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

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12

13 **Abstract**

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

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

#### 41 **Keywords**

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

#### 44 **1 Introduction**

45 The majority of young people in Europe and around the globe fail to meet the recommended  
46 amount of physical activity (PA) (Guthold, Stevens, Riley, & Bull, 2020; Steene-Johannessen  
47 et al., 2020) of an average of at least 60 min/day across the week (Bull et al., 2020; WHO,  
48 2020). This is concerning because the health benefits of PA in childhood and adolescence  
49 are evidenced (Janssen & LeBlanc, 2010; Poitras et al., 2016; WHO, 2020). Further, these  
50 PA-related health benefits as well as the PA behaviors can persist into adulthood (Corder et  
51 al., 2019; Telama et al., 2014). Recent research reinforces a PA gap between boys and girls,  
52 with girls being consistently less active across all age groups (Guthold et al., 2020; Steene-  
53 Johannessen et al., 2020). This is also evident in Germany with girls meeting the WHO  
54 guidelines less frequently than boys (Burchartz et al., 2021).

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

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

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<sup>1</sup> 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)

72 15 year-olds showed that girls were significantly less likely to cycle to school than boys  
73 (Schönbach, Brindley, Reimers, Marques, & Demetriou, 2020). Thus, there is still room for  
74 improvement for adolescent boys and girls. Apart from the benefit both boys and girls could  
75 gain from increased AT, promoting girls' AT might specifically contribute to reducing the  
76 sex/gender gap in PA, since girls generally demonstrate lower PA levels than boys (Guthold  
77 et al., 2020; Steene-Johannessen et al., 2020). The importance of taking a sex/gender-  
78 differentiated approach to health behaviors has been highlighted by recent research in the  
79 field of sex/gender (Schlund et al., 2021). Nevertheless, especially intervention studies  
80 concerning the promotion of AT in children and adolescents do not sufficiently consider  
81 sex/gender (Marzi et al., 2020). To facilitate the development of sex/gender-sensitive  
82 intervention programs, the determinants of adolescents' travel behavior should be examined  
83 from such a sex/gender perspective.

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

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

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

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

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

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

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

## 155 **2 Methods**

### 156 *2.1 Study design*

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

### 164 *2.2 Procedure of data collection*

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

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

### 192 2.3 Study population

193 The study population consisted of 254 girls ( $M_{age} = 12.92 \pm 1.35$ ) and 263 boys ( $M_{age} = 13.21$   
 194  $\pm 1.33$ ) from cities with more than 100,000 inhabitants (29.2%), medium-sized towns  
 195 consisting of 20,000–99,999 inhabitants (17.4%), small towns with 5,000–19,999 inhabitants  
 196 (22.2%), and regions with less than 5,000 inhabitants (30.8%) across the whole of Germany.  
 197 87.2% of adolescents reported no migration background, 10.3% indicated a migration  
 198 background from one parent and 2.5% reported a migration background from both parents.  
 199 Details on characteristics of the study population are presented in Table 1. One adolescent  
 200 was excluded prior to analyses because the adolescent indicated a diverse gender and the  
 201 sample size of  $n=1$  was too small to allow for a separate analysis.

202 **Table 1**

203 *Characteristics of the study population.*

	Total	Boys	Girls
N	517	263 (51%)	254 (49%)
<b>Age</b>			
11	81	31	50
12	113	60	53
13	109	52	57
14	119	64	55
15	95	56	39
<b>Residence</b>			
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		
<b>Type of school</b>			

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		
<b>Migration background</b>			
Yes, from both parents	13	9	4
Yes, from one parent	53	27	26
No migration background	451	227	224
<b>Perceived social support for AT from parents **</b>	5.50 (1.01)	5.54 (0.06)	5.48 (0.06)

204 Note: \* In Germany, students in secondary school are taught at different performance levels either in one school  
205 (comprehensive secondary school) or in separate schools (Hauptschule, Realschule or Gymnasium)

206 \*\* measured on a 7-point Likert Scale and expressed as a mean value (standard deviation); for detailed  
207 information on measurement please see (Reimers et al., 2022)

208

## 209 2.4 Measures

### 210 2.4.1 Travel behavior

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



230 
$$\text{Proportion of ways traveled actively} = \frac{N_{\text{ways traveled actively}}}{N_{\text{ways traveled actively}} + N_{\text{ways traveled passively}}} \times 100$$

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

232 
$$\text{Proportion of ways traveled passively} = \frac{N_{\text{ways traveled passively}}}{N_{\text{ways traveled actively}} + N_{\text{ways traveled passively}}} \times 100$$

#### 233 2.4.2 Behavioral regulation in active travel

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

#### 257 2.5 Data analysis

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

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

267 Second, a confirmatory factor analysis (CFA) tested the six-factor structure of the  
268 questionnaire used for the present sample. Maximum likelihood method with Bollen-Stine  
269 bootstrap correction (5000 samples) was used since Mardia's test for normality indicated that  
270 the data might not be normally distributed (total sample: Mardia's coefficient = 128.756,  
271 critical ration (c.r.) = 43.165) (Kline, 2015). According to the recommendation to use a  
272 combination of diverse fit measures (Hu & Bentler, 1999), the following fit indices were  
273 considered to inform about model fit: chi-squared test ( $\chi^2$ -test), chi-square and degrees of  
274 freedom ratio ( $\chi^2/df$ ), the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root  
275 mean square error of approximation (RMSEA) and the standardized root mean square  
276 residual (SRMR). Because the sensitivity of the  $\chi^2$ -test increases with sample size, even  
277 small deviations from a perfect model lead to the rejection of the model (Hu & Bentler, 1999).  
278 Thus, we additionally included the  $\chi^2/df$ , which is appropriate with values below 3 (Kline,  
279 2015). CFI and TLI indicate good model fit with values around .95. However, CFI and TLI  
280 values lower or equal to .08 still indicate good model fit, if SRMR (< .11) and RMSEA (< .08)  
281 are also taken into account (Hu & Bentler, 1999). Additionally, the 90% confidence interval  
282 for the RMSEA should not include 0 and the upper border should not exceed .10 (Kline,  
283 2015). The standardized regression weights values should be above 0.40 (Hair, Anderson,  
284 Babin, & Black, 2010) and correlations among latent variables should not exceed values  
285 greater than 0.85 so as to demonstrate an adequate conceptual discrimination (Kline, 2015).  
286 Next, to test whether the item characteristics can be compared between girls and boys, a  
287 multi-group factor analysis of invariance across sex/gender was performed according to  
288 Milfont and Fischer (2010). Whether the more restrictive model fits, was evaluated by means  
289 of  $\chi^2$ -difference test. Additionally, both models are considered to reflect the data structure  
290 equally well, as long as differences in CFI and RMSEA remain below values of .010 and .015  
291 respectively (Chen, 2007). For reliability analysis, internal consistency of the subscales was  
292 calculated through Cronbach's alpha with the respective values indicating excellent > .9,  
293 good > .8, acceptable > .7, questionable > .6, poor >.5, and unacceptable < .5 fit (Blanz,  
294 2021). Additionally, composite reliability was assessed indicating good internal consistency  
295 with values greater or equal to .70 (Hair et al., 2010). Average Variance Extracted (AVE)  
296 indicates good convergent validity with values equal to or greater than .50 (Hair et al., 2010),  
297 yet, AVE values below 0.50 can still be accepted when composite reliability is greater than  
298 .60 (Fornell & Larcker, 1981).

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

310 Lastly, to assess the effect of the behavioral regulations on AT behavior, a logistic regression  
311 analysis was conducted including the behavioral regulations as predictor variables and travel  
312 behavior as the dependent variable. For this purpose, the sum scores of ways traveled  
313 actively and passively were supplied in the glm function in R to denote success (ways  
314 traveled actively) and failure (ways traveled passively). This procedure takes the different  
315 amount of ways taken into account by calculating the probability of success (traveling to a  
316 destination using an active mode of transport). In order to get a better understanding of how  
317 the six behavioral regulations operate within both sex/genders, the regression analysis was  
318 performed for the whole sample and separately for girls and boys. Regression analyses were  
319 controlled for age, social support and degree of urbanization. Regression coefficients (b)  
320 were then transformed to odds ratios (OR) via the exponential function of the regression  
321 coefficient ( $e^b$ ) (Szumilas, 2010). To determine statistical significance, the obtained p-value  
322 from the Wald test was considered for each regression parameter and set to  $< .05$  with a  
323 95% confidence interval (95%CI).

### 324 **3 Results**

#### 325 *3.1 Descriptive statistics of travel behavior*

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

335 *3.2 Confirmatory factor analyses of the questionnaire used to assess behavioral regulation in*  
 336 *active travel*

337 The CFA indicated acceptable model fit:  $\chi^2$  (215, N=517) = 739.59,  $p = .00$ ;  $\chi^2/df = 3.44$ ; CFI  
 338 = .92; TLI = .91; SRMR = .079; RMSEA[90%CI] = .069 [.063,.074]; p-close = .000.  
 339 Standardized regression weights ranged from .55 (item 7) to .89 (item 10). The simplex  
 340 structure proposed within SDT was supported, whereby the latent variables (i.e. the six  
 341 behavioral regulations) were more strongly and positively correlated to those that are  
 342 theoretically adjacent than to more distant ones. Details on latent correlations (ranging from -  
 343 .53 to .93) and factor loadings are provided in the supplementary material (Supplementary 2).  
 344 In addition, and as shown in Table 2, Cronbach's alpha values ranged from .69 (introjected  
 345 regulation) to .91 (intrinsic motivation), indicating acceptable internal consistency for all  
 346 subscales except for introjected regulation, where consistency was marginally below .70.  
 347 However, composite reliability values all remained equal or above .70 demonstrating good  
 348 internal consistency. Average variance extracted values ranged from .37 (introjected  
 349 regulation) to .72 (intrinsic motivation).

350 **Table 2**

351 *Cronbach's alpha, composite reliability and average variance extracted for the six subscales*  
 352 *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

353 CR = composite reliability, AVE = average value extracted

354

355 *3.3 Invariance analysis*

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

359 **Table 3**

360 *Factor invariance across sex/gender.*

	$\chi^2$	df	$\chi^2/df$	CFI	TLI	SRMR	RMSEA [90%CI]	MC	$\Delta\chi^2$	$\Delta$ CFI	$\Delta$ RMSEA
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

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

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

364

### 365 3.4 Sex/gender differences

366 Compared to girls (M = 0.58; SD = 0.32), boys (M = 0.66; SD = 0.30) reported a significantly  
367 higher proportion of ways which they usually travel actively,  $t(515) = 3.20$ ;  $p = .001$ ;  $d = 0.28$ .

368 For the behavioral regulations, significant differences between boys and girls were found in  
369 intrinsic motivation and amotivation (see Table 4 for means, standard deviations, p-values  
370 and effect sizes). Compared to girls, boys expressed significant higher levels in intrinsic  
371 motivation and significant lower levels in amotivation. However, Hedges' g shows only small  
372 effects. No differences between boys and girls were found in integrated, identified, introjected  
373 or external regulation. Descriptive statistics of the proportion of active and passive ways, and  
374 of the behavioral regulations are presented in Table 4 for the overall sample and with regard  
375 to sex/gender.

### 376 Table 4

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

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

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					.001 <sup>b*</sup>
	Boys	0.66, 0.30	-0.47	-0.78	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					.001 <sup>b*</sup>
	Boys	0.34, 0.30	0.47	-0.78	g = 0.26
	Girls	0.42, 0.32	0.16	-1.13	

379 SD = standard deviation

380 <sup>a</sup> Welch's test was performed when Levene's test ( $p < .05$ ) indicated unequal variances of groups

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

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

384

### 385 *3.5 Association of behavioral regulations and active travel behavior in adolescents*

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

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

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

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

408 **Table 5**

409 Association between behavioral regulations and traveling active for total, male and female  
 410 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	<b>.15*</b>	1.16 [1.01, 1.33]	15.8	.07	1.07 [0.88, 1.29]	6.9	<b>.23*</b>	1.25 [1.03, 1.53]	25.3
Identified Regulation	<b>.18**</b>	1.20 [1.05, 1.38]	20.3	<b>.34**</b>	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	<b>.18*</b>	1.20 [1.03, 1.41]	20.3
Amotivation	<b>-.26**</b>	0.77 [0.69, 0.86]	-23.0	<b>-.21**</b>	0.81 [0.70, 0.95]	-18.8	<b>-.31**</b>	0.73 [0.63, 0.86]	-26.6

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

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

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

415

#### 416 4 Discussion

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

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

434 motivations, this is in line with the findings from the original BR-ACS by Burgueño et al.  
435 (2019) and with the Portuguese version of BR-ACS by Marques et al. (2022). Cronbach's  
436 alpha and composite reliability values provided support for acceptable internal consistency.  
437 Even though AVE values fall below .50, convergent validity of the construct is still adequate  
438 since composite reliability is higher than .60 (Fornell & Larcker, 1981). Invariance analysis  
439 across sex/gender for the six-factor structure supports the use of the questionnaire to  
440 evaluate sex/gender differences in the behavioral regulations towards AT. This is in line with  
441 the original Spanish questionnaire (Burgueño et al., 2019). We conclude that the  
442 questionnaire applied in this study is appropriate to assess behavioral regulations towards  
443 AT in the sample of German speaking adolescent boys and girls.

444 The examined sex/gender differences in behavioral regulation showed significantly higher  
445 levels of intrinsic motivation and significantly lower levels of amotivation in boys compared to  
446 girls. Additionally, boys reported significantly more trips for which they used an active mode  
447 of transport than girls. These results support the tenets within SDT that intrinsic motivation  
448 (or high quality motivation) is linked to the adoption and execution of the desired behavior  
449 whereas amotivation is rather detrimental (Ryan & Deci, 2017). To the best of our  
450 knowledge, no previous study has systematically examined sex/gender differences in the  
451 behavioral regulations towards the AT context. In the context of PA and exercise, some  
452 studies have investigated sex/gender differences (Gillison, Standage, & Skevington, 2006;  
453 Lauderdale, Yli-Piipari, Irwin, & Layne, 2015; Luque-Casado, Mayo, Lavín-Pérez, Jiménez, &  
454 Del Villar, 2021), however, evidence is rare. Similar to our results, a mixed-methods study  
455 based on SDT reported significantly lower levels of PA and autonomous forms of motivation  
456 in adolescent girls compared to boys (Luque-Casado et al., 2021). A study among British  
457 adolescents revealed that boys who reported significantly more leisure-time exercise than  
458 girls, also expressed more intrinsic goals for exercise participation while girls expressed  
459 more extrinsic goals (Gillison et al., 2006). In contrast, a study with college students found  
460 that, even though males reported more internal motives for PA engagement than females,  
461 PA levels were not significantly different between males and females (Lauderdale et al.,  
462 2015). This study not only demonstrated sex/gender differences in the behavioral  
463 regulations, but also builds on the findings reported by Teixeira et al. (2012) that, depending  
464 on sex/gender, the individual regulations may cause different effects on the respecting  
465 behavior. In this sense, a study from Germany showed that different behavioral regulation  
466 profiles were associated with different PA levels: girls with a specific combination of intrinsic  
467 and external regulations had the highest moderate-to-vigorous PA levels in physical  
468 education (Bachner, Sturm, García-Massó, Molina-García, & Demetriou, 2020).

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



471 findings might originate from the AT context. Specifically, traveling a distance to a certain  
472 location is mostly not performed for the pure interest and enjoyment of traveling nor does it  
473 offer other attributes inherent to intrinsic motivation (e.g., optimal challenge), yet merely to  
474 reach a destination. Thus, extrinsic forms of motivation are highly relevant and applicable to  
475 the AT context (e.g., only method of travel, because of health benefits). This issue was also  
476 considered by Burgueño et al. (2019) who found that integrated and identified regulation  
477 were more beneficial in promoting AT to/from school than intrinsic motivation. White et al.  
478 (2018) reported that 32% of students walk to school because they 'have to' as it is their only  
479 form of transport. These authors also found that approximately half of their sample reported  
480 experiencing negative affect, feeling forced into the action, and being bored in terms of AT.  
481 Such results are consistent with the notion that controlled (or poor quality) forms of  
482 motivation yield psychological costs. These issues withstanding, the non-significant  
483 relationship in the current work is surprising and should receive attention in further research.  
484 Looking at girls and boys separately, the association remains non-significant. This is an  
485 important finding that should be considered for intervention development: promoting intrinsic  
486 motivation for AT in adolescents might not result in a change of travel behavior.

487 In contrast to intrinsic motivation, integrated regulation significantly increased the odds for AT  
488 in the total sample (15.8%), which is in line with SDT (Ryan & Deci, 2000). Burgueño et al.  
489 (2019) also reported strong positive associations between integrated regulation and AT  
490 behavior in adolescence. In our study, integrated regulation in girls showed the strongest  
491 positive relation with AT behavior (25.3%) but only a small and non-significant relationship in  
492 boys. This suggests that adolescent girls are more likely to travel actively when they consider  
493 themselves as 'that type of person who travels actively' because it fits their values and needs  
494 (integrated regulation). Thus, in contrast to boys, it seems important that girls internalize this  
495 activity as part of their own identity.

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

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

507 this result might also be attributed to AT in adolescence. As described above, traveling  
508 includes the non-optional component of 'must arrive somewhere'. Additionally, adolescents  
509 seem to be mostly unaware, on how much PA is needed to achieve a healthy lifestyle (Lago-  
510 Ballesteros, García-Pascual, González-Valeiro, & Fernández-Villarino, 2021). Thus, if one  
511 manages to reach a destination somehow, adolescents might not perceive choosing a  
512 passive mode of transport as 'failure' because one still has achieved to arrive at the desired  
513 destination. It should be considered that introjected regulation reached a low AVE value of  
514 .37, which is still acceptable with a composite reliability value over .50, however, this might  
515 have contributed to the null finding.

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

527 In accordance with SDT, amotivation showed the strongest negative association with AT  
528 behavior. This association was present in all three regression analyses (total sample: -  
529 23.0%; boys:-18.8%; girls:-26.6%). From a theoretical perspective, the negative association  
530 of amotivation and AT behavior makes logical sense, as amotivation describes the absence  
531 of motivation (Ryan & Deci, 2017). Nevertheless, in previous research, such a relation was  
532 not observed (Burgueño et al., 2019).

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

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

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

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

563 Nevertheless, the study has limitations that need to be addressed. The present investigation  
564 is of cross-sectional design and, thus, does not allow conclusions about causation. Further,  
565 the purposeful sampling method prevents generalizability of the results. Along with this  
566 limitation, a further problem may arise from performing the validation in a single data set, an  
567 issue that which has been discussed previously as a limitation by work (Bujang et al., 2018)  
568 that our study followed as a guideline. In terms of the CFA, the sample size of 517  
569 participants might have compromised the results somewhat, because a ratio of at least 10  
570 cases per parameter is recommended (Kline, 2015). Nevertheless, the study's sample size  
571 exceeds those of comparable studies in this field (e.g., Burgueño et al., 2019; Marques et al.,  
572 2022). Further, the assessment of AT behavior was based on the usual mode of transport to  
573 the described destinations, which does not account for the frequency these ways were  
574 undertaken. Additionally, the assessments were based on self-reported data, which are  
575 prone to bias due to its subjective nature and the corresponding issues of social desirability  
576 and recall bias. The aspect of common-method variance should also be kept in mind.  
577 Another critical aspect concerns the data collection which took place during the COVID-19  
578 pandemic. We cannot estimate the extent to which the COVID-regulations might have

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

## 581 **Conclusion**

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

## 594 **Declaration of Competing Interest**

595 The authors declare that they have no competing interests.

## 596 **Author contributions**

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

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