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The Relationship Between Cycling Behaviour, Attitude to Traffic and Attitude to Daily Life of Junior and Senior High School Students

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ABSTRACT: The objective of this study was to investigate the relationship between junior and senior high school students' cycling behavior, attitudes to traffic and attitude to daily life examining the effects of their gender and age on the behaviour, and to explore the underlying psychological determinants. Past studies on automobile driving have reported that the lower the level of a driver' attitude to safety, the higher the frequency of his/her risky behaviour and near-accident or accident involvement experience; that male and young drivers' level of safety behaviour is lower and they tend to exhibit risky behaviour more frequently than other drivers. It has also been reported that errors and lapses may correspond to accident experience. Although there has not been much research on riding of mopeds and bicycles, it has reported similar results. We conducted a survey on 2,077 junior and senior high school students, asking them to evaluate their traffic-related attitude/experience, behaviour as a cyclist, and their attitude to daily life. Factor analysis led us to extract three factors: "risky cycling", "social desirability", and "near accident". Drivers with weaker "social desirability" characteristic had a stronger tendency to "risky cycling". And it was also shown that the stronger the tendency towards "risky cycling", the more frequent the "near accident" experience occurred. Further, factor analysis focused only on items of cycling behaviour derived two factors: "distracted cycling" and "rapid cycling". Analysis of the correlation of these two factors and the aforementioned three factors showed that cyclists with a stronger tendency to "risky cycling" and weaker tendency to "social desirability" had a stronger tendency to "distracted cycling" and "rapid cycling". It was also shown that the higher the factor score of "risky cycling", the more frequent was the "near accident" experience. The number of accidents while cycling was found to be related to the factors "risky cycling", "social desirability", "near accident", "distracted cycling", and "rapid cycling". Based on the result above, it was speculated that the psychological determinants of cycling and car driving might be common, and it was considered that traffic safety education on cycling for junior and senior high school students is also effective for later car driving.

KEYWORDS: Distracted cycling; Rapid cycling; Traffic behaviour; Near-accident; Social desirability; Junior and senior high school students

NOTE: This study is a reconstruction based on Taniguchi, Y., Taniguchi, S., & Shidoji, K. (2012). Analysis of psychological factors that determine cyclist's behaviour – from the data of paper survey targeting junior and senior high school students. *Proceedings of the 77th Congress of the Japanese Association of Traffic Psychology,* 35–38.

1. INTRODUCTION

Yahashi & Taniguchi (2000) suggested that there is a correspondence between the driver's traffic behaviour and daily behaviour. Based on this, Taniguchi and Taniguchi (2008) found that cycling behaviour may be related to daily behaviour in terms of safety. From these, we speculate that common psychological factors might be acting on the cycling and car driving.

Many studies have revealed relationships between automobile driving behaviours and the driver's psychological characteristics. Reason, Manstead, Stradling, Baxter, & Campbell (1990) showed that intentional violations were more frequent in men than women and also more frequent in older than younger drivers, while age was irrelevant to the occurrence of behavioural errors, and lapses occurred more frequently in women than men. de Winter & Dodou (2010) reported that the results of the Driver Behaviour Questionnaire (DBQ) concerning errors and violations were significantly related to the drivers' self-reported number of accidents in which they had been involved. The DBQ also indicated that men caused fewer errors but more violations than women, and young drivers showed the strongest correlation between violations and accidents. Parker, Reason, Manstead, & Stradling (1995a) and Parker, West, Stradling, & Manstead (1995b) showed that accidents could be predicted from the tendency of violations but not from the tendency of errors or lapses. Iversen H., Rundmo T. (2004) demonstrated that drivers with less awareness of traffic safety, or, in particular, drivers who are more inclined towards legal violations and excessive speed, tend to exhibit risky behaviours in traffic more frequently; that drivers who exhibit risky behaviours frequently experience many near- and actual accidents; and that poor attitudes toward traffic safety and risky behaviours are seen more in younger and male drivers. Nordfjærn, Jørgensen, & Rundmo (2010) indicated that male, young, and poorly educated drivers had a greater tendency to display a poor attitude towards safe driving, and to drive riskily. Lucidi, Mallia, Lazuras, & Violani (2014) showed that the more positive drivers' attitude toward traffic safety is, the less often their driving is risky. Lucidi, Giannini, Sgalla, Mallia, Devoto, & Reichmann (2010) showed that risky drivers had

more driving violations, errors, lapses and accidents – and lower levels of traffic safety attitude and risk perception – than worried drivers and careful drivers. Iversen, H., & Rundmo, T. (2002) reported that sensation-seeking, normlessness, and aggression in drivers indicated a higher likelihood of risky driving, was associated with speeding and violation of traffic laws, and increased experience of near-accidents or crashes.

Thus, research has identified psychological factors relevant to automobile driving. Yet means of transportation other than automobiles include motorcycles, mopeds, and bicycles. Analysis of moped riders has been conducted by Lucidi, Mallia, Giannini, Sgalla, Lazuras, Chirico, Alivernini, Girelli, & Violani (2019). They reported that three personality types (risky, worried, and careful) of high-school-aged moped riders' were related to their risky riding behaviours, attitudes toward traffic safety, risk perception, and self-reported accident involvement. They also showed that this result resembled the results of studies on automobile drivers of different ages. A study by Twisk, Commandeur, Vlakveld, Shope, & Kok (2015) targeted cyclists. They analyzed relationships between cyclists' behaviour and crashes or near-crashes in two adolescent age groups: 12–13 year-olds and 14–16 year-olds. The results indicated that for the 12–13 year-olds, the risk behaviours such as errors, age-specific dangerous play, and lack of protective behaviour predicted the frequency of crashes or near-crashes. For the 14–16 year-olds, only errors predicted the frequency of crashes or near-crashes. Moreover, psychological factors such as knowledge of traffic rules, opinions about traffic rules, carelessness, opinions about social behaviour, and hazard awareness predicted risky behaviour.

As explained above, there have been many studies on psychological factors relevant to automobile driving, which have clarified the relationships between driver personality, attitude toward traffic rules, driving attitude and behaviour, and experience of accident involvement. Research on riders of mopeds and bicycles, though not plentiful, has reported similar results. Twisk et al. (2015), in particular, conducted detailed analysis on cyclist behaviour and clarified the psychological factors that lie behind risky cyclist behaviour. On the other hand, comparative studies on car driving and cycling are not sufficient. Cycling and car driving are different modes of transportation in terms of driving force, speed level and body weight, size, structure, etc. However, there is a common aspect that a human drive them on public roads by manipulating the direction of travel while adjusting the strength of the driving force regardless of human or engine power. Psychological factors are considered to be involved in the driving operation of a car or a bicycle by humans, but it is necessary to distinguish between the factors common to both and the unique factors.

National Public Safety Commission (2016) reveals the purpose, goal and contents of traffic safety education in general. The Ministry of Education, Culture, Sports, Science and Technology of Japan (2016) specifies the curriculum that should be promoted in school education. Of these, traffic safety education for junior and senior high school students is to be systematically implemented throughout school education activities such as health and physical education classes and comprehensive study time. In addition, it is an education that is very closely related to transportation education to acquire a spirit of valuing life, a spirit of caring for others, and a sense of norm such as judgment of right and wrong. However, in reality, it is difficult to carry them out regularly and continuously. Therefore, in Japan, the time to receive education on traffic rules is very limited, and it is common to study at a driving school in order to obtain a driver's license after graduating from senior high school. They can get a motorcycle driver's license from the age of 16, but in many cases they cannot get it due to the rules of high school, so they actually use a bicycle as a means of transportation.

According to the Institute for Traffic Accident Research and Data Analysis (2019), in Japan, accidents involving junior and senior high school students report a significantly higher number of injuries or fatalities when they are cycling rather than walking, in comparison to other age groups. The numbers of bicycle traffic accidents involving (as primary party) adolescents aged 13–15 years were 981 for boys and 435 for girls. The numbers of accidents involving adolescents aged 16–19 years were 1,723 for boys and 900 for girls. This is consistent with the results of the present study in that boys are more frequently involved in accidents. However, the frequencies of cycling (the level of exposure to road traffic) of boys and girls are not clarified.

According to the Traffic Bureau of the National Police Agency (2019), in 2018 70.2% of accidents involving cyclists (primary/secondary parties) resulting in fatality/serious injury were associated with legal violations. Specifically, 78.6% of senior high school cyclist accidents and 80.5% of junior high school cyclist accidents involved violations.

Shiga is a county prefecture adjacent to Kyoto, where this research was conducted. The population of Shiga prefecture in 2007 was 1,394,809, and the population of junior high school students was about 42,261, and that of senior high school students was 39,484 (Shiga Prefecture, 2019). 89.7% of the initial survey subjects (87.8% of junior high school students and 91.9% of high school students) answered that "they use a bicycle at least once or twice a week".

Traffic Department of Shiga Prefectural Police Headquarters (2009) recorded that casualties due to traffic accidents in 2008 was 11,745 (79 dead), 821 (0 dead) for junior high school students and younger, and 376 (1 dead) for senior high school students. Of these, 334 (40.7%) and 259 (68.9%) were injured in the bicycle accident, respectively. The percentage of 1578 (9 dead) injured in bicycle accidents of all ages was 10.5% for junior high school students and 16.4% for senior high school students, which were higher than other age groups.

Kishida (1999) analyzed human factors of accidents caused by bicycles in different age groups from elementary school children to adults, and identified the behaviour characteristic to cyclists who have experienced accidents or near-accidents while cycling. However, the study did not examine psychological factors. Taniguchi & Taniguchi (2008) conducted a questionnaire to clarify how junior and senior high school students' cycling behaviour and understanding of traffic rules are related to their behaviour in daily life. The results of the survey demonstrated the importance of education on traffic laws and regulations for junior high and senior high school students and their social development in their daily lives. Taniguchi, Taniguchi, & Shidoji (2015) revealed that traffic-related attitudes of elementary school children in higher years correspond to their daily life behaviour "social desirability", which is a tendency similar to that of junior high and senior high school students.

The present study therefore aimed to identify the behavioural characteristics unique to cyclists, the psychological factors related thereto, and the impact of gender and age thereon, based on the data of past research targeting junior high and senior high school students.

2. METHOD

2-1. Survey sheet

In order to explore cycling behaviour, daily behaviour and the psychological factors behind the traffic behaviour of young people, we created a questionnaire to measure the consciousness, attitude, and experience of thoe behaviours.

Five face items were set: school year, gender, cycling frequency, hours of cycling per day, and experience of minor collisions/crashes while cycling. Behaviour items were 40 items: 14 items about traffic-related experience, 12 items about cycling style, 8 items about traffic rules, and 6 items about daily life (Table 1).

The frequency of cycling was selected from four choices: rarely riding, once or twice a week, three to four times a week, and riding almost every day. Bicycle ride time was asked for answers in hours and minutes. Regarding the experience of minor collisions or crashes with an automobile (the number of accident involvements) while cycling, we asked them to enter the number of times (asking to enter zero if never). For general traffic behaviour and daily behaviour, we referred to Yahashi and Taniguchi (2000), and for cycling behaviour, we used the same items as Taniguchi and Taniguchi (2008). The answer options were the Likert scale, which is "not applicable at all" (1 point), "almost not applicable" (2 points), "not very applicable" (3 points), "somewhat applicable" (4 points), "approximately applicable" (5 points), and "well applicable" (6 points), etc.

2-2. Subjects and procedures

We asked nine junior high schools and four senior high schools in one prefecture to cooperate and the survey was conducted on the second-year students of those schools (13 or 14 years old at junior high school; 16 or 17 years old at senior high school) using homeroom class time, etc. from late November to mid-December in 2007. There are 107 junior high schools and 54 high schools in the prefecture surveyed in 2007, which are distributed from the city center to the county (Shiga Prefectural Board of Education, 2019). It is somewhat doubtful whether the sample of this study correctly represents the junior and senior high school students in the surveyed prefectures, but it does not impair the purpose of this study. The reason why the second grade of junior high and senior high school students was targeted for the survey was that this grade was easier to obtain cooperation in the survey than the first grade (busy immediately after admission) or the third grade (preparation for senior high school or university entrance examination) in each high school.

We initially collected data from 2,314 students in total: 1,218 junior high school students and 1,096 senior high school students. The analysis targeted the cases of all respondents except those who answered "seldom" for cycling frequency (230 respondents, 9.9%) and the seven non-respondents (0.3%). The hours of cycling per day were 0.772 hours on average (SD = 0.584 hours) and the mode was 0.5 hours. The total number of respondents selected for analysis turned out to be 2,077: 1,070 junior high school students (571 boys (53.4%), 481 girls (45.0%), and 18 gender-unknown students (1.7%)) and 1,007 senior high school students (523 boys (51.9%), 468 girls (46.5%), and 16 gender-unknown students (1.6%)). There was no difference in male-female ratio of respondents between junior high schools and senior high schools (χ^2= .463, p = .496).

The allowable error within the 99% confidence interval was 0.23 for the least sample group analyzed (468) in junior and senior high schools and gender groups ($2.58 \times 2/\sqrt{468}$, confidence interval = 2.58, largest SD = 2). We consider the value is sufficient for our research purposes.

2-3. Analysis of data

SPSS for Windows (Version 26) was used for data processing. First, descriptive statistics were obtained. Next, we searched for basic background factors by factor analysis of all items. In addition, we conducted a factor analysis of items related to cycling and explored the basic psychological factors that regulate cycling. Factor scores of each subject were calculated and saved for both factor analyses. After that, the scores of each factor were compared according to gender and junior and senior high school, and finally the scores of each factor were compared according to the number of accidents.

3. RESULTS

3-1. Selecting the items for factor analysis

First, among the behaviour items, regarding a total of 31 items: 13 items about traffic-related experience (excluding an item asking the number of times of accident involvement), 12 items about the style of cycling, and 6 items about daily life, we selected items to be included in factor analysis.

Table 1 shows details of the items, and basic statistics. First, we excluded three items with question content that was likely to cause difficulty in interpretation of factors (B2 Have you ever had memorable traffic safety education? B6 Will a car stop when you are walking across a pedestrian crossing which does not have traffic lights? B7 Will a car stop when you are cycling across a pedestrian crossing or bicycle crossing which does not have traffic lights?). For "C5 You cycle with a helmet", since junior high school students are strictly required to wear helmets, we thought that the degree of decision-making freedom of cyclists was low. Therefore, this item was also excluded from analysis targets.

Next, we excluded question items with a narrow distribution range of evaluation and which would show the floor or ceiling effect. Specific criteria were: standard deviation less than 1.30, and Mean value − Standard deviation < 1; or standard deviation less than 1.30, and Mean value + Standard deviation > 6.

The three items that met these criteria (B10 If you want to cycle across a pedestrian crossing or a bicycle crossing, and the green light starts blinking before you start to cross, what would you do? C11 You cycle without brakes. E2 Do you try to say "thank you" or "sorry"?) were excluded.

Finally, the two items (C7 You email on your mobile phone while cycling. C8 You talk on your mobile phone while cycling.) were highly correlated (r = .794, n = 2048, p < .001) and the questions were similar, we excluded the item with a relatively small SD (C8).

As a result, a total of 23 items turned out to be subject to factor analysis: 9 items about traffic-related experience, 9 items about the style of cycling, and 5 items about daily life. For factor analysis, we employed the major factor method and conducted promax rotation to obtain a simplified structure.

3-2. Factor analysis of all items

First, we conducted factor analysis for 23 items and derived a three-factor solution based on examination of the scree plot and the interpretability of factors.

It was found that for "C12 You cycle without lights at night". and "B5 How often do you fasten your seat belt when you ride in the back seat of a car?", the loadings were small for all factors (between −0.272 and 0.250). So we excluded these two items and conducted factor analysis again for the remaining 21 items.

The first factor represents "risky cycling" (α = .790), with higher loadings on items placed for "C. About the style of cycling".

The second factor represents "social desirability" (α = .722), with higher loadings on items related to traffic rules and safety in "E. About daily lives" and "B. About traffic-related experience".

The third factor represents "near-accident experience" (α = .752), with higher loadings on three items relating to experience of near collision with a pedestrian or a car in "B. About traffic-related experience".

Question number	Item Number	Contents of question	*n*	*M*	*SD*	*M* - *SD*	*M* + *SD*
B1	B1	Do you ever talk about traffic safety with your family?	2072	2.13	1.32	0.81	3.44
B2	B2	Have you ever had memorable traffic safety education?	2074	2.53	1.35	1.18	3.88
B3	B3	Do you think it is important to follow traffic rules while cycling?	2071	4.58	1.27	3.31	5.85
B4	B4	How often do you fasten your seat belt when you ride in the front seat of a car?	2070	4.74	1.77	2.97	6.51
B5	B5	How often do you fasten your seat belt when you ride in the back seat of a car?	2073	1.63	1.33	0.30	2.96
B6	B6	Will a car stop when you are walking across a pedestrian crossing which does not have traffic lights?	2069	3.59	1.63	1.96	5.22
B7	B7	Will a car stop when you are cycling across a pedestrian crossing or bicycle crossing which does not have traffic lights?	2073	3.41	1.63	1.78	5.03
B8	B8	When you cycle across the road at a green light, do you check to see if a car is coming ?	2046	4.36	1.65	2.70	6.01
B9	B9	If you want to walk across a pedestrian crossing, and the green light starts blinking before you start to cross, what would you do?	2043	4.81	1.39	3.42	6.20
B10	B10	If you want to cycle across a pedestrian crossing or a bicycle crossing, and the green light starts blinking before you start to cross. what would you do?	2043	5.08	1.22	3.85	6.30
B11	B11	When you are cycling on the sidewalk, do you ever almost collide with a walking person?	2045	3.07	1.54	1.53	4.60
B12	B12	When you are cycling, do you ever almost collide with a car curving suddenly?	2048	3.31	1.52	1.79	4.82
B13	B13	When you don't stop while cycling at an intersection without traffic lights, do you ever almost collide with a car?	2044	2.57	1.42	1.15	3.99
C1	C1	You cycle next to your friend cycling on the road.	2049	4.16	1.59	2.57	5.76
C2	C2	You cycle with listening to the headphone stereo.	2046	2.96	1.93	1.04	4.89
C3	C3	You cycle with another one on a bicycle.	2052	2.38	1.59	0.79	3.97
C4	C4	You cycle across the road at a red light.	2048	2.47	1.53	0.93	4.00
C5	C5	You ride with a helmet.	2047	4.61	2.00	2.61	6.61
C6	C6	You cycle through the side of cars in a traffic jam.	2045	3.15	1.56	1.59	4.72
C7	C7	You email on your mobile phone while cycling.	2049	2.74	1.74	1.00	4.48
C8	C8	You talk on your mobile phone while cycling.	2050	2.36	1.59	0.77	3.95
C9	C9	You cycle at high speed on narrow sidewalks.	2048	3.21	1.43	1.78	4.64
C10	C10	You cycle with an umbrella.	2048	3.12	1.90	1.22	5.03
C11	C11	You ride a bicycle without brakes.	2045	1.65	1.17	0.48	2.81
C12	C12	You ride without lights at night.	2045	2.37	1.86	0.51	4.23
E1	E1	Do you greeting of "good morning" or "Hello" from the usual family has been said to be important.	2064	4.27	1.62	2.65	5.89
E2	E2	Do you try to say "thank you" or "sorry"?	2065	5.17	1.11	4.06	6.28
E3	E3	Do you try to keep the school rules in your school life?	2057	4.58	1.22	3.36	5.81
E4	E4	Do you pay attention not to waste water or electricity?	2062	4.14	1.36	2.79	5.50
E5	E5	Do you try to separate ordinary garbage from plastic and empty cans?	2064	4.33	1.54	2.79	5.87
E6	E6	Do you leave home earlier in the morning not to be late for school and club activities?	2064	4.11	1.69	2.42	5.80

Note: Items in gray were excluded from analysis target.

Table 1. Item Details and Basic Statistics, as well as Mean ± Standard Deviation

Item	F1	F2	F3
C3	**.671**	.001	-.052
C7	**.660**	.049	-.026
C4	**.609**	-.145	.015
C10	**.595**	.060	-.020
C1	**.536**	.074	-.011
B9	**.479**	.039	-.032
C2	**.462**	.070	.028
C6	**.408**	-.091	.144
C9	**.380**	-.087	.153
E5	.127	**.668**	-.016
E4	.176	**.662**	-.006
E3	-.052	**.551**	-.030
E1	.099	**.445**	.032
B3	-.230	**.435**	.026
E6	.014	**.418**	-.080
B8	-.127	**.412**	.024
B1	-.088	**.350**	.163
B4	-.081	**.349**	.017
B12	-.066	.022	**.822**
B13	.048	.000	**.695**
B11	.073	.030	**.602**
Interfactor correlation			
F1	1.000		
F2	-.421	1.000	
F3	.409	-.025	1.000

Table 2. Results of factor analysis on items concerning traffic-related experience, style of cycling, and daily life (Major factor method, after promax rotation, *n* = 1962)

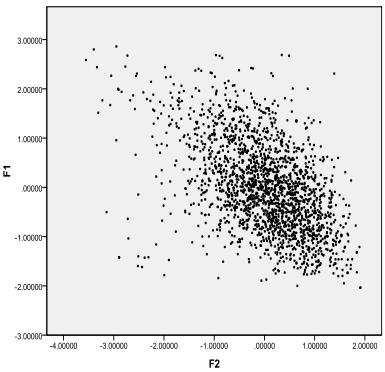

Fig. 1. Scatter plot of factor scores of the second factor (F2: social desirability) and the first factor (F1: risky cycling)

Here, for each factor, we calculated the factor scores of those surveyed and examined the mutual relationships. Fig. 1 is a scatter plot of the second factor (F2: social desirability) and the first factor (F1: risky cycling).

It shows that cyclists with a weaker characteristic of "social desirability" have a stronger tendency to "risky cycling" ($r = -.497$, $p < .001$, $n = 1962$).

Incidentally, there is a small group of dots located in the upper left of this graph, an area deviating from areas where the majority is distributed. This group seems to represent students who have an extremely weak characteristic of "social desirability" and are often involved in "risky cycling".

Fig. 2 is a scatter plot of the first factor (F1: risky cycling) and the third factor (F3: near accident). It shows that the stronger a cyclist's tendency to "risky cycling", the more frequently the cyclist experiences "near-accident" involvement (r= .482, p < .001, n = 1962).

Incidentally, the correlation coefficient of the second factor (F2: social desirability) and the third factor (F3: near accident) is –0.039 (p < .1, n = 1962) and therefore the two factors are mostly considered independent.

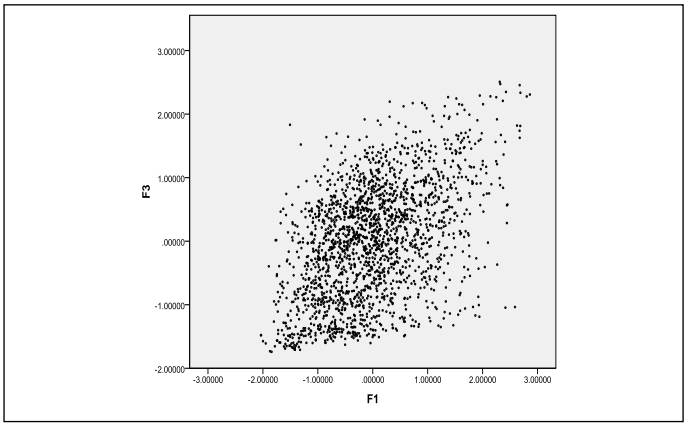

Fig. 2. Scatter plot of factor scores of the first factor (F1: risky cycling) and the third factor (F3: near accident)

3-3. Factor analysis on items concerning the style of cycling

Next, from the items extracted as the first factor "risky cycling" in the factor analysis described above, we picked up eight items relevant to the style of cycling and conducted factor analysis targeting the eight items to identify background factors. (Table 3)

Item	F1	F2
C3	**.773**	-.093
C10	**.668**	-.087
C7	**.582**	.099
C4	**.454**	.278
C2	**.435**	.044
C1	**.360**	.177
C6	-.076	**.796**
C9	.050	**.547**
	Interfactor correlation	.597

Table 3. Results of factor analysis on items concerning the style of cycling
(Major factor method, after promax rotation, n = 2028)

In these results, the first factor represents "distracted cycling", or cycling while talking with others or doing something else, with higher loadings on items related to cycling next to another cyclist, listening to headphones, carrying a passenger, jumping a red light, emailing, and cycling with an umbrella (α = .753).

The second factor represents "rapid cycling", with higher loadings on two items: slipping past waiting vehicles and cycling fast on narrow sidewalks (α = .592).

Fig. 3 is a scatter plot of the first factor (F1: distracted cycling) and the second factor (F2: rapid cycling). Here, it is shown that cyclists who are strongly inclined to distracted cycling are more often associated with rapid cycling behaviour such as slipping past cars and cycling at high speed (r = .729, p < .001, n = 2028) (Fig. 3).

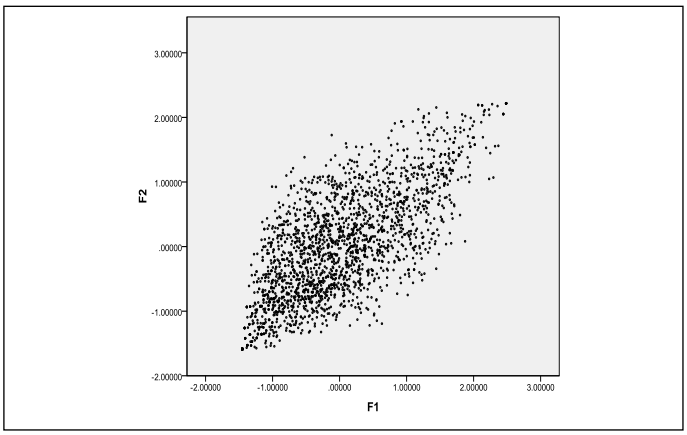

Fig. 3. Scatter plot of factor scores of the first factor (F1: distracted cycling) and the second factor (F2: rapid cycling)

Of the nine items on which loading of the "risky cycling" factor is high as explained above, eight items were assigned to "C. About the style of cycling", and the same items are included in the "distracted cycling" and "rapid cycling" factors. Therefore, the "risky cycling" factor is positively correlated with the "distracted cycling" factor (r = .962, p < .001, n = 1962) and the "rapid cycling" factor (r = .827, p < .001, n = 1962). The "near accident" factor, which showed a highly positive correlation with the "risky cycling" factor, is also positively correlated with the "distracted cycling" factor (r = .396, p < .001, n = 1962) and the "rapid cycling" factor (r = .451, p < .001, n = 1962). On the other hand, the "social desirability" factor, which showed a highly negative correlation with the "risky cycling" factor, is also negatively correlated with the "distracted cycling" factor (r = –.414, p < .001, n = 1962) and the "rapid cycling" factor (r = –.423, p < .001, n = 1962).

3-4. Factor scores by gender and high school type (junior high or senior high)

We conducted a two-factor analysis of variance with regard to factor scores by gender and the type of high school. For "risky cycling", there was no difference between genders but senior high school students scored higher than junior high school students (F (1, 1927) = 97.5, p < .001, η^2 = .048). The interaction of the two factors showed significance: junior high school girls scored higher than boys while senior high school boys scored higher than girls (F (1, 1927) = 2.76, p < .1, η^2 = .001) (Fig. 4).

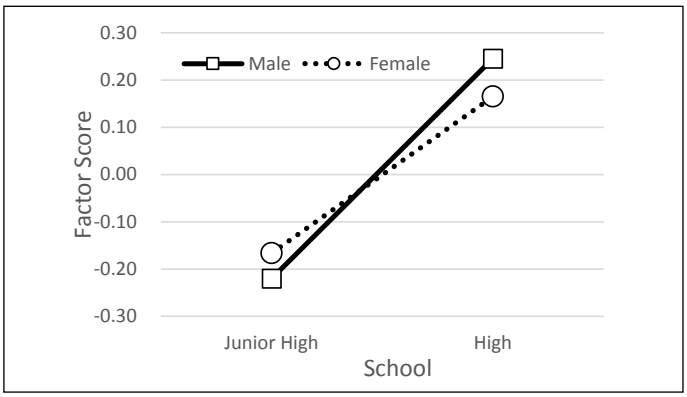

Fig. 4. Comparison between junior and senior high school students for risky cycling

For "social desirability", girls scored higher than boys (F (1, 1927) = 23.1, p < .001, η^2 = .012), and senior high school students scored higher than junior high school students (F (1, 1927) = 6.18, p < .05, η^2 = .003) (Fig. 5). The interaction was not significant.

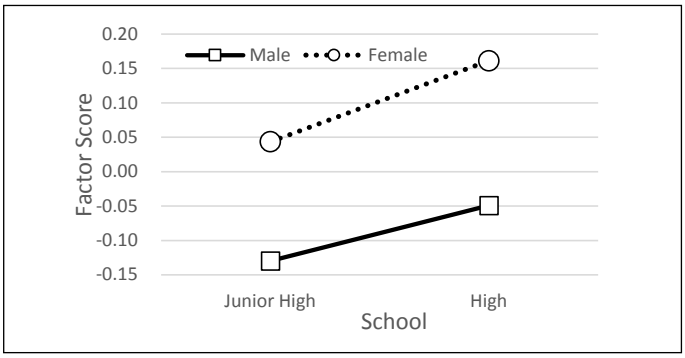

Fig. 5. Comparison between junior and senior high school students for social desirability

For "near accident", girls scored higher than boys (F (1, 1927) = 6.14, p < .05, η^2 = 003), and senior high school students scored higher than junior high school students (F (1, 1927) = 108.5, p < .001, η^2 = .003) (Fig. 6). The interaction was not significant.

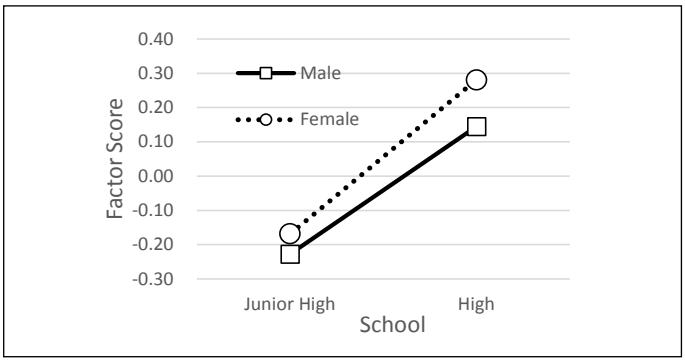

Fig. 6. Comparison between junior and senior high school students for near-accident involvement

For "distracted cycling", there was no difference between genders but senior high school students scored higher than junior high school students (F (1, 1991) = 150.3, p < .001, η^2 = .070). The interaction of the two factors showed significance: junior high school girls scored higher than boys (F (1, 1991) = 4.36, p < .05, η^2 = .070) (Fig. 7).

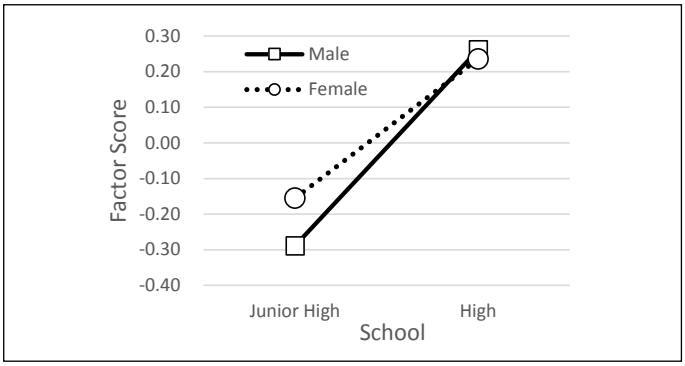

Fig. 7. Comparison between junior and senior high school students for distracted cycling

For "rapid cycling", boys scored higher than girls (F (1, 1991) = 12.1, p < .001, η^2 = 0.006), and senior high school students scored higher than junior high school students (F (1, 1991) = 14.1, p < .001, η^2 = .007) (Fig. 8). The interaction was not significant.

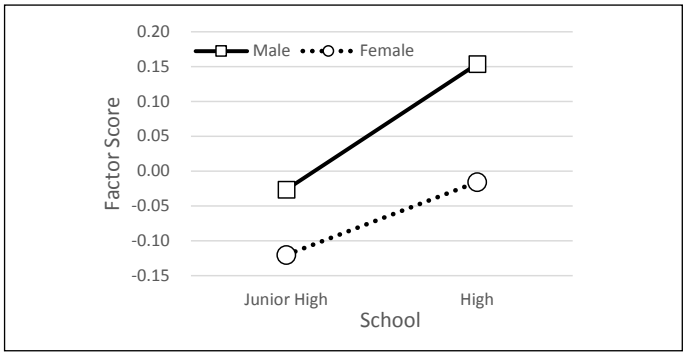

Fig. 8. Comparison between junior and senior high school students for rapid cycling

3-5. Relationship between the number of times of accident involvements and factor scores

The number of minor collisions or crashes with an automobile (the number of accident involvements) while cycling shows a Poisson distribution, with the mean value at 0.71 times (SD = 2.50), skewness at 12.4, and kurtosis at 215.4. Regarding the number of accident involvements, we divided the respondents into three groups of zero times (n = 1539 (65.4%)), once (n = 325 (15.6%)) and twice or more (n = 393 (18.9%)), and compared the three groups' mean values of factor scores. Significant differences were seen in the above-mentioned factors of "risky cycling" (F (2, 1959) = 41.8, p < .001, η^2 = .041), "social desirability" (F (2, 1959) = 16.0, p < .001, η^2 = .016), "near accident" (F (2, 1959) = 110.2, p < .001, η^2 = .101), "distracted cycling" (F (2, 2025) = 30.5, p < .001, η^2 = . 029), and "rapid cycling" (F (2, 2025) = 35.1, p < .001, η^2 = .033). While the factor score of "social desirability" declined as the number of accidents increased, all the other factors scored higher when the number of accidents rose. (Fig. 9, Fig. 10)

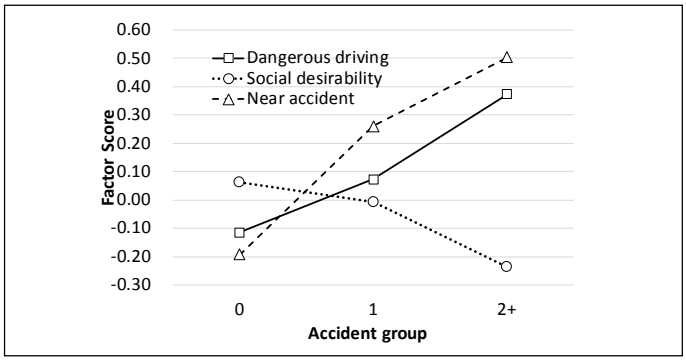

Fig. 9. Comparison of "risky cycling", "social desirability", and "near accident" by the number of accident involvements

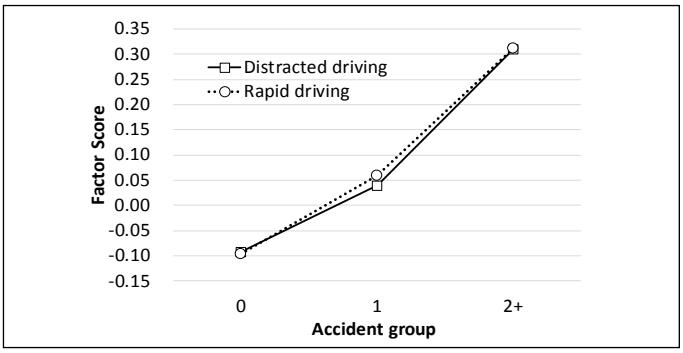

Fig. 10. Comparison of "distracted cycling" and "rapid cycling" by the number of accident involvements

3-6. Number of accident involvements by gender and high school type (junior high or senior high)

We conducted a two-factor analysis of variance with regard to the number of times of accident involvements by gender and the type of high school. There was no difference between junior high school and senior high school students while boys experienced more accidents than girls (F (1, 1905) = 21.1, $p < .001$, $\eta^2 = .011$). The interaction was not significant.

4. DISCUSSION AND CONCLUSION

The "risky cycling" factor presented in this study consists of items related to the safety or risk of a cyclist's behaviour. The "social desirability" factor consists of items related to basic social attitudes in daily life. The "near accident" factor consists of items related to risk experience while cycling. The (negative) correlation between the "risky cycling" factor and the "social desirability" factor suggests that basic social attitudes in daily life are expressed in the safety or risk of a cyclist's behaviour. The (positive) correlation between the "risky cycling" factor and the "near accident" factor indicates that risky or safe cycling attitudes are actually related to the risk of collision with others. Meanwhile, the mutual independence of the "social desirability" and "near accident" factors means that basic social attitudes in daily life are not directly relevant to risk experience while cycling. It should be noted that there are a small number of students who scored extremely low for the "social desirability" factor and high for the "risky cycling" factor. They are antisocial in both daily life and traffic behaviour, and it seems necessary to provide a special education program for them.

It is natural that the "distracted cycling" and "rapid cycling" factors, which were obtained in the factor analysis of items related to the style of cycling, are highly positively correlated with the "risky cycling" factor, because these factors include several items in common. Moreover, the negative correlation of the "distracted cycling" and "rapid cycling" factors with the "social desirability" factor and the positive correlation with the "near accident" factor also seem to be consistent with the correlation of the "risky cycling" factor with the "social desirability" and "near accident" factors.

For the "risky cycling" factor, there was no difference between genders and senior high school students scored higher than junior high school students. Junior high school girls scored higher than boys while senior high school boys scored higher than girls. For "near accident", girls scored higher than boys, and senior high school students scored higher than junior high school students. Junior high school students and senior high school students are in their developmental stage of adolescence, when gender-specific behavioural changes occur rapidly to both boys and girls. Differences by gender or age regarding "risky cycling" and "near accident" as described above are probably attributed to such developmental characteristics, though elucidation of the specific mechanism will be our future task.

For the "social desirability" factor, girls scored higher than boys, and senior high school students scored higher than junior high school students. This seems contradictory to the finding that the "social desirability" factor is negatively correlated with the "risky cycling" factor and that there is no difference between genders regarding the "risky cycling" factor, with senior high school students scoring higher than junior high school students. However, the higher scores marked by girls and senior high school students are the representative values of the survey target groups. On the contrary, the correlation between the "social desirability" and "risky cycling" factors represent the association of personal characteristics and therefore there is no contradiction.

For the "distracted cycling" factor, there was no difference between genders and senior high school students scored higher than junior high school students. There was an interaction between the high school type and gender factors, with junior high school girls scoring higher than boys. On the other hand, there is gender difference for the "rapid cycling" factor, with boys scoring higher than girls. And senior high school students scored higher than junior high school students. The reason for these results can be explained by the developmental aspect related to age and gender. Although the junior high school students and senior high school students who were the subjects of the present study differ by only three years, it seems that the rapid behavioural changes unique to this period are reflected. Details of this issue should be examined in the future.

The relationship between the number of accident involvements and each factor was evident. All of "risky cycling", "social desirability", "near accident", "distracted cycling", and "rapid cycling" were related to actual accident experience.

In the results of the present study, senior high school students scored higher for the factors "risky cycling", "near accident", "distracted cycling", and "rapid cycling" than junior high school students. This indicates that the cycling behaviour of junior high school students shifts in a riskier direction as they grow to senior high school students. It is noteworthy that junior high school girls score higher than boys for the "risky cycling" and "distracted cycling" factors but boys score higher than girls for the "risky cycling" factor when they become senior high school students. This suggests that behavioural changes based on the developmental characteristics unique to this age group differ between boys and girls.

The present study found the girls' "near accident" factor score high. This is possibly related to the finding in automobile driving that women are more frequently involved in lapses (Reason et al., 1990) or errors (de Winter & Dodou, 2010). The fact that boys scored higher for the "rapid cycling" factor and have experienced more accidents than girls corresponds to the finding in automobile driving that men are associated with more violations than women (Reason et al., 1990; de Winter & Dodou, 2010; Parker et al., 1995a; Parker et al., 1995b). According to the Institute for Traffic Accident Research and Data Analysis (2019), the numbers of bicycle traffic accidents involving (as primary party) adolescents aged 13–19 years for boys was almost twice of that for girls. This is consistent with the results of the present study in that boys are more frequently involved in accidents. However, the frequencies of cycling (the level of exposure to road traffic) of boys and girls are not clarified. In the present study, respondents with higher scores for the "social desirability" factor had experienced fewer accidents while those with higher scores for the "risky cycling", "near accident", "distracted cycling", and "rapid cycling" factors had experienced more accidents. These results are similar to the results of Iversen, H., & Rundmo, T. (2002), that drivers with a strong sense of sensation-seeking, normlessness, and aggressiveness were more often involved in risky driving, associated with speeding and violation of traffic laws, and they also experienced near-accidents or crashes more often than others. They are also consistent with the results of Iversen H., Rundmo T. (2004), that drivers with less awareness of traffic safety, or in particular, drivers who are more inclined towards legal violations and excessive speed, tend to exhibit risky behaviours in traffic more frequently; that drivers who exhibit risky behaviours frequently experience many near-accidents and accident involvements; and that poor attitudes toward traffic safety and risky behaviours are seen more in younger and male drivers.

Gender and age (junior and senior high school difference) are biological characteristics and can be regarded as basic factors that determine consciousness and behaviour. And,

it can be considered that the experience of minor collisions or crashes with an automobile while cycling (the number of accident involvements) is a more direct measurement of accident proneness compared to other questionnaire items. Therefore, we considered that these factors could be causal relatively to explain other variables.

The present study showed that the subject students who scored low for the "social desirability" factor scored high for the "risky cycling" factor; that those with higher scores for the "risky cycling" factor had more often experienced near-collision with a pedestrian or a car; that those with higher scores for the "risky cycling" factor scored higher for the "distracted cycling" and "rapid cycling" factors; that those with lower scores for the "social desirability" factor scored higher for the "distracted cycling" and "rapid cycling" factors;, and that those with higher scores for the "near accident" factor scored higher for the "distracted cycling" and "rapid cycling" factors. Moreover, the number of minor collisions or crashes with an automobile (the number of times of accident involvements) while cycling showed a significant difference in all factors.

A study (Twisk et al. 2015) targeting pedestrians and cyclists in age groups (12–13 years old, and 14–16 years old) similar to those of the present study also showed that psychological factors are associated with highly frequent risky behaviour, and that the risky behaviour is associated with collision frequency.

The attitudes and behavioural characteristics of junior and senior high school students related to cycling revealed in the present study resemble the results obtained with higher-year elementary school children. Taniguchi, Kanemitsu, & Taniguchi (2010) showed, based on a survey targeting elementary school students (4th to 6th years), that the better a student's compliance with traffic rules while cycling, and the higher the level of social desirability of the student's attitude in daily life, the fewer near-accidents the student experienced.

The limitation of this study is that there were some confounding factors that could not be well controlled in this study. However, the suggestion that the cycling behaviour is similar to that of car driving can be considered to be due to the same psychological factors acting on them, although there are superficial differences in behaviour between the two. This is a problem that needs to be solved by accumulating further data. Some of the findings of these studies, though with some unsolved research issues remaining, have been incorporated in an education program developed by Otani, Kanemitsu, Taniguchi, Mukai, Ogawa, & Yamaguchi (2016) which places emphasis on compliance with daily life norms as well as traffic rules.

The subjects of the present study were junior high school and senior high school students, who are below the legal driving age in Japan (18 years old), but some of their behavioural characteristics while cycling were suggested to be similar to behavioural characteristics of automobile drivers. We have not found those literature which refer directly to the point of view. In order to draw conclusion about the commonality between cycling behaviour and car driving, cohort studies are inevitable. However, tracking an individual is difficult in terms of privacy protection, but we would like to develop a research and/or analysis method that can solve the problem in the future.

We think that safety education for cycling will lead to subsequent safe automobile driving. As one of the educational methods based on the results of our research, the following discussion issues might be given in traffic safety education for junior and senior high school students; Rapid cycling, such as passing by a car or pedestrian, or distracted cycling while using a mobile phone could cause an accident. The same thing seems to be true even after you start driving a car. This kind of debate task will form a metacognition for safe traffic behaviour among junior and senior high school students, and is expected to form a safe attitude not only in current cycling but also in future automobile driving.

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