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Children's travel to school: satisfaction, current mood, and cognitive performance

Jessica Westman[1] · Lars E. Olsson[1] · Tommy Gärling[2] · Margareta Friman[1]

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Abstract We investigate whether travel mode, travel time, and activities during travel influence children's satisfaction with their travel to school, their current mood, and their cognitive performance after arriving at school. A sample of 344 children (165 girls) between the ages of 10 and 15 years were recruited at five public schools in Värmland County, Sweden. Directly after arriving at school, the children rated how they felt on two scales ranging from very sad to very happy and from very tired to very alert, filled out the Satisfaction with Travel Scale adapted for children (STS-C), reported details about their journeys, and took a word-fluency test. The results for STS-C showed that traveling by school bus and walking or cycling was experienced as having a higher quality than traveling by car. Children who engaged in conversation during their journeys reported a higher quality and more positive feelings than children who were engaged in solitary activities during their journeys. A shorter journey was experienced as having a higher quality and resulting in more positive feelings. Children traveling for longer durations performed better in the word-fluency test if using their smartphones or doing a combination of activities during their journeys.

Keywords Children · School travel · Satisfaction · Current mood · Cognitive performance

Introduction

Today children make more journeys by car than they did only 10–15 years ago, and many of the journeys that were previously made on foot or on a bike (referred to as active modes) are now made by car (McDonald 2005; McMillan 2007). Research shows that the

✉ Jessica Westman
jessica.westman@kau.se

[1] Karlstad University, Karlstad, Sweden

[2] Department of Psychology, University of Gothenburg, Gothenburg, Sweden

prevalence of impaired metabolic health, impaired cardio-respiratory fitness, obesity, and asthma are all symptoms of an inactive life style, toward which motorized travel contributes (Cooper et al. 2006; Roth et al. 2012; Østergaard et al. 2012). The younger segment of the population is particularly susceptible to these negative health impacts (Nishimura et al. 2013).

The majority of research on children's daily travel focuses on the increased reliance on cars and the consequences of this for the environment and physical health (Davison et al. 2008; McDonald et al. 2015; Merom et al. 2005). Children's satisfaction with their travel, and their experience of it, has so far received little attention in research. By interviewing primary school children, Barker (2009) found that car journeys allow multiple activities including relaxation, homework, and use of commodities, in addition to providing a space suitable for social interaction with family members. In studying British children between the ages of 12 and 18, Jones et al. (2012) found that traveling by bus provide a sense of independence, an opportunity to socialize with friends, and an opportunity to be active by having to walk to and from bus stops. A study we conducted revealed that the travel to school is the most frequent journey that school children make on a daily basis, yet it is the journey that elicits the lowest degrees of alertness and pleasure (i.e. current mood) (Westman et al. 2013). In the present study we extend this previous study by providing more detailed information about why school children experience travel to school less positively. We investigate effects of travel mode, travel time, and activities during travel by measuring satisfaction with travel, current mood, and cognitive performance after arriving at school. We also investigate whether these effects vary with the children's sex and age.

In studies of adults, it has been found that characteristics of a journey affect the travel experience. A short work commute (10–20 min) leads to more satisfaction than a long work commute (more than 30 min) (Olsson et al. 2013; Wachs et al. 1993; Young and Morris 1981). Satisfaction with travel is also dependent on activities during travel (Ettema et al. 2012; Mokhtarian and Salomon 2001). Engaging in conversation increases satisfaction by counteracting boredom, while reading and resting elicit relaxation that decrease satisfaction, and the use of smartphones increases satisfaction by filling downtime (Wang

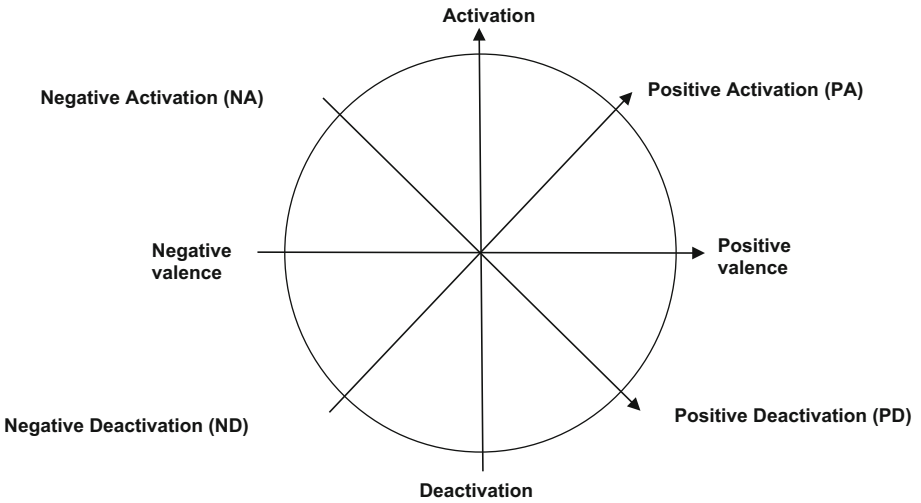

Fig. 1 Dimensional representation of core affects

et al. 2014). Cycling leads to more satisfaction than traveling by car or bus (Olsson et al. 2013), and bus leads to less satisfaction than traveling by car. In the present study, we investigate whether travel time, travel mode, and activities during travel affect children's satisfaction with their school journeys in the same way that they have been found to affect adults' satisfaction with their work commute.

Current mood is defined as how people feel at the moment (Diener and Lucas 2000). It varies in the two orthogonal dimensions of *valence* ranging from negative to positive through neutral, and *activation* (or arousal) ranging from deactivation to activation through neutral (see Fig. 1; Posner et al. 2009; Russell 1980; Yik et al. 1999). Current mood has been shown to be affected by age and sex (Kirmil-Gray et al. 1984; Larson and Richards 2000; Larson et al. 2002), by internal events (e.g., bodily changes, ruminations or mental contents) (Russell 2003), and by emotions elicited by external events such as travel (Olsson et al. 2013). In our previous study (Westman et al. 2013), we found that children who travel to school using an active mode are in a more positive mood when arriving at school and during their school day than children who travel by motorized transportation. In the present study we want to also determine how travel time and travel mode affect current mood immediately upon arriving at school in the morning and later on in the afternoon.

Martínez-Gómez et al. (2011) found that girls who commute to school using an active mode have approximately 4 % higher school grades than girls who travel by motorized transportation. This may be explained by the beneficial effects of physical activity on cognitive performance (Ruiz et al. 2010; Trudeau and Shephard 2008). Since we wanted to investigate whether the travel itself affects performance, a cognitive performance test was conducted directly after arriving at school. Such a test will be more sensitive to capture performance effects than children's overall school grades, which depend on many other factors throughout the school year. If cognitive performance is shown to be affected by traveling to school, then it is possible that performance attributable to school travel will be one factor contributing toward school grades. Based on research on adults showing that commute-induced stress increases with travel time (Van Rooy 2006) and that longer commutes result in poorer proofreading performance and higher of perceived commuter stress (Evans and Wener 2006), we will investigate whether longer travel times impair the children's cognitive performance. We also want to investigate whether an active travel mode improves their cognitive performance.

In summary, the aim of the present study is to investigate how children in different ages and of different sexes are influenced by travel to school. Specifically, we attempt to show influences of travel mode, travel time, and activities during travel on the children's satisfaction with their travel to school, their mood immediately after arriving in the morning and later in the afternoon, and their cognitive performance at school after arriving.

Method

Setting

Five schools were selected such that sufficient variation was achieved in travel distance to these schools and in accessibility to travel modes. The school principals were contacted and approved of the study.

The schools are located in Värmland County in southwest Sweden. The county has approximately 273,000 residents. One school is located in Karlstad municipality

(population approx. 84,000, geographic area 1167 km^2), two schools in Arvika municipality (population approx. 26,000, geographic area 1659 km^2), and two schools in Torsby municipality (population approx. 12,700, geographic area 4187 km^2). The schools differ in their numbers of pupils (Karlstad having 450, Arvika 420 and 230, and Torsby 400 and 35) and in how far they are located from their pupils' homes (median distance in Karlstad being 2.5 km, in Arvika 2 km, and in Torsby 4.5 km). The shortest distance for the municipality to provide free school bus service is in Karlstad 4 km (grades 4–9), in Arvika 2 km (grades 4–6) and 5 km (grades 7–9), and in Torsby 3 km (grades 4–5) and 4 km (grades 6–9). Exceptions to these rules are made for children with disabilities, or for children living close to routes with high volumes of traffic.

Participants

Children in grades 4 (aged 10–11), 6 (aged 12–13), and 8 (aged 14–15) were invited to participate. Letters were sent to their parents containing written information about the study and a consent form to sign and return. Since information by mail was insufficient to obtain the required consent from everyone, a research assistant contacted the non-responding households by phone. Only three parents refused to let their child participate. Data were obtained for 345 children (47.8 % girls), 97 in grade 4, 147 in grade 6, and 101 in grade 8. For 25 % of the children, at least one parent had a university degree, with monthly net household income being approximately SEK 45,000. All had access to at least one car. These statistics conform to the country statistics (Statistics Sweden 2016).

Procedure

The data collection period lasted from December 2012 to March 2013, with outside temperatures of approximately +1 to −20 °C (34 to −4 °F) and a snow cover from a few centimeters to a few decimeters.

In each class immediately before the first morning lesson on Tuesdays, Wednesdays, or Thursdays, a research assistant distributed questionnaires to be filled out by the children in their classrooms. In the first part of the questionnaire the children rated their current mood on two five-point rating scales, one ranging from *very sad* (1) to *very glad* (5) (valence) and the other ranging from *very sleepy* (1) to *very alert* (5) (activation). Current mood was once again rated in the afternoon on the same two scales. In the morning, questions were asked about what travel mode had been used to get to school (walking, cycling [inline skates and scooters included], car, school bus, public transport, or other), the duration of the travel (<5 min, 5–15 min, 16–30 min, 31–45 min, >45 min), whether traveling to school was made alone or in the company of others, and the activities the children engaged in while traveling (looking out of the window, listening to music/radio, using a smartphone, sleeping/resting, reading/doing homework, talking with friends/family, doing nothing). In the subsequent analyses the travel mode was coded as car, active mode, and school bus. A small number of journeys (18) were made by public transport and were included in the school bus category. Cycling and walking were included in the active mode category. Travel time was coded as being equal to or less than 15 min versus more than 15 min. Activities were coded in four categories, solitary activities (looking out of the window, listening to music/radio, sleeping/resting, reading/doing homework, doing nothing), using a smartphone, social activities (talking to others), or combinations of activities. The first category (solitary activities) differed from the second (social activities) in that the latter always includes a friend or family member. The third category (using a smartphone) was

considered to be both solitary and social since the smartphone usage of children and young people often entails social networking (e.g., Facebook, Twitter, ClubPenguin, or Habbo Hotel). Some children did several activities while traveling. Since we did not know which the main activity was, these are included in the separate category with combinations of activities.

Finally, questions were asked about satisfaction with travel to school. An adapted version of the Satisfaction with Travel Scale (STS, see Friman et al. 2013) was used. The STS consists of nine rating scales that are aggregated to one cognitive (overall quality evaluation) and two affective evaluation indices. Based on a pilot study some of the adjective pairs defining the rating scales were slightly altered to adapt them to the children's vocabulary. The scale is henceforth referred to as STS-Children (STS-C). The three numerical five-point rating scales (1–5) assessing the cognitive quality evaluation (STS-C/CE) had endpoints defined by the following adjective pairs, translated from Swedish: (the journey) worked very poorly–worked very well, (the journey was) really useless–really excellent, and (the journey was the) worst imaginable–best imaginable. Two orthogonal affect dimensions were also assessed using the STS derived from the affect circumplex (see Fig. 1). Three scales assessing positive activation/negative deactivation (STS-C/PAND) had endpoints defined by the following adjective pairs: (during my journey, I felt) very bored-very interested, very spiritless–very excited, and very tired–very alert. Another three scales assessing positive deactivation/negative activation (STS-C/PDNA) had endpoints defined by the adjective pairs: (during my journey, I felt) very stressed–very calm, very worried–very carefree, very hurried–very relaxed. The three STS-C indices were calculated by averaging the scale ratings.

Directly after having answered the questionnaire a word-fluency test[1] was administered. The children were requested to write down on a blank sheet of paper as many words as possible in 1 min. All the words had to begin with the letter *F* as announced by the research assistant when the test started. The instructions read as follows: "Write as many words as you can think of that begin with a letter of the alphabet that I will tell you. You do not have to worry about spelling or grammar. You will have 1 min to write the words, and I will tell you when to stop". In scoring the performance, the words that were counted were either found in a Swedish dictionary, were well-known slang words or names. Words were deleted from the analyses if they could not be interpreted or read, or if they were repetitions. The total counted words was used in the analyses.

Results

Overview

In the Appendix Tables 5, 6 and 7, means and standard deviations are for girls and boys in each grade presented of the dependent variables satisfaction with travel, current mood, and cognitive performance related to travel mode, travel time, and activity during travel. Cross-tabulations showed that travel mode was not strongly related to travel time ($\phi = .53$, $p < .001$) or to activity during travel ($\phi = .34$), and that travel time was weakly related to activity during travel ($\phi = .20$). Furthermore, preliminary analyses of variance (ANOVAs) on each dependent variable, including travel mode, travel time, and activity during travel, did not reveal any significant ($ps > .05$) interactions between these factors. In what

[1] For further information about word fluency tests, see Cohen and Stanczak (2000) and Ruff et al. (1997).

Table 1 Mean ratings (and Standard Deviations) of STS-C related to sex, grade, travel mode, travel time, and activities during travel

	STS-C PAND M (SD)	STS-C PDNA M (SD)	STS-C CE M (SD)
Boys	3.19 (0.94)	4.33 (0.75)	4.05 (0.72)
Girls	3.40 (0.91)	4.38 (0.63)	4.17 (0.65)
Grade 4	3.68 (0.94)	4.35 (0.69)	4.33 (0.65)
Grade 6	3.26 (0.90)	4.45 (0.71)	4.17 (0.59)
Grade 8	2.96 (0.83)	4.23 (0.67)	3.82 (0.77)
Car	3.12 (0.93)	4.38 (0.65)	3.92 (0.78)
School bus	3.32 (0.93)	4.40 (0.65)	4.24 (0.58)
Active mode	3.47 (0.90)	4.25 (0.81)	4.18 (0.67)
Travel time <15	3.39 (0.89)	4.35 (0.70)	4.21 (0.64)
Travel time >15	2.97 (1.03)	4.43 (0.63)	3.79 (0.77)
Solitary activity	3.02 (0.90)	4.16 (0.80)	3.96 (0.68)
Social activity	3.85 (0.88)	4.55 (0.60)	4.46 (0.49)
Smartphone use	3.15 (0.96)	4.48 (0.61)	4.02 (0.73)
Combination of activities	3.42 (0.84)	4.43 (0.59)	4.19 (0.69)

The ratings vary from 1 to 5

follows, we thus separately analyze the effects of each dependent variable on travel mode, travel time, and activity during travel. Neither grade nor sex produced any significant interaction effects ($ps > .05$) with travel mode, travel time, or activities. Only significant main effects of grade and sex are therefore reported below.

Multivariate analyses of variance (MANOVAs) were performed on the multidimensional measures of satisfaction with travel and current mood, followed by univariate analyses of variance (ANOVAs) or *t*-tests and Bonferonni-corrected post hoc *t*-tests. A univariate ANOVA was conducted on the performance measure. The significance levels were set to $p < .05$.

Satisfaction with travel

Means and standard deviations are given in Table 1 for STS-C/CE, STS-C/PDNA, and STS-C/PAND (Cronbach's alpha = .70/.66/.75, respectively) related to sex, grade, travel mode, travel time, and activities during travel.

The effects of travel mode are analyzed first. Data from 15 participants were deleted. Fourteen participants reported a combination of travel modes and one did not report a travel mode at all. A 3 (grade: 4 vs. 6 vs. 8) by 2 (sex: boy vs. girl) by 3 (travel mode: school bus vs. car vs. active mode)[2] MANOVA yielded significant main effects of travel mode, $F(6, 592) = 3.37$, $p = .005$, and grade, $F(6, 592) = 6.17$, $p < .001$. In univariate ANOVAs significant main effects were found of travel mode on STS-C/CE and of grade on all three STS-C indices. Bonferroni-corrected post hoc *t*-tests showed that children who traveled to school by car were significantly lower on STS-C/CE ($M = 3.92$) than those

[2] The effects of sex and grade are reported only once for each dependent variable since the results were close to identical in all the analyses.

who traveled either by school bus ($M = 4.24$) or by active mode ($M = 4.18$). Children in grade 8 were significantly lower on STS-C/CE ($M = 3.82$) than children in grades 4 ($M = 4.33$) and 6 ($M = 4.17$). Children in grade 4 were significantly higher on STS-C/PAND ($M = 3.68$) than children in grade 6 ($M = 3.26$), who were significantly higher than children in grade 8 ($M = 2.96$). No grade differences for STS-C/PDNA were significant in the post hoc tests.

A second MANOVA yielded significant main effects of travel time (less than or equal to 15 min vs. more than 15 min) on the STS-indices, $F(3336) = 12.17$, $p < .001$. Children traveling to school for more than 15 min reported less quality (STS-C/CE, $M = 3.79$ vs. $M = 4.21$; $t(338) = 21.51$, $p < .001$) and excitement (STS-C/PAND, $M = 2.97$ vs. $M = 3.39$; $t(338) = 12.05$, $p = .001$).

A third MANOVA yielded a significant main effect of activities during travel (solitary activities vs. social activities vs. using a smartphone vs. combinations of activities) on the STS-indices, $F(9101) = 4.95$, $p < .001$. In univariate ANOVAs significant main effects of activities were obtained on all indices, STS-C/CE, $F(3338) = 7.40$, $p < .001$, STS-C/PAND, $F(3338) = 11.30$, $p < .001$, and STS-C/PDNA, $F(3338) = 5.89$, $p = .001$. Those who engaged in social activities during travel were significantly higher on STS-C/CE ($M = 4.46$) than those who engaged in solitary activities ($M = 3.96$), or who used a smartphone ($M = 4.02$). Children who engaged in social activities were significantly higher on STS-C/PAND ($M = 3.85$) than those who engaged in any other activities (solitary activities: $M = 3.02$; smartphone use: $M = 3.15$; combination of activities: $M = 3.42$). Children who engaged in social activities ($M = 4.55$), who used a smartphone ($M = 4.48$), or who engaged in a combination of activities ($M = 4.43$) were significantly higher on STS-C/PDNA than those who engaged in solitary activities ($M = 4.16$).

In summary, the lowest degrees of experienced quality (as assessed by the cognitive dimension STS-C/CE) are observed for travel by car and longer travel times, whereas a higher experienced quality is observed for social activities during travel. Furthermore, children engaging in social activities during travel report more excitement (STS-C/PAND) and lower stress (STS-C/PDNA). Higher stress levels are found among those engaged in solitary activities.

Current mood

In Table 2, means and standard deviations of the ratings of valence and activation in the morning and afternoon are given related to sex, grade, travel mode, travel time, and activities during travel.

In the morning questionnaires ratings were missing for 17 children and in the afternoon questionnaires for 39 children who did not attend class. A 3 (grade) by 2 (sex) by 3 (travel mode) MANOVA on valence and activation in the morning and afternoon only yielded a significant main effect of grade, $F(8530) = 2.32$, $p = .019$. In univariate ANOVAs, the main effects of grade on all measures of valence and activation (both morning and afternoon) were significant.

Bonferroni-corrected post hoc *t*-tests showed that children in grade 8 rated valence significantly lower both in the morning ($M = 3.86$) and in the afternoon ($M = 3.92$) than children in grade 4 ($M = 4.24$ and $M = 4.33$, respectively) and grade 6 ($M = 4.16$ and 4.32, respectively). Children in grade 8 also reported lower activation in the morning ($M = 2.84$) and afternoon ($M = 3.32$) compared to those in grade 4 ($M = 3.38$ and $M = 3.95$, respectively).

Table 2 Mean ratings (and Standard Deviations) of current mood related to sex, grade, travel mode, travel time, and activities during travel

	Valence morning/afternoon		Activation morning/afternoon	
	M (SD)	M (SD)	M (SD)	M (SD)
Boys	4.08 (0.86)	4.19 (0.88)	2.93 (1.13)	3.58 (1.26)
Girls	4.11 (0.83)	4.21 (0.79)	3.22 (1.11)	3.61 (1.13)
Grade 4	4.24 (0.89)	4.33 (0.91)	3.38 (1.26)	3.95 (1.19)
Grade 6	4.16 (0.86)	4.32 (0.82)	3.04 (1.12)	3.57 (1.20)
Grade 8	3.86 (0.73)	3.92 (0.73)	2.84 (0.96)	3.32 (1.13)
Car	3.98 (0.88)	4.11 (0.85)	2.89 (1.06)	3.49 (1.22)
School bus	4.15 (0.82)	4.26 (0.80)	3.03 (1.15)	3.59 (1.22)
Active mode	4.14 (.83)	4.22 (0.87)	3.35 (1.14)	3.74 (1.14)
Travel time <15 min	4.11 (0.83)	4.23 (0.83)	3.19 (1.13)	3.57 (1.21)
Travel time >15 min	4.03 (0.92)	4.11 (0.87)	2.80 (1.09)	3.68 (1.12)
Solitary activity	3.96 (0.85)	4.06 (0.86)	3.03 (1.15)	3.43 (1.25)
Social activity	4.19 (0.77)	4.38 (0.85)	3.40 (1.04)	3.95 (1.06)
Smartphone use	4.13 (0.92)	4.26 (0.80)	2.93 (1.18)	3.54 (1.23)
Combination of activities	4.17 (0.80)	4.26 (0.82)	3.18 (1.10)	3.65 (1.11)

The ratings vary from 1 to 5

A second MANOVA on valence and activation in the morning and valence and activation in the afternoon yielded a significant main effect of travel time, $F(4303) = 3.21$, $p = .013$. *t*-tests showed that children traveling to school for more than 15 min had lower activation in the morning ($M = 2.80$) than children traveling equal to or less than 15 min to school ($M = 3.19$), $t(306) = 6.32$, $p = .012$.

A third MANOVA on valence and activation in the morning and afternoon did not yield any significant main effect of activities during travel, $F(12,912) = 1.14$, $p > .05$.

In summary, the children in grade 8 experience the lowest degree of valence and activation both in the morning and afternoon. Longer travel time leads to a lower degree of activation in the morning.

Performance

Means and standard deviations of the performance measure (number of words produced in the word fluency test) are given in Table 3 related sex, grade, travel mode, travel time, and activities during travel.

A 3 (grade) by 2 (sex) by 3 (travel mode) ANOVA only yielded main effects of grade, $F(2, 290) = 34.20$, $p < .001$, and sex, $F(1, 290) = 35.45$, $p < .001$. Bonferroni-corrected post hoc *t*-tests showed that performance significantly increased with grade ($M = 6.83$, 8.20, and 10.83) and that in all grades girls ($M = 9.82$) performed better than boys ($M = 7.29$).

A second ANOVA showed a significant main effect of travel time, $F(1, 330) = 5.55$, $p = .019$. Children with longer than 15 min to school performed significantly better ($M = 9.38$) than children with shorter than or equal to 15 min to school ($M = 8.28$).

Table 3 Means (and Standard Deviations) of cognitive performance related to sex, grade, travel mode, travel time, and activities during travel

	Performance M (SD)
Boys	7.29 (3.20)
Girls	9.82 (3.58)
Grade 4	6.83 (2.82)
Grade 6	8.20 (3.52)
Grade 8	10.82 (3.35)
Car	8.66 (3.51)
School bus	8.71 (3.58)
Active mode	8.13 (3.81)
Travel time <15	8.28 (3.61)
Travel time >15	9.38 (3.21)
Solitary activity	7.72 (3.71)
Social activity	7.47 (2.70)
Smartphone use	9.18 (3.84)
Combination of activities	9.46 (3.24)

The scores are number of produced words in word fluency test

A third ANOVA yielded a significant main effect of activities during travel, $F(3, 331) = 6.80$, $p < .001$. Bonferroni-corrected post hoc t-tests showed that children who used a smartphone and were engaged in combinations of activities performed better ($M = 9.18$ and 9.46, respectively) than children who engaged either in social activities ($M = 7.47$) or solitary activities ($M = 7.72$).

In summary, a longer travel time, using a smartphone, or doing a combination of activities positively affects cognitive performance.

Discussion

The aim of the study was to investigate the impacts of travel mode, travel time, and activities during travel on children of different sexes and ages when traveling to school. We measured satisfaction with travel, current mood, and cognitive performance immediately after arriving at school in the morning, with current mood again being measured in

Table 4 Summary of results

	Satisfaction with travel	Current mood	Cognitive performance
Travel mode	Negative effects of travel by car on experienced quality		
Travel time	>15 min' travel has negative effects on experienced quality and excitement	>15 min' travel has negative effects on activation	>15 min' travel has positive effects on performance
Activities during travel	Positive effects of social activity on experienced quality and excitement and negative effects on stress of being solitary		Using smartphone or doing a combination of activities have positive effects on performance

the afternoon. The main results to be discussed are summarized in Table 4. We also note that our analyses yielded no significant interaction effects that otherwise would have indicated that the impacts of travel mode, travel time, and activities during travel are different depending on the children's sex and grade. We therefore have no empirical basis for concluding from our results that school travel impacts differently on children of different sexes and ages. Some studies have found sex differences on children's travel (Cooper et al. 2006) while some have not (Metcalf et al. 2004). Below we only comment on significant main effects of sex and grade.

Consistent with research on adults (Friman et al. 2013; Olsson et al. 2013), travel mode was found to affect the children's satisfaction with their travel. Active mode and school bus give a higher quality than the car. One possible explanation for this is the physical activity associated with an active mode and with walking to and from the bus stop (Olsson et al. 2013; Westman et al. 2013). Another explanation is that the school bus and the active mode involve desirable social interactions. Children like meeting and talking to their friends (Jones et al. 2012). In support of this, we found that engagement in social activities during travel resulted in higher quality than engagement in solitary activities or smartphone use. Moreover, those children who engaged in social activities experienced more excitement than those who engaged in other activities. Engaging in solitary activities resulted in more stress and worry. Thus, being sociable and interacting with friends and acquaintances seem to be enjoyable activities that the school journey may facilitate. The use of a smartphone may only be a way of counteracting boredom. That an active travel mode or social activities did not affect activation of current mood ($p = .28$) was however unexpected. A reason may be that the study was performed in the middle of the winter when the sun does not rise before school starts and darkness has been shown to negatively affect children's alertness (Swedo et al. 1995).

Lower quality and excitement were reported by children with a longer duration of travel. The older children similarly experienced the lowest quality and excitement. Current mood immediately after travel was also affected by travel time, with children who traveled longer reporting lower activation. A longer trip may have this kind of effect on current mood, but the children with a longer distance to school also started traveling earlier in the morning, which may add to their low activation. The older children reported lower valence and activation, both in the morning and afternoon. These results are consistent with adolescence being a period of flux, when previously satisfied youngsters tend to become dissatisfied (Larson et al. 2002; Pipher 1994) with less frequencies of positive emotions (Larson and Richards 2000). Also, adolescents report being tired almost every morning during school weeks (Tynjälä et al. 1993).

Travel time had an effect on cognitive performance, with children who traveled for longer producing significantly more words. We expected instead that a longer journey, leading to lower activation of current mood, would impair cognitive performance. However, the correlation between cognitive performance and activation was only $r = .07$. Martínez-Gómez et al. (2011) found that children with more than 15 min of active commuting to school produced higher scores in cognitive performance tests than children who spent less time actively commuting. In our study 4.5 % of the children with a longer travel time used active mode compared to 32.0 % of those with a shorter travel time. Therefore, longer active travel does not explain our results. It is still possible that a longer travel time allows children to engage in the types of activities, for instance using a smartphone and doing a combination of activities, which improve performance.

Activities during travel affected cognitive performance positively in that the use of a smartphone, or doing a combination of activities, resulted in better cognitive performance.

Studies have found that the use of ICTs (e.g. playing interactive games) is strongly related to multiple dimensions of creativity (Jackson et al. 2012) and to visual-spatial skills (Green and Bavelier 2003, 2006, 2007) and also believed to be important for success in mathematics, engineering, and science (Subrahmanyam et al. 2006). Shifting attention by means of multiple combinations of activities (or smartphone use) may be an indicator of cognitive flexibility, which is linked with some measurements of intelligence (Colzato et al. 2006).

Limitations and future research

The most important limitation of the study is that our inferences concerning the effects of travel to school may lack internal validity because it was not possible to randomize with regard to travel mode, travel time, and engagement in activities. It is thus not possible to conclusively conclude that the effects we observe are caused by the travel to school. Future research would need to either capitalize on natural experiments or try to set up randomized experiments. It would, for instance, be possible to do an experimental study if a new school bus service is started. Yet, such field experiments aimed at increasing internal validity may also reduce generalizability.

Another limitation of the study is that all measures were made retrospectively. It may in future research (see Carrel et al. 2016) be possible to make observations and measurements during actual travel, at least on public school buses.

Concluding remarks

Car travel to school is an environmentally unsustainable travel mode which impairs children's physical activity, social interactions, and possibilities of exploring their local environment (Cooper et al. 2006; O'Brien et al. 2000; Roth et al. 2012). It also has negative effects on travel experience and residual mood (Westman et al. 2013). In contrast, school buses are sites of valued socialization (Jones et al. 2012) and the positive travel experience may lead to a more positive attitude towards public transportation which will transfer to future travel mode choice (Friman et al. 2001).

Parents and school teachers need to be made aware of the positive effects of school journeys on children. This understanding can be used to motivate them to reduce their car use and changing their perceptions of their children's travel behavior, in addition to influencing them to promote choices of active commuting and school bus.

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Appendix

See Tables 5, 6 and 7.