found that integrated and identified regulation were more beneficial in promoting AT to/from school than intrinsic motivation. White et al. (2018) reported that 32% of students walk to school because they 'have to' as it is their only form of transport. These authors also found that approximately half of their sample reported experiencing negative affect, feeling forced into the action, and being bored in terms of AT. Such results are consistent with the notion that controlled (or poor quality) forms of motivation yield psychological costs. These issues withstanding, the non-significant relationship in the current work is surprising and should receive attention in further research. Looking at girls and boys separately, the association remains non-significant. This is an important finding that should be considered for intervention development: promoting intrinsic motivation for AT in adolescents might not result in a change of travel behavior.

In contrast to intrinsic motivation, integrated regulation significantly increased the odds for AT in the total sample (15.8%), which is in line with SDT (Ryan & Deci, 2000). Burgueño et al. (2019) also reported strong positive associations between integrated regulation and AT behavior in adolescence. In our study, integrated regulation in girls showed the strongest positive relation with AT behavior (25.3%) but only a small and non-significant relationship in boys. This suggests that adolescent girls are more likely to travel actively when they consider themselves as 'that type of person who travels actively' because it fits their values and needs (integrated regulation). Thus, in contrast to boys, it seems important that girls internalize this activity as part of their own identity.

Similar to integrated regulation, and again consistent with SDT, identified regulation significantly increased the odds for AT (20.3%) when analyzing the total sample. In the separate analyses for boys and girls, the increase in the odds for AT was significant only in boys (40.2%). Providing a meaningful rationale for AT could be a particularly effective strategy (see SDT behavior change techniques by Teixeira et al. (2020) for more strategies) to increase AT among boys because they are more likely to use an active mode of transport when they personally value its importance. However, based on our results, this strategy would have no effect on AT in girls.

Introjected regulation showed no significant association in the whole sample or in either of the sex/gender subsamples. Considering the theoretic origin of the desire to avoid failure and the resulting wording of the items (see Supplementary 1) to capture introjected regulation,

this result might also be attributed to AT in adolescence. As described above, traveling includes the non-optional component of ‘must arrive somewhere’. Additionally, adolescents seem to be mostly unaware, on how much PA is needed to achieve a healthy lifestyle (Lago-Ballesteros, García-Pascual, González-Valeiro, & Fernández-Villarino, 2021). Thus, if one manages to reach a destination somehow, adolescents might not perceive choosing a passive mode of transport as ‘failure’ because one still has achieved to arrive at the desired destination. It should be considered that introjected regulation reached a low AVE value of .37, which is still acceptable with a composite reliability value over .50, however, this might have contributed to the null finding.

External regulation showed no significant association with AT in the total sample. This was also found in boys. In girls, external regulation increased the odds for AT by 20.3%. These results suggest that adolescent girls are more likely to travel actively when they are influenced or feel pressured by other people (i.e., feeling forced to undertake the behavior). As they tend to evaluate negative interpersonal responses as more stressful than boys (Rudolph, 2002), the strong relationship of external regulation and AT behavior in order to please others or avoid conflicts, seems plausible. However, the positive relationship between external regulation and AT behavior is contradictory to SDT. Previous research has also reported a non-significant relationship of external regulation and AT to/from school, which is commensurate with our findings from the analysis of the total sample (Burgueño et al., 2019). Again, this emphasizes the importance of sex/gender-sensitive analysis.

In accordance with SDT, amotivation showed the strongest negative association with AT behavior. This association was present in all three regression analyses (total sample: -23.0%; boys:-18.8%; girls:-26.6%). From a theoretical perspective, the negative association of amotivation and AT behavior makes logical sense, as amotivation describes the absence of motivation (Ryan & Deci, 2017). Nevertheless, in previous research, such a relation was not observed (Burgueño et al., 2019).

In summary, the results from the regression analyses emphasize the importance of sex/gender-sensitive analyses. Analyzing the associations of the single behavioral regulations only for the total sample, without differentiating between boys and girls, would have masked the fact that some behavioral regulations are beneficial or disadvantageous for girls but not for boys and vice versa. This suggests that the promotion of some behavioral regulations might not be equally effective among adolescent girls and boys. However, this is the first study to address this issue and the results provide initial indications that need to be further explored.

Meanwhile, our findings have important implications for the development of interventions to promote AT among adolescents. First, interventions should incorporate a sex/gender-

sensitive development. Second, interventions concerning AT promotion among adolescent boys should aim to establish AT as a meaningful and important opportunity (identified regulation). Third, interventions designed for adolescent girls should mainly focus on integrating AT as an important part of their personality (integrated regulation). Lastly, external encouragement, especially from family and friends (external regulation), should be considered when designing interventions for girls. With these findings in mind, and in the context of SDT (Ryan & Deci, 2017), it would be interesting to examine whether external regulation yields poor quality experience and wellbeing outcomes in the AT context prior to promoting such contingencies via intervention.

This study has several strengths worth mentioning. First, our study included a nationwide sample of adolescents in Germany, who are under-researched compared to younger populations and at a high risk regarding physical inactivity. Second, we aimed for a comprehensive analysis of travel behavior among adolescents and covered several important destinations e.g. friends/relatives or shopping destinations, rather than focusing only on the school setting. Third, when analyzing the behavioral regulations, we decided not to collapse single regulations into aggregated measures of controlled and autonomous motivation to allow rich interpretations with great opportunities for tailored interventions. Lastly, we used a questionnaire which was previously proven to be valid in the adolescent population (Burgueño et al., 2019). Because we translated and slightly adapted this questionnaire, we additionally examined the psychometric properties of this tool.

Nevertheless, the study has limitations that need to be addressed. The present investigation is of cross-sectional design and, thus, does not allow conclusions about causation. Further, the purposeful sampling method prevents generalizability of the results. Along with this limitation, a further problem may arise from performing the validation in a single data set, an issue that which has been discussed previously as a limitation by work (Bujang et al., 2018) that our study followed as a guideline. In terms of the CFA, the sample size of 517 participants might have compromised the results somewhat, because a ratio of at least 10 cases per parameter is recommended (Kline, 2015). Nevertheless, the study's sample size exceeds those of comparable studies in this field (e.g., Burgueño et al., 2019; Marques et al., 2022). Further, the assessment of AT behavior was based on the usual mode of transport to the described destinations, which does not account for the frequency these ways were undertaken. Additionally, the assessments were based on self-reported data, which are prone to bias due to its subjective nature and the corresponding issues of social desirability and recall bias. The aspect of common-method variance should also be kept in mind. Another critical aspect concerns the data collection which took place during the COVID-19 pandemic. We cannot estimate the extent to which the COVID-regulations might have

impacted the usual choice of transportation mode, however, data collection was conducted in June 2021 when restrictions were low.

Conclusion

Sex/gender differences in AT behavior and behavioral regulations for AT reflected SDT assumptions that more autonomous forms of motivation support the adoption and execution of the respective behavior. However, when examining the relationships of the individual behavioral regulation types with AT in adolescents, results were brought to light that do not completely match the SDT. Presumably, the context of AT is responsible for these results. When designing interventions or assessing motivational constructs concerning AT promotion, further research should take these findings into account by acknowledging the purpose of AT to reach a destination. Further, the disparities found between adolescent boys and girls in the association of the individual behavioral regulations on AT are particularly noteworthy. These results emphasize the need to develop tailored interventions that address to the different needs of girls and boys. This could substantially contribute to developing effective and target group specific interventions to promote AT among adolescent boys and girls.

Declaration of Competing Interest

The authors declare that they have no competing interests.

Author contributions

Denise Renninger: Conceptualization; Methodology; Formal Analysis; Writing – original draft; Writing – review & editing; Anne Kelso: Methodology; Writing – review & editing; Anne K. Reimers: Methodology; Writing – review & editing; Project administration; Isabel Marzi: Methodology; Writing – review & editing; Franziska Beck: Methodology; Writing – review & editing; Eliane S. Engels: Methodology; Writing – review & editing; Martyn Standage: Methodology; Writing – review & editing; Yolanda Demetriou: Conceptualization; Methodology; Writing – review & editing; Supervision; Project administration

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