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"Not as Safe as I Believed": Differences in Perceived and Self-Reported Cycling Behavior between Riders and Non-Riders

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Abstract: Cycling behavior remains a key issue for explaining several traffic causalities occurring every day. However, recent studies have shown how the assessment of the own safety-related behaviors on the road may substantially differ from how third parties assess them. Thus, the aim of this study was to evaluate the differences between cyclists' self-reported behavior and the proxy-reported behavior that other (non-cyclist) road users perceive from bike riders. For this purpose, this study used data from two samples: (*i*) 1064 cyclists (M = 32.83 years) answering the Cycling Behavior Questionnaire—CBQ, and (*ii*) 1070 non-cyclists (M = 30.83 years) answering an adapted version of the CBQ for external raters—ECBQ. The results show how the self-reported and proxy-reported behaviors of cyclists greatly differ in terms of all behavioral factors composing the CBQ model, i.e., traffic violations, riding errors, and positive behaviors. Also, external raters (non-cyclists) are those targeting significantly riskier behaviors than those self-reported by cyclists. These discrepancies between perceived behaviors may give rise to conflicting viewpoints on the interaction between bicycle riders and other road users. Therefore, this study underscores the importance of behavioral awareness, providing highlights for future studies on the behavioral interaction between cyclists and other road users. Results can be used to improve the road safety of all road users by giving indications on self-and proxy-perceived safety-related behaviors and visibility of protective riding habits.

Keywords: cycling behavior; CBQ; ECBQ; data sources; cyclists; non-cyclists; cycling safety; traffic crashes

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1. Introduction

Cycling is an active mode of transportation with well-established health and economic benefits, so much so that authorities are constantly developing cycling-promoting specific-strategies with the aim of increasing cycling participation [1–3]. However, the safety of cyclists in traffic remains a major concern [3–5].

It is widely known that traffic casualties constitute a challenging barrier to the sustainability of road safety [6]. As previously reported, people tend to choose transport modes that they perceive as safer [7]. In this sense, pedestrians, cyclists, and motorcycle users are the most vulnerable users, since they are much less protected on the road [1,8]. Accordingly, almost 5% of the total crashes with casualties in Spain during the year 2018 involved cyclists, 70% of them being in urban areas [9].

In-depth studies of potential risk factors and safety outcomes are needed to ensure that the most appropriate actions are taken to improve safety. For instance, better cyclist-driver awareness and more interaction between car drivers and cyclists are among the recognized strategies that should improve bicycle safety [3]. Also, recent evidence has shown that one of the most important factors affecting the safety of road users is their own behavior; however, low awareness among road users seems to be a challenging issue to face [6,10,11].

There are numerous instruments to assess cyclists' behavior and attitudes. For instance, the Cycling Behavior Questionnaire (CBQ) has proven to be useful in assessing self-reported cycling behavior through the identification of risky and positive behaviors [11]. The CBQ was validated with 29 items clustered in three dimensions: violations, errors, and protective behaviors [11]. This behavioral questionnaire has been validated in Spanish, English [12–14], Chinese [15], and is being validated in French, and Dutch [16]; also, a similar questionnaire with special relevance for addressing cycling behaviors under the behavioral questionnaire (BQ) paradigm has been developed in China (the Chinese Cycling Behavior Questionnaire [17]). The questionnaire has proven to be sensitive to age and gender-based differences [11–14], and it has shown correlations with risk perception, psychological distress, road distractions, and traffic-rule knowledge [12–14]. Furthermore, this questionnaire has been correlated with other personality traits or factors such as cycling anger, sensation seeking, impulsiveness, and normlessness [15].

However, this and other similar tests are carried out employing self-report-based data, and several studies have shown how self-report measures may carry different biases, such as acquiescent answers (i.e., the participants' total agreement with the presented questions), social desirability, and lack of sincerity [18]. Furthermore, positive/negative affects/mood may impact the response style of participants, especially when addressing issues that may seem sensitive, even when responding to anonymous questionnaires, as pointed out by Chai et al. [19] and Af Wåhlberg [20] in previous studies dealing with drivers and their road safety outcomes. Also, some studies have documented the existence of substantial discrepancies between attitudes, self-reports, and observed behaviors of road users [21,22]. For instance, it is interesting that, despite their situation of vulnerability on the road, cyclists perceive a lower risk of crashing with cars, if compared with what drivers perceive in the same situation [23]. Bearing in mind that an important number of the total crashes involving cyclists also involved other vehicles or road users [1,24] it proves necessary to approach cyclists' behavior from a multifactorial perspective that includes other road users in the equation.

To bridge this gap between the self-reported and actual observed behavior, proxy reports (i.e., using an external rater to assess a specific issue that needs to be addressed from a non-self-reported approach) are used in many fields such as healthcare [25–27] and social functioning [28]. In road safety research, proxies have been used to assess driving behaviors among older adults [18,29–31], fitness to drive in stroke patients [32], or to compare the risk perception between drivers and other road users [23]. The term proxy report refers to the use of an external rater when a different perspective is needed for a full understanding of a particular construct, among other reasons [28], and thus both terms (external rater and proxy) will be interchangeably used throughout this paper. Some of the usually used proxies are family, caregivers, friends, and other community members [18,28]. To the best of our knowledge, no previous instruments nor empirical studies have assessed the perception that non-cyclist road users have of the behavior of the population of cyclists as road users under the Behavioral Questionnaire (BQ) Paradigm. Due to all these facts, the question arises whether the proxy-reported behavior of cyclists could be similar to that self-reported by a random sample of cyclists.

Objective and Hypotheses of the Study

Bearing in mind the aforementioned, the core aim of this study was to assess the differences between cyclists' self-reported behavior and the proxy-reported behavior that other (non-cyclist) road users perceive from bike riders, through an adapted version of

the CBQ, i.e., the "*External Rater Cycling Behavior Questionnaire*" (ECBQ), a self-report questionnaire assessing an identical set of cycling behaviors, but seen from the perspective of road users different to cyclists, establishing commonalities and differences on cycling behaviors from two different data sources.

It was hypothesized that: (a) the outcomes of the proxy-reported ECBQ will be different than those obtained in the sample of cyclists with the CBQ, and (b) there will be significant differences according to the demographic profile of both cyclists and non-cyclists (proxies) regarding the perceived road behavior of bike riders.

2. Materials and Methods

2.1. Study Design

This cross-sectional empirical study consisted of comparing the outcomes in the Cycling Behavior Questionnaire (CBQ) from a self-and-proxy-report perspective. The analyses performed in this study were based on the pooled data of two samples: one composed of non-cyclist road users and one of cyclists. For such purpose, two approaches were used to obtain the study data: the original self-reported CBQ and the new External Rater Cycling Behavior Questionnaire (ECBQ), which was applied using a proxy-reported methodology (see Section 2.3). The outcomes of the original CBQ were extracted from a previous study of our research group [11] and thus, further details on the study sample, design, and application of this questionnaire can be consulted in the mentioned article. On the other hand, the ECBQ was firstly applied in this research. After gathering data on the CBQ and ECBQ in both samples (proxies and cyclists; see Section 2.2), the outcomes were statistically compared (see Section 2.4).

As previously pointed out, the use of proxies may be of great interest in the understanding of the factors that influence the safety of cyclists, and this has never been done before from the Behavioral Questionnaire (BQ) perspective. Negative biases related to self-report questionnaires may be overcome with this new approach, as mentioned in the introduction. It is important to take into consideration that the nature of the relationship between the proxy and the subject may affect the research outcomes [28]. Bearing in mind that the number of cyclists is constantly increasing in Spain and that they represent a huge number of the total group of road users [2,33], it is easy to think that all road users, no matter what type they are (i.e., pedestrians, motorized users), usually interact with bicycle-riders in different situations. For this reason, a multimodal approach including any non-cyclist road user as an external rater (proxy) was used.

For the new ECBQ, respondents were directly asked (non-probabilistic convenience sampling method) to take part in the study through an e-mail invitation using an inter-institutional mailing list, shared by different universities and research groups from different regions of Spain. Participants were also encouraged to share the e-survey with other people.

2.2. Participants

As previously mentioned, data for this study were retrieved from two samples, all of them Spanish-speaking road users: (*i*) the *proxies* (n = 1070 non-cyclist road users from different regions of the country, age ranged between 16 and 79 years [M = 30.83, SD = 12.92 years], see Table 1), and (*ii*) the cyclists (n = 1064 cyclists, 413 females and 651 males, with a mean age of M = 32.83 years [SD = 12.63; see Table 1 and Useche et al. [11] for further details]). Descriptive data on self-reported knowledge of traffic rules/regulations and risk perception, as well as road distractions [34], are displayed in Table 2. Additionally, the mean scores to four questions exclusively addressed at cyclists are also displayed below.

The proxy sample had to be representative of the full Spanish census (almost 47 million inhabitants), which was assumed as population size. An initial n of about 772 individuals was determined as the minimum sample size by an a priori power analysis (G*Power 3.0; [35]), assuming an effect size (f) of 0.13, a power (1–ß) of 0.95, and a maximum margin of error/confidence interval (CI) of 5%. Bearing in mind the considerably big population size, which entails the need of collecting higher amounts of data (number of surveys) to

decrease the margin of error, and the relatively elevated response rate, the research team collected more respondents for the final sample, attaining a greater sample size for the research. The post hoc power analyses revealed that an optimum statistical power was achieved with both the sample of proxies (n = 1070) and the total pooled sample (n = 2134), with an error (a) of 0.05, and effect size (f) of 0.30. The response rate was around 67% for the proxies and 42.6% for the riders, keeping in mind that almost 1600 and 2500 invitations to participate were initially delivered, respectively.

It is important to bear in mind that the majority of the population knows how to ride a bicycle. Due to this, and aimed at avoiding problematic overlap biases, we used a classification criterion to differentiate between cyclists and non-cyclists in terms of riding regularity (i.e., at least once a month).

Table 1. Sociodemographic features and road crash history of both samples.

Feature	Category	Proxy-Reported (Non-Cyclists; ECBQ)		Self-Reported (Cyclists; CBQ)	
		Frequency	Percentage	Frequency	Percentage
Gender	Female	642	60.0	413	38.8
	Male	428	40.0	651	61.2
Age Group	Young Adult (≤25)	588	55.0	390	36.7
	Adult (26–50)	358	33.5	541	50.9
	Aging Adult (>50)	124	11.6	132	12.4
Education	Primary studies or lower	71	6.6	5	0.5
	Secondary-high school	230	21.5	111	10.4
	Technical studies	188	17.6	97	9.1
	University degree	477	44.6	533	50.1
	Postgraduate degree	104	9.7	318	29.9
Occupation	Unemployed	52	4.9	28	2.6
	Employee	353	33.0	417	39.2
	Independent worker	69	6.4	145	13.6
	Student	527	49.3	404	38.0
	Retired	25	2.3	7	0.7
	Householding	25	2.3	7	0.7
	Other	19	1.8	56	5.3
Traffic crashes (last 5 years)	No	960	89.7	639	60.1
	Yes	110	10.3	425	39.9

Notes for the table: ECBQ: External Rater Cycling Behavior Questionnaire (filled out by non-cyclist proxies); CBQ = Cycling Behavior Questionnaire (filled out by cyclists).

Table 2. Road safety skills (knowledge of traffic rules, risk perception, and road distractions) of the full sample, and riders' perception of their relationship with drivers and other cyclists.

Factor	Proxies		Riders		p-Value
	Mean	*SD*	Mean	*SD*	
Knowledge of traffic rules	2.82	0.83	3.08	0.71	<0.001 *
Risk perception	2.87	0.79	3.44	0.50	<0.001 *
Road distractions	4.77	1.97	4.84	1.80	0.378
I think people perceive cyclists as imprudent/reckless road users.			2.83	0.97	
I perceive drivers are hostile to cyclists.			2.72	1.13	
Bicycle riders' behaviors reflect an appropriate road safety education.			1.94	1.12	
It would be necessary to educate cyclists on how to safely ride.			3.69	0.67	

Notes for the table: Mean values of knowledge of traffic rules or regulations, risk perception, and the last four statements are expressed on a Likert scale between 0 (lowest score/agreement) and 4 (highest score/agreement). Road distractions values are obtained from a dichotomous scale (yes/no) consisting of eight questions (highest score 8 points). Significant between-group differences are displayed (*). *SD*: standard deviation.

2.3. Procedure and Instruments

Participants underwent an online-based questionnaire consisting of three sections: one enquiring about their sociodemographic features (i.e., age, gender, education level, occupation), one asking about the road safety skills of the full sample and the riders' perceptions, and one focused on obtaining the outcomes for the dependent variables (self-reported CBQ and proxy-reported ECBQ).

2.3.1. Complementary Variables

One question was included to inquire about the traffic crashes suffered by participants during the previous five years, regardless of their severity. Knowledge of traffic regulations and risk perception of all the subjects (proxies and cyclists) were measured using an adaptation of the Cyclist Risk Perception and Regulation Scale (RPRS) [14,36]. The result was a Likert scale composed of 12 items, assessing the degree of risk perceived in objective risk factors (7 questions) and the knowledge of general road regulations (5 questions) with scores between 0 (no knowledge/risk perceived) and 4 (highest knowledge/risk perceived). Road distractions, as general road users, were assessed through a dichotomous (yes/no) 8-item scale [36]. Finally, this section of the questionnaire also included four questions about the riders' perception of other road users, which were answered on a scale from 0 to 4 (see Table 2).

2.3.2. Dependent Variables: The CBQ and the ECBQ

The CBQ was specifically conceived for the self-assessment of highly risky (errors and violations) and positive (protective) riding behaviors among cyclists [11]. This test was applied in our sample of Spanish-speaking cyclists using a self-reported methodology.

For this research, this validated questionnaire was converted into a proxy-report tool consisting of the same 29 questions and 3 factors (violations, errors, and positive behaviors), which was named the External Rater CBQ (ECBQ). Regarding the specific application of the transformed instrument, the basic instruction "Estimate how often you do the following when cycling", was changed and converted into "Estimate how often you see a rider doing the following whilst riding a bicycle". The entire questionnaire followed a 5-level, frequency-based Likert scale: 0 = never; 1 = hardly ever; 2 = sometimes; 3 = frequently; 4 = almost always, just like the original version of the CBQ.

2.4. Data Processing

All the statistical procedures were performed using the IBM SPSS Statistics for Macintosh (Version 26.0; IBM Corp., Armonk, NY, USA), while statistical power analyses were carried out with the software G*Power (Version 3.1.9.6; [35]). First, a basic data curation was carried out to perform descriptive-analytic procedures on the sample features and the scoring of the questionnaires. The data were ordinal and did not meet the assumption of normality with the Kolmogorov–Smirnov test; however, given the considerably big sample size and that the parametric tests are largely robust to violations of normality, the following analyses were carried out:

A one-way analysis of variance (ANOVA) with the Bonferroni correction was used to assess differences between the proxies and riders in each one of the 29 items. Afterward, between-group analyses (ANOVA and Brown-Forshyte's robust tests for mean differences) were carried out: (*i*) for the overall (aggregate) score of each dimension of cyclists' behavior (i.e., violations, errors, and positive behaviors) between cyclists and non-cyclists, and (*ii*) evaluating differences in these regards between genders and age groups of respondents. Effect size (ES) was evaluated with eta partial squared (ηp^2), where $0.01 < \eta p^2 < 0.06$ constitutes a small effect, $0.06 \leq \eta p^2 \leq 0.14$ constitutes a medium effect, and $\eta p^2 > 0.14$ constitutes a large effect. The post hoc testing for the age group was also applied using the Bonferroni adjustment. Considering the disproportional number of subjects in each group (gender and age groups; see Table 1), the sample was weighed and rebalanced without

affecting the means, standard deviations/errors, or confidence intervals of the contrasted variables.

Moreover, bivariate correlation analysis (Pearson's *r*) analyzed the association between pairs of variables (age and road safety skills). The cutoff criteria or significance level for this study was uniformly established at $p < 0.05$.

3. Results

3.1. Behavioral Questionnaire Outcomes (ECBQ and CBQ)

The comparison of the results of the cyclists and the non-cyclists in each of the three dimensions of the test (i.e., violations, errors, and positive behaviors) are displayed in Table 3. Item-based values and significant differences in perceived cycling behavior between external raters and riders can be seen in Table 4. It is worth highlighting that highly significant differences existed between both groups in the aggregate scores of each dimension, with Violations: mean difference (m.d.) 1.01, 95% CI [0.96–1.07], F (1, 2133) = 1269.32, $p < 0.001$, $\eta p^2 = 0.37$; Errors: m.d. 1.01, 95% CI [0.96–1.07], F (1, 2133) = 1321.04, $p < 0.001$, $\eta p^2 = 0.38$; Positive Behaviors: m.d. 1.24, 95% CI [1.29–1.18], F (1, 2133) = 1663.70, $p < 0.001$, $\eta p^2 = 0.44$. Also, significant differences existed in all the test items with effect sizes (ηp^2) ranging from 0.043 to 0.437.

Table 3. Mean (*M*), standard deviation (*SD*), and 95% confidence interval (CI) of the three factors of the ECBQ and CBQ.

	Factor	Proxy-Reported ECBQ				Self-Reported CBQ				Mean Differences (ANOVA)		
		M	*SD*	*95% CI*		*M*	*SD*	*95% CI*		F	Sig.	ηp^2
				Lower	*Upper*			*Lower*	*Upper*			
1	Traffic Violations	1.70	0.77	1.66	1.75	0.69	0.51	0.66	0.72	1269.32	<0.001 ***	0.373
2	Riding Errors	1.53	0.81	1.48	1.58	0.52	0.40	0.49	0.54	1321.04	<0.001 ***	0.383
3	Positive Behaviors	1.88	0.52	1.83	1.92	3.11	0.63	3.08	3.15	1663.70	<0.001 ***	0.438

Notes for the table: Mean values are expressed on a scale between 0 and 4. ***: statistically highly significant difference with a large effect size; F: statistic value of the ANOVA; Sig.: significance; ηp^2: partial eta squared as a measure of the effect size (small effect: $0.01 < \eta p^2 < 0.06$; medium effect: $0.06 \leq \eta p^2 \leq 0.14$; large effect: $\eta p^2 > 0.14$). ECBQ: External rater Cycling Behavior Questionnaire (CBQ).

Table 4. Item content, the factor the item belongs to, mean (*M*), standard deviation (*SD*), and reliability of the ECBQ and CBQ.

Factor	#	Component	Proxy-Reported ECBQ		Self-Reported CBQ		Mean Differences (ANOVA)		
			M	*SD*	*M*	*SD*	F	Sig.	ηp^2
Factor 1: Traffic Violations	1	Cycling under the influence of alcohol and/or other drugs or hallucinogens.	1.33	0.92	0.28	0.63	951.51	<0.001 ***	0.309
	2	Going against the direction of traffic (wrong way).	1.98	0.99	0.88	0.87	743.85	<0.001 ***	0.259
	3	Zigzagging between vehicles when using a mixed lane.	1.91	1.12	0.67	0.98	746.32	<0.001 ***	0.259
	4	Handling potentially obstructive objects while riding a bicycle (food, packs, cigarettes . . .).	1.51	1.09	0.39	0.69	810.74	<0.001 ***	0.276
	5	Going at a higher speed than they should be going at.	1.99	1.12	1.06	1.02	397.53	<0.001 ***	0.157
	6	Crossing what appears to be a clear crossing, even if the traffic light is red.	2.19	1.10	1.59	1.29	132.99	<0.001 *	0.059
	7	Carrying a passenger on the bicycle without it being adapted for such a purpose.	1.54	1.05	0.31	0.69	1020.96	<0.001 ***	0.324
	8	Having a dispute in speed or "race" with another cyclist or driver.	1.17	1.07	0.36	0.74	411.03	<0.001 ***	0.162

Table 4. *Cont.*

Factor	#	Component	Proxy-Reported ECBQ		Self-Reported CBQ		Mean Differences (ANOVA)		
			M	*SD*	*M*	*SD*	F	Sig.	ηp^2
Factor 2: Errors	9	Crossing the street without looking properly, making another vehicle brake to avoid a crash.	1.68	1.07	0.53	0.67	877.19	<0.001 ***	0.292
	10	Colliding (or being close to it) with a pedestrian or another cyclist while cycling distractedly.	1.25	1.02	0.26	0.51	815.04	<0.001 ***	0.277
	11	Braking suddenly and be close to causing an accident.	1.50	1.02	0.57	0.72	597.00	<0.001 ***	0.219
	12	Failing to notice the presence of pedestrians crossing when turning.	1.84	1.09	0.47	0.67	1223.21	<0.001 ***	0.365
	13	Not braking on a "Stop" or "Yield" sign and being close to colliding with another vehicle or pedestrian.	2.07	1.13	0.41	0.71	1652.83	<0.001 ***	0.437
	14	Braking very abruptly on a slippery surface.	1.54	1.01	0.64	0.77	532.15	<0.001 ***	0.200
	15	While being distracted, not realizing that a pedestrian intended to cross a crosswalk and so not stopping to let him or her do so.	1.68	1.04	0.57	0.72	822.76	<0.001 ***	0.278
	16	Not realizing that a vehicle that was parked intends to leave and having to brake abruptly to avoid colliding with it.	1.67	1.07	0.86	0.87	368.19	<0.001 ***	0.147
	17	When driving on the right, not realizing that a passenger is getting out of a vehicle or bus and are close to hitting him or her.	1.71	1.03	0.63	0.81	724.08	<0.001 ***	0.254
	18	Trying to overtake a vehicle that had previously used its indicators to signal that it was going to turn, having to brake.	1.60	1.09	0.31	0.62	1128.22	<0.001 ***	0.346
	19	Misjudging a turn and hitting something on the road or being close to losing balance (or falling).	1.22	1.01	0.64	0.76	225.71	<0.001 **	0.096
	20	Unintentionally, hitting a parked vehicle.	1.20	1.03	0.32	0.60	581.03	<0.001 ***	0.214
	21	Failing to be aware of the road conditions and therefore falling over a bump or hole.	1.32	1.02	0.92	0.84	96.27	<0.001 *	0.043
	22	Mistaking one traffic signal for another and maneuvering according to the latter.	1.22	1.02	0.22	0.53	802.93	<0.001 ***	0.274
	23	Trying to brake but not being able to use the brakes properly due to poor hand positioning.	1.41	1.06	0.42	0.68	669.02	<0.001 ***	0.239
Factor 3: Positive Behaviors	24	Stopping and looking at both sides before crossing a corner or intersection.	1.77	1.04	3.33	0.93	1341.42	<0.001 ***	0.386
	25	Trying to move at a prudent speed to avoid sudden mishaps or braking.	1.78	0.98	3.08	0.95	971.68	<0.001 ***	0.313
	26	Keeping a safe distance from other cyclists or vehicles.	1.72	1.02	3.09	0.95	1035.99	<0.001 ***	0.327
	27	When using the bike path (or bike lane), always using the indicated lane.	2.07	1.04	3.49	0.85	1188.96	<0.001 ***	0.358
	28	Avoid cycling under adverse weather conditions.	2.00	1.01	2.75	1.14	255.70	<0.001 **	0.107
	29	Avoid cycling if feeling very tired or sick.	1.94	0.99	2.95	1.13	478.67	<0.001 ***	0.183

Notes for the table: Mean values are expressed on a scale between 0 and 4. *: statistically highly significant differences with a small effect size; **: statistically highly significant difference with a medium effect size; ***: statistically highly significant difference with a large effect size; F: statistic value of the ANOVA; Sig.: significance; ηp^2: partial eta squared as a measure of the effect size (small effect: $0.01 < \eta p^2 < 0.06$; medium effect: $0.06 \leq \eta p^2 \leq 0.14$; large effect: $\eta p^2 > 0.14$). ECBQ: External rater Cycling Behavior Questionnaire (CBQ).

3.2. Internal Consistencies

Cronbach's Alpha (α) estimates were all above the criteria established in the psychometric literature of $\alpha = 0.700$ criterion, which indicates adequate internal reliability. Moreover, numerous expert sources suggest the use of the Composite Reliability Index as a second coefficient for supporting the internal reliability of factors, as a reliability measurement alternative to the Cronbach's Alpha, which may be biased, especially in the case of short or novel scales [37–39]. In this sense, the composite reliability indices (CRIs) had very satisfying reliability values for all the three latent constructs measured through the questionnaire.

Specifically, the reliability and consistency indices obtained for the three factors considered in the study were:

Traffic violations: CRI = 0.845, α = 0.876 (ECBQ); CRI = 0.798, α = 0.703 (CBQ).
Riding errors: CRI = 0.810, α = 0.953 (ECBQ); CRI = 901, α = 0.851 (CBQ).
Positive Behaviors: CRI = 0.893, α = 0.843 (ECBQ); CRI = 0.868, α = 0.705 (CBQ).

3.3. Between-Group Comparisons

The sample was divided by gender and by age groups to perform comparisons, as previously reported in Section 2.4. The mean values and the ANOVA results can be found in Table 5. No effect of gender or age was observed in the ECBQ (all $p > 0.05$). On the other hand, gender was found to be a determinant factor ($p < 0.05$) in the self-reported traffic violations and protective behaviors. Specifically, male cyclists reported committing more violations and performing fewer protective behaviors. Similar results (significant differences) were found for the case of age-based analyses in the three dimensions of the CBQ, with the young cyclists committing more violations and errors, and fewer protective behaviors. The aging adults reported being the most well-behaved group committing fewer traffic violations and riding errors and performing more positive/protective behaviors.

Table 5. Gender and age-based differences in CBQ and ECBQ factors.

Study Variable	Factor		Group	N	Mean	SD	95% CI for Mean		Mean Dif. [4]	
							Lower	Upper	F	Sig.
F1: Traffic Violations	Gender	Proxied (ECBQ)	Female	642	1.67	0.79	1.61	1.74	2.26	0.133
			Male	428	1.75	0.75	1.68	1.82		
		Self-reported (CBQ)	Female	413	0.52	0.41	0.48	0.56	94.19	0.000 *
			Male	651	0.80	0.53	0.76	0.84		
	Age	ECBQ	Young adults	588	1.71	0.73	1.65	1.77	2.02	0.133
			Adults	358	1.74	0.83	1.65	1.82		
			Aging adults	124	1.57	0.83	1.42	1.72		
		CBQ	Young adults	390	0.83 [2,3]	0.52	0.78	0.88	40.35	0.000 *
			Adults	541	0.66 [3]	0.40	0.62	0.70		
			Aging adults	132	0.43	0.37	0.37	0.49		
F2: Riding Errors	Gender	ECBQ	Female	642	1.54	0.83	1.48	1.60	0.27	0.604
			Male	428	1.51	0.80	1.44	1.59		
		CBQ	Female	413	0.49	0.40	0.46	0.53	2.36	0.125
			Male	651	0.53	0.41	0.50	0.56		
	Age	ECBQ	Young adults	588	1.55	0.78	1.49	1.61	1.37	0.255
			Adults	358	1.53	0.86	1.44	1.62		
			Aging adults	124	1.42	0.80	1.28	1.56		
		CBQ	Young adults	390	0.60 [2,3]	0.39	0.56	0.64	13.98	0.000 *
			Adults	541	0.48	0.41	0.45	0.51		
			Aging adults	132	0.44	0.38	0.37	0.50		
F3: Positive Behaviors	Gender	ECBQ	Female	642	1.90	0.78	1.84	1.96	1.35	0.246
			Male	428	1.85	0.72	1.78	1.92		
		CBQ	Female	413	3.30	0.58	3.24	3.36	62.93	0.000 *
			Male	651	3.00	0.64	2.95	3.05		
	Age	ECBQ	Young adults	588	1.86	0.73	1.81	1.92	0.40	0.671
			Adults	358	1.88	0.79	1.80	1.97		
			Aging adults	124	1.93	0.81	1.79	2.08		
		CBQ	Young adults	390	3.00 [2,3]	0.59	2.94	3.06	16.91	0.000 *
			Adults	541	3.13 [3]	0.65	3.08	3.19		
			Aging adults	132	3.35	0.60	3.25	3.46		

Notes for the table: Mean values are expressed on a scale between 0 and 4. Disproportional groups were weighted for the age and gender comparative analyses. *: statistically significant differences between groups; CI = 95% Confidence Interval for the Mean; [2,3]: statistically significant differences with group 2 (adults) or 3 (aging adults), respectively. ECBQ: External Rater Cycling Behavior Questionnaire (CBQ); [4] Brown-Forsythe (robust mean comparison test score).

3.4. Correlation Analyses

The correlation analysis of the study has shown interesting and significant Pearson's association coefficients between the pairs of variables included in the study. Specifically, significant positive associations were found between the knowledge of traffic rules and all the three dimensions of the ECBQ and the positive behaviors in the CBQ. In turn, the knowledge of traffic rules was negatively associated with violations and errors in the CBQ. Also, it is worth highlighting the correlation between the risk perception and the violations and errors; while in the ECBQ both variables are positively correlated, in the CBQ they show a negative correlation. The full set of correlations and the significance levels are shown in Table 6.

Table 6. Bivariate correlations among study variables.

		ECBQ					
		2	**3**	**4**	**5**	**6**	**7**
1	Age (years)	−0.075 *	0.023	0.034	−0.049	−0.059	0.031
2	Knowledge of Traffic Rules	–	0.622 **	−0.069 *	0.183 **	0.146 **	0.084 **
3	Risk Perception		–	0.058	0.199 **	0.185 **	0.047
4	Road Distractions			–	0.107 **	0.154 **	−0.026
5	Traffic Violations				–	0.781 **	−0.207 **
6	Errors					–	−0.133 **
7	Positive Behaviors						–
		CBQ					
		2	**3**	**4**	**5**	**6**	**7**
1	Age (years)	0.362 **	0.244 **	0.151 **	−0.284 **	−0.143 **	0.186 **
2	Knowledge of Traffic Rules	–	0.350 **	−0.026	−0.174 **	−0.285 **	0.276 **
3	Risk Perception		–	0.057	−0.211 **	−0.163 **	0.366 **
4	Road Distractions			–	0.036	0.204 **	−0.030
5	Traffic Violations				–	0.469 **	−0.446 **
6	Errors					–	−0.348 **
7	Positive Behaviors						–

Notes for the table: ** Correlation is significant at 0.01 level (2-tailed); * Correlation is significant at 0.05 level (2-tailed).

4. Discussion

To the best of our knowledge, this is the first study aimed at comparing the self-reported cycling behavior and the external-rated behavior that other road users (non-cyclists) perceive in cyclists, looking forward to contributing to unveiling existing dissonances in terms of behavioral awareness and traffic interactions. For such purpose, a Behavioral Questionnaire (BQ) approach through the validated Cycling Behavior Questionnaire (CBQ) [11] and the External Rater Cycling Behavior Questionnaire (ECBQ), with three dimensions (traffic violations, errors, and positive protective behaviors) was employed [11,40,41]. This three-factor-based methodology is a key point in the promotion of safe habits through traffic regulation policies, but also by means of road safety education, and other social-based matters [42]. Before interpreting the dependent variables of the study, it is important to briefly discuss self-reported road-safety skill scores of both samples. While the cyclists reported having suffered more road crashes than non-cyclists, they showed significantly more knowledge of traffic regulations, more risk perception, and also slightly (non-significant) higher values in the road distractions scale, compared to proxies (see Table 2). Concerning the dependent variables of the study, it is worth mentioning that both questionnaires showed high within-factor reliability values, with all α above 0.70, similar to the validation of the CBQ [11]. The most notable finding of this study was that significant differences (all $p < 0.001$) were found in all 29 items and the three dimensions between the ECBQ and the CBQ (see Table 3), which confirms the first hypothesis. As it could be expected, external raters reported higher values for the traffic violations and errors and lower values for the positive behavior, in comparison to what riders reported.

Hereunder, this discussion will be developed: first, identifying the main behaviors (violations, errors, and positive) reported in both questionnaires (ECBQ and CBQ); afterward, analyzing the sociodemographic grouping variables; and finally, examining the differences between the self-and-proxy-reported behavior to extract conclusions.

4.1. What Are the Main Violations, Errors, and Protective Behaviors Identified by Riders and Non-Riders? Do They Perceive the Same?

The main traffic violations identified were the same in both the ECBQ and the CBQ (e.g., crossing with a red light, riding at a higher speed than allowed, and going against the right direction of traffic, items 6, 5, and 2, respectively). It is also worth mentioning that the behavior in which the greatest statistical difference (effect size [ηp^2] of 0.324) between the self and the proxy report was observed was carrying a passenger (item 7), and the one in which the least difference (more agreement) was found was crossing with a red light (effect size [ηp^2] of 0.059; item 6). On the other hand, the riding errors that obtained the highest punctuation in both questionnaires were different (ECBQ: not braking on a Stop, failing to notice the presence of pedestrians, and not realizing a passenger is going out of a vehicle, items 13, 12, and 17; CBQ: failing to be aware of the road conditions, not realizing that a parked vehicle intends to leave, braking on a slippery surface, and misjudging turns, items 21, 16, 14, and 19). While cyclists reported errors related to the technical aspect of riding, external raters reported errors related to the traffic circulation. The highest difference (effect size [ηp^2] of 0.437) between the self-and-proxy-reported behavior was found in item 13 (not braking on a Stop), and the minimum difference in item 21 (failing to be aware of the road conditions, effect size [ηp^2] of 0.043). Finally, the main positive behavior reported by both groups (riders and external raters) was riding on the indicated line of the bike path. However, while the external raters reported avoiding riding under adverse conditions or feeling sick as the other main observed behaviors, riders reported looking at both sides before crossing, keeping a safe distance, and moving at a prudent speed. The behavior in which the greatest disagreement (effect size [ηp^2] of 0.386) between both groups was found was stopping and looking at both sides before crossing (item 24), and the one in which the least disagreement (effect size [ηp^2] of 0.107) was found was avoiding cycling under adverse weather conditions (item 28).

It could be understood that those items in which further agreement is found are actually the more performed behaviors, and therefore it would be of great interest for authorities to consider them to promote road safety policies aimed at diminishing (violations and errors) or enhancing (positive behaviors) these behaviors.

4.2. The Gender and Age of the External Rater Do Not Influence the Behavior They Perceive in Cyclists

No influence of the subjects' age or gender was observed when they acted as proxies (see Table 4). On the other hand, these sociodemographic factors had been previously found to determine self-reported behaviors [11]. This dissonance in the influence of sociodemographic factors in the results of the ECBQ and CBQ may be due to behavioral differences between sexes and ages. Previous expert literature has found differences in the behaviors and cycling performance of subjects from different gender and age groups [43–48]. However, no previous reference to the influence of age or gender on the road perceived behavior has been found in the literature. Our results, that found no significant differences between the groups of proxies, imply that the cyclists' behavior is perceived similarly in subjects of different age or gender, and thus, this kind of proxy-reported questionnaire could be applied in different populations groups without the need for filtering by these sociodemographic variables.

4.3. Influence of Road Safety Skills (Knowledge of Traffic Rules, Risk Perception, Road Distractions) on the Perceived Behavior

Through the correlational analyses (Table 5) it could be observed that, while the proxies with higher knowledge of traffic regulations identify more violations, errors, and positive

behaviors, the cyclists with higher knowledge of traffic rules commit fewer violations and errors and perform more positive behaviors. The proxies with higher risk perception and more road distractions reported higher violations and errors, but not positive behaviors. In turn, the cyclists with higher risk perception reported performing fewer violations and errors, and more positive behaviors. It is also interesting that non-cyclist proxies perceiving that cyclists commit more violations also tend to believe they commit more errors—that unlike violations are involuntary—and fewer positive behaviors, similarly to that observed among cyclists self-rating their cycling behavior through the CBQ. This could suggest that there might be both a "profile" of non-cyclist (rater) perceiving that cyclists do not behave appropriately, and a profile of rider who—actually—do not behave appropriately, an idea that would be interesting to explore in a further study. These findings are in accordance with the four questions answered by the cyclists (see Table 2), in which it could be seen that cyclists also perceive that the behavior performed by the other cyclists needs to improve.

All these behavioral dichotomies could be explained by a higher awareness of what is positive and/or hazardous for safe trips and highlight the need for implementing road safety education policies to create well-behaved cyclists and improve the perception other road users have of them, therefore enhancing harmonious road interactions with cyclists.

4.4. Assessing the Usefulness of Proxies/External Raters for Cycling Behavior and Road Safety

It is important to bear in mind that we have not assessed the reliability between the proxy-reported behavior of a particular sample of cyclists and their actual behavior. Conversely, we asked a sample of non-cyclists about the behavior they perceive in cyclists they have interacted with. There is some controversy on the use of proxies in different specific research areas such as healthcare, with some studies supporting their use [25–27] and others standing against [49]. Concerning road safety, family members and caregivers have been identified as reliable proxies [29,31,32]. However, no previous research has tested the reliability of proxies non-directly related to the cyclists. Bearing in mind our study's results, and all the aforementioned scientific factors, we could say that a sample of indirect proxies is not able to concur with the behavior of the population of Spanish cyclists. Therefore, future studies should determine whether the riders and the proxies are reflecting the actual behavior of cyclists on the road.

What is particularly interesting from this study is the dissonance in the self-and-proxy-reported behaviors of cyclists from two representative samples of the Spanish General Census (i.e., cyclists and non-cyclists; see Section 2.2). This entails a serious risk for a friendly congruous traffic environment as desired by traffic authorities.

4.5. Limitations of the Study

Even though all the procedures carried out in this study were carefully designed and supervised by an instructed team, there are some limitations that should be listed. Firstly, in regard to the sample, it is important to say that the proxies were not directly rating the behavior of the sample of cyclists, but instead rating the behavior of all the cyclists they had interacted with. The questionnaires were applied in a Spanish-speaking population and a Spanish population, and thus the conclusions should not be extrapolated to different cultures or countries.

5. Conclusions

This study used, for the first time, standardized behavioral questionnaires for assessing cycling risky and positive road behaviors from two different points of view: bicycle riders and external/proxy non-cyclist raters. The results obtained in this study highlight that the self-reported and the external-rated behavior greatly differ in terms of all the three core dimensions of the CBQ paradigm: traffic violations and riding errors (respectively, deliberate and undeliberate risky behaviors) and positive behaviors. Specifically, the external raters (i.e., non-cyclists) identified significantly more risky behaviors (violations and errors) and less positive protective behaviors in comparison to those self-reported

by cyclists. These dissonances in the reported behaviors may condition the interaction between bicycle riders and other road users, but also might contribute to target key issues in terms of behavioral awareness and road user interaction. The results provided by this study highlight the need for strengthening the cyclists' awareness of key aspects of safe riding, from two dimensions: (*i*) their own assessment of their actual behavior—that could be biased by individual and social factors; and (*ii*) how other non-cyclist road users perceive the cyclists' behavior (ECBQ). This was done in order to strengthen a road safety culture that involves a safer interaction among road users. In other words, creating an appropriate road environment for all road users, especially for those who are more vulnerable, would not only facilitate road interactions, but might potentially foster the choice of healthier and sustainable transportation means, whose main exponent worldwide is, clearly, the bicycle.

Future Work

To the best of our knowledge, this is the first study comparing the self-and-proxy-reported behavior of cyclists. The study has been carried out with a carefully designed methodology, in order to establish a foundation for future studies approaching the behavioral interaction between cyclists and other road users, and aiming at improving their road safety, as well as the safety of other vulnerable road users. In this regard, this study should be replicated in different countries/cultures and contexts (e.g., other understudied road users, such as electric-scooter riders). Also, it would be of great interest to relate the findings of this study with other road safety key issues such as road disputes, compliance with traffic rules, and road safety education of specific groups of road users whose necessities may differ. Another interesting study line that could be raised following the results of this study could be differentiating the perceptions between the type of road users (e.g., pedestrian, car/bus/truck drivers, motorcycle riders) and/or the type of road (e.g., urban or inter-urban) in which the interaction is rated. This comparison may enlighten traffic authorities with further specific data on problematic road interactions between cyclists and other road users in different contexts.

Furthermore, and bearing in mind that there exist differences in the self-reported behavior of cyclists between genders and age groups, it could be of great interest to enquire with the external raters about the specific behavior they perceive in cyclists depending on their gender and/or age group.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author (S.A.U.), upon reasonable request.

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