Transportation Research Part F: Psychology and Behaviour 91 (2022) 386–400

Contents lists available at ScienceDirect

Transportation Research Part F: Psychology and Behaviour

journal homepage: www.elsevier.com/locate/trf

Cross-culturally approaching the cycling behaviour questionnaire (CBQ): Evidence from 19 countries

Sergio A. Useche [a,*], Francisco Alonso [a], Aleksey Boyko [b], Polina Buyvol [b], Isaac Castañeda [c], Boris Cendales [d], Arturo Cervantes [c], Tomas Echiburu [e], Mireia Faus [a], Zuleide Feitosa [f], Javier Gene [a], Adela Gonzalez-Marin [g], Victor Gonzalez [h], Jozef Gnap [i], Mohd K. Ibrahim [j], Kira H. Janstrup [k], Arash Javadinejad [a], Irijna Makarova [b], Rich McIlroy [l], Miroslava Mikusova [i], Mette Møller [k], Sylvain Ngueuteu-Fouaka [m], Steve O'Hern [n], Mauricio Orozco-Fontalvo [o], Ksenia Shubenkova [b], Felix Siebert [k], Jose Soto [e], Amanda N. Stephens [p], Raquel Valle-Escolano [a], Yonggang Wang [q], Ellias Willberg [r], Phillip Wintersberger [s], Linus Zeuwts [t], Zarir H. Zulkipli [h], Luis Montoro [a]

[a] *University of Valencia, Valencia, Spain*
[b] *Kazan Federal University, Kazan, Russia*
[c] *Anahuac University, Mexico*
[d] *El Bosque University, Bogotá, Colombia*
[e] *Universidad Católica de Chile, Santiago, Chile*
[f] *Universidade de Brasilia, Brasilia, Brazil*
[g] *University Center of Defense, Murcia, Spain*
[h] *INTEC Technological Institute, Santo Domingo, Dominican Republic*
[i] *University of Žilina, Bratislava, Slovakia*
[j] *Malaysian Institute of Road Safety Research, Kajang, Malaysia*
[k] *Technical University of Denmark, Copenhague, Denmark*
[l] *University of Southampton, Southampton, England*
[m] *Université de Dschang, Dschang, Cameroon*
[n] *Tampere University, Tampere, Finland*
[o] *Universidade de Lisboa, Lisboa, Portugal*
[p] *Monash University, Melbourne, Australia*
[q] *Chang'an University, Chang'an, China*
[r] *University of Helsinki, Helsinki, Finland*
[s] *Technical University of Wien, Wien, Austria*
[t] *Ghent University, Ghent, Belgium*

ARTICLE INFO

Keywords:
Urban cycling
Riding behaviour
Behavioural questionnaires
CBQ
Cycling safety
Regions

ABSTRACT

Given different advances in applied literature, risky and positive behaviours keep gaining ground as key contributors for riding safety outcomes. In this regard, the Cycling Behaviour Questionnaire (CBQ) represents one of the tools available to assess the core dimensions of cycling behaviour and their relationship with road safety outcomes from a behavioural perspective. Nevertheless, it has never been psychometrically approached through a cross-cultural perspective. Therefore, this study aimed to perform the cross-cultural validation of the CBQ, examining

* Corresponding author.

https://doi.org/10.1016/j.trf.2022.10.025
Received 8 February 2022; Received in revised form 29 September 2022; Accepted 30 October 2022
Available online 5 November 2022
1369-8478/

its psychometric properties, reliability indexes, validity insights and descriptive scores in 19 countries distributed across five regions: Europe, America, Asia, Africa, and Oceania. For this purpose, it was used the data retrieved from a full sample of 7,001 urban cyclists responding to a large-scale electronic survey. Participants had a mean age of $M = 36.15$ ($SD = 14.71$), ranging between 16 and 83 years. The results of this large-scale study empirically support the assumption that the 29-item version of the CBQ has a fair dimensional structure and item composition, good internal consistency, reliability indexes, and an interesting set of validity insights. Among these results, there can be highlighted that: (*i*) Structurally speaking, the questionnaire works better under a three-factor dimensionality, keeping all its 29 items, whose factor loadings are >0.400 in

Table 1
Previously published studies analysing structural, reliability and validity-related features of the Cycling Behaviour Questionnaire.

Citation	Sample	Region(s)	CBQ subscales applied	Reliability indexes	Validity insights
(Useche, Montoro, Tomas, & Cendales, 2018a) (Useche et al., 2018b) (Useche et al., 2019a)	1,064 cyclists aged between 16 and 80 years.	Americas and Europe	(F1) Traffic Violations (F2) Errors (F3) Positive Behaviours	Cronbach's alphas ranged between 0.703 (F1) and 0.850 (F2). CRIs ranged between 0.798 (F1) and 0.901 (F1)	CBQ shows a suitable factor structure and internal consistency through different analysis methods, including competitive CFA[1], SEM[2], and MGSEM[3]. In terms of concurrent validity, the test has shown to differentiate well according to demographic and cycling-related differences.
(Useche et al., 2019b)	911 cyclists aged between 17 and 79 years.	Central and South America	(F1) Traffic Violations (F2) Errors (F3) Positive Behaviours	Cronbach's alphas ranged between 0.645 (F3) and 0.901 (F2).	The CBQ shows a reasonably good set of validity insights, including coherent correlations with crash-related factors and the discriminant ability for age group and cycling frequency.
Zheng et al. (2019)	628 cyclists aged between 15 and 59 years	Asia	(F1) Traffic Violations (F2) Errors	Cronbach's alphas ranged between 0.700 (F1) and 0.850 (F2).	The first two factors of the CBQ (i.e., risky behaviour) show reasonable and significant and associations with personality traits: sensation-seeking, normlessness, impulsiveness, and cycling anger. PCA4 endorses its hypothesized structure for the factors measured.
(O'Hern, Estgfaeller, Stephens, & Useche, 2021)	1,102 riders ranging 18–80 years	Oceania	(F1) Traffic Violations (F2) Errors (F3) Positive Behaviours	Cronbach's alphas ranged between 0.650 (F3) and 0.860 (F2).	Multivariate analyses (MANCOVA[5]) allowed for the establishment of coherent associations among CBQ factors and riders' self-reported crash likelihood.
(Useche et al., 2021a)	577 cyclists over 18 years	Central and South America	(F1) Traffic Violations (F2) Errors (F3) Positive Behaviours	Cronbach's alphas ranged between 0.702 (F3) and 0.841 (F2).	Multi-group SEM (MGSEM) analyses allowed to determine significant structural differences, endorsing the influence of the reason(s) for cycling on-road behaviour and self-reported crashes.
(Useche et al., 2021b)	1,897 cyclists ranging between 18 and 81 years; mean age of 41.1 years	Europe	(F1) Traffic Violations (F2) Errors (F3) Positive Behaviours	Cronbach's alphas ranged between 0.603 (F3) and 0.782 (F2). CRIs ranged between 0.867 (F3) and 0.978 (F1)	EFA/CFA and SEM analyses allowed to determine that the three-dimensional structure of the CBQ was sensitive to age and gender-based differences. A strong convergent validity was also found to a set of factors, including age, trait anger, and cycling anger-related expressions.
(Useche, Gene-Morales, Siebert, Alonso, & Montoro, 2021d)	2,134 participants: 1,064 cyclists (mean age of 32.8 years) and 1,070 non-cyclists (mean age of 30.8 years) between 16 and 79 years	Americas and Europe	(F1) Traffic Violations (F2) Errors (F3) Positive Behaviours	Cronbach's alphas ranged between 0.703 (F1) and 0.953 (F2). CRIs ranged between 0.798 (F1) and 0.901 (F1)	Both CBQ versions have shown good concurrent validity insights, especially as for their correspondence with gender and age-based groups.
(Li et al., 2021)	1,094 cyclists ranging between 17 and 79 years; mean age of 31.8 years	Asia, Oceania and South America	(F1) Traffic Violations (F2) Errors (F3) Positive Behaviours	Cronbach's alphas ranged between 0.651 (F3) and 0.805 (F2). CRIs ranged between 0.887 (F3) and 0.993 (F2)	This study endorsed the hypothesised structure of the CBQ through a three-factor model, finding good-to-optimal goodness-of-fit (GOF) indices and convergent validity with cyclists' demographic factors.

Notes for the table: [1]EFA/CFA = Exploratory/Confirmatory Factor Analyses; [2]SEM = Structural Equation Modelling; [3]MGSEM = Multigroup Structural Equation Modelling; [4]PCA = Principal Component Analysis; [5]MANCOVA = Multiple Analysis of Covariance.

all cases; (*ii*) The CBQ shows greater reliability indexes than in previous applications using smaller samples, with good Cronbach's alphas [0.768 - 0.915], McDonald's omegas [0.770 - 0.913] and Composite Reliability Indexes [981 - 0.994]; and (*iii*) Robust tests comparing riding behaviours of riders with different levels of risk perception and crash involvement support the concurrent validity of the Cycling Behaviour Questionnaire. These outcomes endorse the usefulness of the CBQ to assess both risky and positive riding behaviours of cyclists in different countries, contributing to assess and improve cycling safety from the human factors approach.

1. Introduction

Decades of applied research endorses the assumption that active transportation is, perhaps, the best way to harmonize daily life demands, mental and physical health needs and sustainability challenges in urban scenarios (Doğru, Webb & Norman, 2021; Green, Sakuls & Levitt, 2021). Accordingly, and surprisingly enhanced by the need for social distancing that the recent COVID-19 pandemic has supposed worldwide, cycling keeps growing in many cities (Buehler & Pucher, 2021).

Said otherwise, one of the current challenges for many policymakers is knowing if, apart from achieving a greater demand, it is possible to make tangible cycling an opportunity to develop more efficient, inclusive and environmentally friendly mobility on a global scale (Büchel, Marra & Corman, 2022; Tirachini & Cats, 2020). There is, at the very least, potential: besides aligning with the current United Nations' Sustainable Development Goals for 2030 (SDGs), stimulating active transportation by promoting greater use of bicycles has been forecasted to imply several mid-and long-term benefits for public health in the near future (Kahlmeier et al., 2021).

However, risky behaviours of both cyclists and other road users remain a key issue that endangers riding safety and security (de Hartog, Boogaard, Nijland & Hoek, 2010; Kummeneje & Rundmo, 2020). Previous studies have also highlighted that, although cycling is overall highly accepted as a healthy means of transport with a beneficial value for mobility, sustainability and users' economy (Banerjee, Łukawska, Jensen & Haustein, 2021; Handy, van Wee & Kroesen, 2014), individual willingness to cycle can decrease for different reasons. Some of these issues commonly found in the literature are: difficult weather conditions (Iwińska et al., 2018), road conflicts and near misses with other users, especially drivers (Aldred, 2016; Møller & Haustein, 2017), poor infrastructures and/or lack of separation from motor traffic (Aldred et al., 2017), helmet-related constraints (Pucher & Buehler, 2007; Walker, 2007), and urban insecurity (Useche et al., 2019c). However, safety-related threats commonly stand out, especially in countries where 'cycling tradition'or bicycle-friendly cultures are relatively scarce (Thomas & DeRobertis, 2013). Consequently, studying and improving the road behaviour of cyclists is necessary to improve their safety and define cycling as a sustainable and attractive means of transport worldwide.

The CBQ as a behavioural tool for assessing riding behaviour.

During the last decade, different scientific initiatives have aimed to approach the safety of road users from a behavioural perspective, considering that a better understanding of their road behaviour could be an appropriate starting point to develop interventions with a higher user and context-related knowledge (Vuori, 2011). Indeed, a recent systematic review found that intervention strategies focused on improving cyclists' behavioral issues tend to be the most effective, even over those improving infrastructures or physical environments (Doğru, Webb & Norman, 2021). In other words, a greater understanding of users' behavioral features could be expected to help depict the influence of these behaviors on certain safety outcomes, making it possible to develop more effective actions aimed at preventing crashes, injuries and fatalities involving them (Beck et al., 2016; Prati et al., 2017; Useche, Alonso, Montoro & Esteban, 2018c).

Among these initiatives, the development and validation of self-report questionnaires stand out, which is in relative growth. Particularly, the Cycling Behaviour Questionnaire (CBQ) (Useche, Montoro, Tomas, & Cendales, 2018a) has proved, through different previous applications, to be a psychometrically valid, reliable and useful questionnaire-based tool to address cycling behaviours and their relationships to demographic, psychosocial and crash-related variables. Table 1 presents a synthesis of the main published studies using the CBQ in the last five years.

However, despite being previously applied in many countries and languages, the CBQ has never been psychometrically approached from a cross-cultural perspective until now.

The three-factor structure of the CBQ.

The CBQ operationalises risky cycling behaviours using the typical error-violation taxonomy proposed by Reason et al. (1990) for the Driving Behaviour Questionnaire (DBQ). In this questionnaire, the key feature allowing to differentiate between risky (also called 'aberrant') road behaviours is their intentionality/unintentionality, even though sometimes both can be in the same action sequence (Reason et al., 1990). In addition, following the preceding work of Özkan & Lajunen (2005) in the case of motor drivers, the CBQ introduced the idea of evaluating 'positive' road behaviours (intended protective habits and comportments) for the first time, in order to: (*i*) assess their relationship with errors and violations; (*ii*) test the questionnaire's concurrent validity with third variables; and (*iii*) provide complementary evidence to the role of cyclists' behavioural features over the crashes they self-report (Useche, Montoro, Tomas, & Cendales, 2018a).

Previous evidence on the CBQ factor structure is relatively consistent. In particular, violation (8 items) and error (15 items) dimensions have been endorsed by both exploratory (EFA), and confirmatory (CFA) factor analyses with relatively high factor loadings and percentages of variance explained (Li et al., 2021; Useche, Esteban, Alonso, & Montoro, 2021a; Useche, Montoro, Tomas, & Cendales, 2018a), while the positive behaviour scale can slightly vary in accordance with the context where it is applied (Useche, Alonso, Montoro, & Esteban, 2019a; Useche, Philippot, Ampe, Llamazares, & de Geus, 2021b).

Regarding the concurrent validity of the scale, the CBQ-based literature has found that risky riding behaviours are consistently associated with each other in a positive and significant way (Li et al., 2021; Zheng, Ma, Li, & Cheng, 2019). In addition, both errors and violations (i.e., regardless of behavioural intentionality) have a negative and also significant relationship to protective (or 'positive') road behaviours, which is the third factor of the scale (O'Hern, Estgfaeller, Stephens, & Useche, 2021; Useche, Alonso, Montoro, & Esteban, 2019a).

Also, evidence on demographic (mainly gender- and age-based) differences in both risky and positive cycling behaviours, has been coherently gathered in previous studies applying the CBQ. These studies have found that, overall, male cyclists of younger age (especially in the segment between 18 and 25 years) are those who usually report greater risky riding patterns and scarcer protective behavioural habits, as well as higher self-reported cycling crash rates (Li et al., 2021; O'Hern, Estgfaeller, Stephens, & Useche, 2021; Useche, Alonso, Sanmartin, Montoro, & Cendales, 2019b; Zheng, Ma, Li, & Cheng, 2019).

Nevertheless, some of these studies suggest that the mechanisms linking road behaviours with further individual factors (e.g., income level, education and main motives for cycling) may differ significantly, and their contribution to risky riding behaviours could actually vary. For instance, a recent study performed in three Latin American countries compared the structural relationships between road safety skills and risky behaviours of cycling commuters and non-commuters. The study found that psychosocial and behavioural factors might explain commuters' cycling crashes more than those suffered by riders using bikes for other purposes, such as leisure or fitness (Useche et al., 2021a).

However, apart from the aforementioned studies, little is yet known about the validity of the CBQ in a region-based perspective and whether the tool and the identified factors are comparable between different geographic and cultural contexts. Likewise, although not among countries, previous CBQ validations have used relatively discrete or disproportional samples among regions, making it impossible to comparatively assess cycling behaviours for large-scale decision-making under a cross-cultural approach.

Study objective and hypothesis.

The aim of this study was to perform and describe in detail the cross-cultural validation of the Cycling Behaviour Questionnaire (CBQ), examining both the psychometric features, fit indexes and validity insights of the CBQ in a large sample of cyclists from five regions: Europe, Oceania, Latin America, Asia and Africa.

Given the data provided by previous applications of the CBQ worldwide, it was hypothesised that the scale would present adequate psychometric issues across the five regions addressed by the study. Also, this research is expected to provide evidence on the cross-cultural validity of the scale and the relationships between cycling behaviours and riders' safety-related features in different geographical contexts.

2. Methods

2.1. Study sample

For this cross-sectional study, data was collected from 7,001 bicycle riders (38.5 % females, 60.8 % males, and 0.7% non-binary participants), aged between [16–83] with a mean of $M = 36.63$ ($SD = 14.17$) years. The research covered a total of 19 countries. Specific age descriptive data and gender distribution observed in each country and in the full sample are shown in detail in Table 2.

Table 2
Country-based age and gender descriptive data of the study participants ($n = 7{,}001$) and data collection features.

Country	Frequency	Percent	Age		Gender			Language	Data collection method
			Mean	SD	Female	Male	Other[1]		
Australia	1,104	15.8 %	50.35	12.67	29.2 %	70.1 %	0.7%	English	Qualtrics
Austria	131	1.9 %	38.40	10.21	46.6 %	51.9 %	1.5 %	German	Google forms
Belgium	342	4.9 %	40.45	12.75	60.5 %	39.5 %	0.0%	Dutch	Google forms
Brazil	226	3.2 %	38.89	11.76	50.9 %	48.7 %	0.4%	Portuguese	Google forms
Cameroon	119	1.7 %	24.77	6.58	16 %	84 %	0.0%	French	Google forms
Chile	303	4.3 %	37.42	9.37	30.4 %	69 %	0.6%	Spanish	Google forms
China	541	7.7 %	28.21	5.82	19.8 %	80.2 %	0.0%	Chinese	Wenjuanxing
Colombia	603	8.6 %	26.07	9.91	36 %	63.8 %	0.2%	Spanish	Google forms
Denmark	576	8.2 %	46.89	14.43	56.1 %	42.5 %	1.4 %	Danish	SurveyXact
Dominican Republic	386	5.5 %	24.38	10.46	35.2 %	64.2 %	0.5%	Spanish	Google forms
Finland	213	3.0 %	43.77	11.78	45.1 %	51.6 %	3.3 %	Finnish	Google forms
Germany	458	6.5 %	28.15	9.66	69 %	29.5 %	1.5 %	German	Google forms
Malaysia	183	2.6 %	45.10	10.63	9.8 %	90.2 %	0.0%	Malay	Google forms
Mexico	330	4.7 %	36.72	10.74	29.7 %	69.4 %	0.9%	Spanish	Google forms
Poland	116	1.7 %	27.79	8.25	13.8 %	86.2 %	0.0%	English; Polish	Google forms
Russia	374	5.3 %	21.61	4.87	31 %	67.6 %	1.4 %	Russian	Google forms
Slovakia	233	3.3 %	30.71	11.48	39.9 %	60.1 %	0.0%	Slovak	Google forms
Spain	335	4.8 %	33.71	14.68	41.8 %	57.9 %	0.3%	Spanish	Google forms
UK	428	6.1 %	44.74	13.18	47.7 %	51.6 %	0.7%	English	Google forms
Total	**7,001**	**100 %**	**36.63**	**14.17**	**38.5 %**	**60.8 %**	**0.7%**	–	–

Notes: [1]Non-binary ("other") participants were highly underrepresented in all countries.

2.2. Procedure and technical considerations

Data collection was performed through an electronic survey, using an online questionnaire translated to each country's most spoken language(s), as shown in the right columns of Table 2. Although the e-survey used a uniformly pre-designed questionnaire format, the platforms employed to gather the data differed in some countries. This was mainly because of convenience/institutional advice to use certain pre-paid surveying platforms (e.g., in Danish and Australian universities), or country-based unavailability/data restrictions (i.e., Google Forms is a banned platform in China).

Regarding recruitment strategies, different actions (i.e., social media advertising, classroom questionnaire-sharing, mailing lists & national cyclist federations) were performed to gather the data in all countries. Finally, no economic incentives were offered to participants of the study.

Given that the CBQ has previously been professionally translated to and tested in various languages (i.e., Chinese, Dutch, English, French, Spanish), country-based research teams directly used these questionnaire versions. However, research staff in countries speaking other languages (i.e., Finnish, German, Malay, Polish, Portuguese, Russian, Slovak) were required to translate and back-translate questionnaires prior to applying them. As all these teams were attached to universities and/or research centres, they counted on graduate experts in traffic psychology and professional translators to perform this task.

2.3. Description of the questionnaire

As mentioned above, the Cycling Behaviour Questionnaire (CBQ) (Useche, Montoro, Tomas, & Cendales, 2018a) is a self-report behavioural questionnaire addressing riding behaviours through a three-dimensional structure composed of 29 items distributed into three subscales, as described in Table 3.

Risk perception was measured through the risk perception (RP) subscale of the Risk Perception and Regulation Scale (RPRS; Useche et al., 2018b). This subscale is a 7-item Likert form ($\alpha = 0.783$) in which the degree of perceived risk towards some of the most road risk-related situations is assessed on a scale from 0 (no risk perceived) to 4 (highest risk perceived).

2.4. Data processing (statistical analysis)

Initially, a careful data curation process was carried out, allowing us to uniformly integrate the data of all 19 countries participating in the study. All the datasets were uniformly codified and subsequently checked in order to allow descriptive and comparative analyses. Basic data coding, management and labelling tasks were performed using SPSS software (version 26.0).

Factor analyses and data modelling

Once the dataset was complete, and the scales were simultaneously scored, the factorial structure of the CBQ was tested through a rigorous set of factor analysis-based procedures. An initial assessment via maximum likelihood Exploratory Factor Analysis with Promax oblique rotations (EFA; used to depict the underlying structure of the scale) allowed us to endorse the suitability of a three-factor structure for the CBQ, that was assessed in depth through competitive Confirmatory Factor Analyses (CFA) with successive fit steps (forward) and item cut-off criteria set at $\lambda = 0.400$. Precisely, confirmatory models were chosen as already-existing insights on the dimensionality of the scale and its validity in various CBQ previous applications (see Table 1). One key advantage of testing such a baseline model through competitive analyses is the possibility of assessing several models under different theoretical assumptions and hypothesised configurations so that the solution offering a better fit can be comparatively determined.

As multivariate normality constitutes a difficultly accomplishable assumption in questionnaire-based studies (neither being met with the current ordinal data), it is methodologically suggestible to use advanced procedures to avoid biased inferences over model parameters, e.g., overrating Chi-square values or lowballing standard errors. Therefore, the model was bias-corrected through a Monte Carlo (parametric) bootstrapping procedure. This resampling technique is based on the use of multiple subsamples of identical size, randomly and successively testing and retesting a certain model, thus allowing to (*i*) correct problems derived from the lack of normality and (*ii*) avoid type I (*false positive*) errors in regression paths.

Goodness-of-fit criteria

The Goodness-of-Fit of structural models was weighed by means of different (and complementary) estimators and indexes: Chi-square (χ^2), Confirmatory Fit Index (CFI), Normed Fit Index (NFI), Tucker-Lewis Index (TLI), Incremental Fit Index (IFI) and Root

Table 3
CBQ dimensional composition, including example items and internal consistency (Cronbach alpha) coefficients found in previous studies.

CBQ Subscale	Nature	N° items	Example item [a]	Cronbach (previous applications) [b]
Traffic violations	Deliberate risky cycling behaviours	8	Circulating against the traffic (wrong way)	[0.645 - 0.798]
Errors	Undeliberate risky behaviours	15	Failing to notice the presence of pedestrians crossing when turning	[0.782 - 0.851]
Positive behaviours	Protective behaviours and habits	6	Trying to move at a prudent speed to avoid sudden mishaps or braking	[0.603 - 0.729]

Notes for the Table: [a] The full-length version of the CBQ-29 is available in the Appendix of a previous CBQ paper (Useche et al., 2021a); [b] As referred in Table 1.

Mean Square Error of Approximation (RMSEA).

The satisfactory model fit cut-off criteria were CFI/NFI/TLI/IFI > 0.900 and RMSEA < 0.080, apart from its theoretical plausibleness (see Marsh, Hau & Wen, 2004). AMOS software (version 26.0) was used for specifying and estimating these models. Likewise, the suitability of the model was also evaluated using the strength and coherence of the estimates, plus the absence of large or unnecessary indices of modification.

Reliability and internal consistency

Given that Cronbach's α_s has been argued to have several flaws if used as a single reliability (internal consistency) index, both McDonald's omega (ω) Composite Reliability Index CFI were also calculated. Statistically, McDonald's ω has the benefit of accounting for item-factor correlations and item-specific measurement errors, offering more realistic scale reliability estimates (Peterson & Kim, 2013).

On the other hand, CRI is simultaneously based on lambda coefficients, residuals and critical ratios of subscales, providing a highly reliable assessment of their reliability (Padilla & Divers, 2016). All these three coefficients keep the advantage of being measured in the same [0–1] scale, making them easily comparable and interpretable.

Validity insights

Finally, the concurrent validity of the CBQ was tested by means of two Criterion Variables (CVs) supported by the literature to be related to cycling behaviour: risk perception and self-reported cycling crashes in a period of five years (see *2.3 Description of the Questionnaire* for further information). These comparisons were performed through robust mean (Brown-Forsythe) tests. Lastly, the cross-cultural validity of the CBQ was assessed by testing the final validated structure to each of the five regions covered by the study while measuring the Goodness-of-Fit of each one in comparison with the fit reported for the general model.

3. Results

3.1. Structural models

As aforementioned, two theory-based CFAs were performed with the aim of competitively assessing the factor structure of the Cycling Behaviour Questionnaire. Firstly, a bifactorial solution comprising risky (F1) and positive (F2) cycling behaviours was tested, merging errors and violations as generic risky cycling behaviours. Secondly, the three-factor solution differentiating traffic violations (F1), errors (F2) and positive behaviours (F3) was assessed. The factorial solution was noticeably inadequate compared with the latter, being the 'traditional' three-dimensional structure, previously used in other studies, the one showing better fit indexes and a reasonable adjustment to the theoretical assumptions of the scale, including the need of analysing violations and errors separately.

A close inspection of this raw three-factor model allowed us to identify a reduced set of very large modification indexes that pointed out a relevant relationship between some items and residuals. After applying these adjustments, the new simplified three-factor constrained model fitted the data reasonably well, presenting the key indices reported in Table 4.

It is also relevant to point out that, apart from presenting a much better fit to the data, the three-factor structure works well with the theoretical item composition, with factor loadings over 0.400 for all the 29 items, which also remained statistically significant even after bias-correcting (bootstrapping) the data.

Table 5 shows the content, descriptive data (average scores and standard deviations), standardized factor loadings (i.e., lambda coefficients) and significance levels of each of the items composing the CBQ. It is noticeable how all factor loadings are large, positive, and statistically significant at their correspondent factors, as also shown in Fig. 1.

3.2. Internal consistency indexes

As aforementioned, the internal consistency of the CBQ subscales was assessed through three different indexes, and all of them showed good-to-optimal values:

Cronbach's alpha estimates were all above the α = 0.700 criteria, suggesting suitable internal reliability for all scales: 0.768 for *Traffic Violations* (Factor 1); 0.914 for *Errors* (Factor 2); and 0.985 for *Positive Behaviours* (Factor 3). McDonald's omegas that can be considered directly complementary to Cronbach's alphas were all ω > 0.700, with: 0.770 for *Violations* (Factor 1); 0.913 for *Errors* (Factor 2); and 0.782 for *Positive Behaviours* (Factor 3).

Additionally, Composite Reliability Indexes (CRIs), a useful complementary assessment tool, showed optimal reliabilities for all the three latent constructs addressed by the CBQ. CRI for F1 (*Traffic Violations*) was 0.981. The CRI for F2 (*Errors*) was 0.994. Finally, CRI

Table 4
Competitive analysis-based fit indices of the structural models.

Model	X^2	df[1]	*p*	RMSEA[2]	90 % CI[3]		CFI[4]	NFI[5]	TLI[6]
					Lower	Upper			
Bifactorial solution	21715.318	376	<0.001	0.090	0.089	0.091	0.726	0.723	0.705
Three-factor baseline model	10911.873	374	<0.001	0.063	0.062	0.064	0.865	0.861	0.853
Three-factor adjusted model	4739.771	248	<0.001	0.051	0.050	0.052	0.942	0.940	0.906

Notes: [1]df = Degrees of freedom; [2]RMSEA = Root Mean Square Error of Approximation; [3]Confidence Interval for RMSEA (α = 0.010); [4]CFI = Confirmatory Fit Index; [5]NFI = Normed Fit Index; [6]TLI = Tucker-Lewis Index.

Table 5
Item-descriptive and factor composition (left) of the retained three-factor model for the CBQ. Bootstrapped bias-corrected values (right) represent resampled coefficients.

Item	Content	Factor	M[a]	SD[b]	λ[c]	S.E.[d]	C.R.[e]	*p*[f]	Bootstrap bias-corrected values[g]				
									Estimate[h]	S.E.[d]	95 % CI[i]		*p*[j]
CBQ1		Factor 1: Traffic Violations	0.50	0.826	0.511	0.023	33.974	<0.001	0.773	0.024	0.724	0.804	0.041
CBQ2			0.70	0.923	0.629	0.078	17.716	<0.001	1.376	0.130	1.168	1.61	0.008
CBQ3		CRI[k] = 0.981	0.74	1.024	0.811	0.098	20.133	<0.001	1.969	0.145	1.732	2.183	0.007
CBQ4			0.61	0.908	0.568	0.034	35.798	<0.001	1.219	0.034	1.164	1.277	0.008
CBQ5		α[l] = 0.768	1.05	1.048	0.470	0.039	30.254	<0.001	1.165	0.044	1.101	1.248	0.006
CBQ6			1.07	1.183	0.418	0.042	27.622	<0.001	1.169	0.041	1.106	1.239	0.007
CBQ7		ω[m] = 0.770	0.27	0.693	0.592	0.054	17.951	<0.001	0.969	0.104	0.782	1.147	0.011
CBQ8			0.55	0.921	0.594	0.038	33.974	<0.001	1.294	0.040	1.243	1.381	0.002
CBQ9		Factor 2: Errors	0.38	0.712	0.756	0.042	26.750	<0.001	1.121	0.076	0.964	1.218	0.019
CBQ10			0.36	0.700	0.715	0.029	31.555	<0.001	0.929	0.061	0.854	1.043	0.009
CBQ11		CRI[k] = 0.994	0.51	0.759	0.654	0.031	30.196	<0.001	0.924	0.061	0.852	1.047	0.008
CBQ12			0.46	0.743	0.710	0.032	31.126	<0.001	0.981	0.064	0.903	1.123	0.007
CBQ13		α[l] = 0.914	0.37	0.741	0.820	0.045	24.912	<0.001	1.129	0.079	1.018	1.286	0.010
CBQ14			0.73	0.893	0.583	0.033	29.191	<0.001	0.965	0.064	0.894	1.119	0.005
CBQ15		ω[m] = 0.913	0.54	0.780	0.675	0.032	30.827	<0.001	0.977	0.063	0.906	1.112	0.008
CBQ16			0.79	0.906	0.591	0.034	28.923	<0.001	0.994	0.066	0.91	1.131	0.009
CBQ17			0.56	0.856	0.607	0.051	19.054	<0.001	0.963	0.072	0.828	1.061	0.032
CBQ18			0.36	0.742	0.687	0.031	30.844	<0.001	0.946	0.063	0.874	1.078	0.007
CBQ19			0.53	0.775	0.728	0.057	18.358	<0.001	1.048	0.096	0.917	1.243	0.011
CBQ20			0.26	0.654	0.693	0.027	30.978	<0.001	0.842	0.056	0.773	0.951	0.009
CBQ21			0.75	0.895	0.535	0.053	16.912	<0.001	0.896	0.066	0.809	1.031	0.010
CBQ22			0.38	0.760	0.665	0.031	30.476	<0.001	0.946	0.064	0.863	1.077	0.008
CBQ23			0.55	0.988	0.488	0.033	26.75	<0.001	0.892	0.064	0.821	1.037	0.005
CBQ24		Factor 3: Positive Behaviours	3.09	1.177	0.451	0.017	31.224	<0.001	0.546	0.035	0.486	0.607	0.012
CBQ25			3.05	1.099	0.741	0.04	37.674	<0.001	1.524	0.058	1.447	1.648	0.007
CBQ26		CRI[k] = 0.983	3.13	1.054	0.701	0.045	31.153	<0.001	1.394	0.051	1.333	1.495	0.004
CBQ27			3.32	1.011	0.565	0.035	30.770	<0.001	1.078	0.030	1.019	1.118	0.014
CBQ28		α[l] = 0.785	2.61	1.266	0.527	0.041	30.733	<0.001	1.260	0.073	1.157	1.389	0.009
CBQ29			2.81	1.239	0.787	0.059	31.224	<0.001	1.831	0.119	1.648	2.058	0.009
		ω[m] = 0.782											

Notes: [a] Arithmetic Mean; [b] Standard Deviation; [c] Standardised factor loading; [d] Standard Error; [e] Critical Ratio; [f] All *p*-values were lower than 0.001; [g] Bootstrapped (bias-corrected) model; [h] Unstandardised estimates; [i] Confidence Interval at the level 95% (lower bound – left; upper bound – right); All *p*-values in bootstrap were lower than 0.010; [k] Composite Reliability Index; [l] Cronbach's alpha; [m] McDonald's omega.

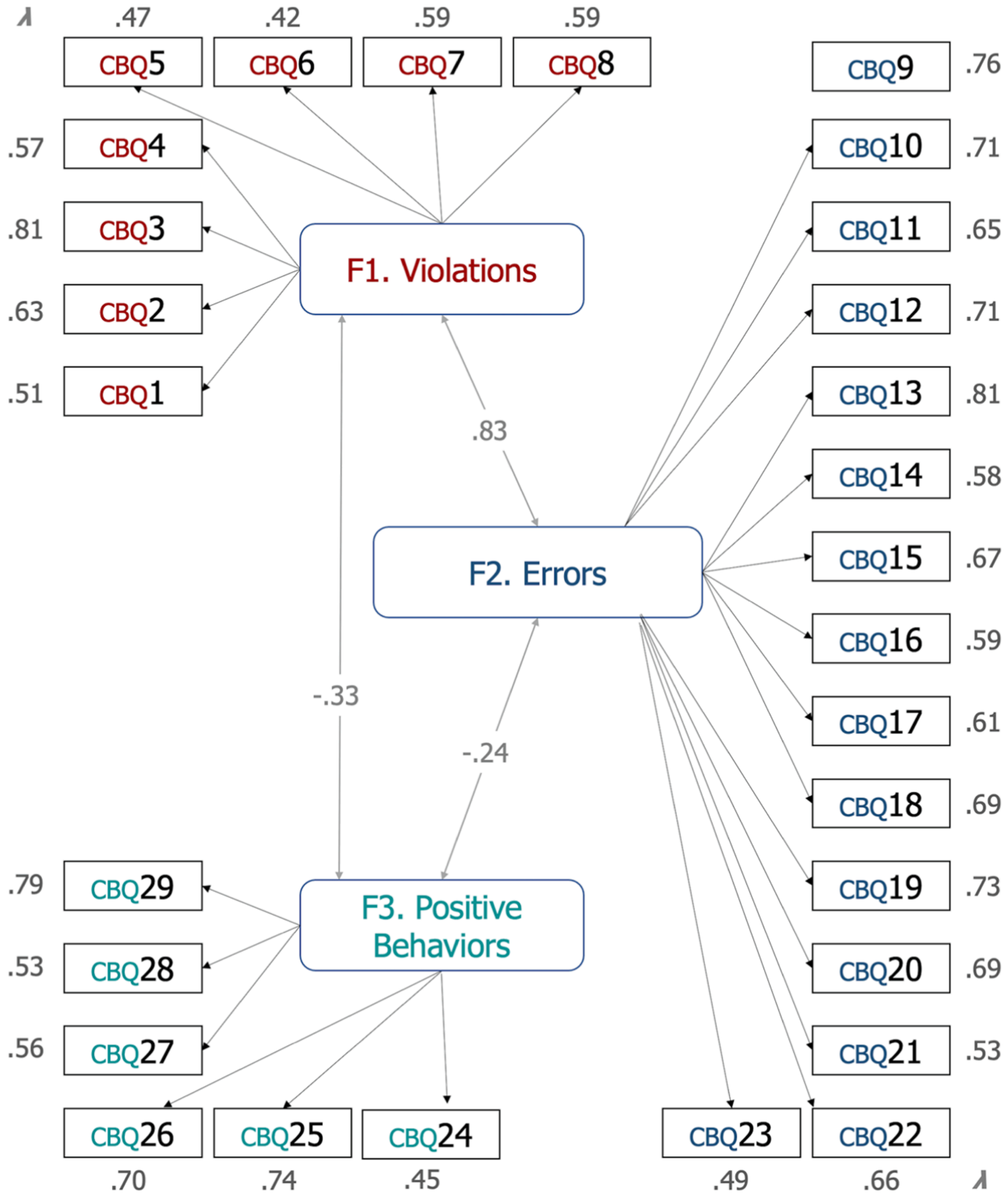

Fig. 1. Standardised parameter estimates and factor correlations. *Notes:* All standardised estimates were $p < .001$; the numbers within squares represent the original numbers of the items in the CBQ (as shown in Table 5).

for F3 (*Positive Behaviours*) was 0.983. Moreover, besides reliability and consistency indexes, all standardised factor loadings were large, positive and significant at their correspondent dimensions.

3.3. Concurrent validity insights

There are several previous pieces of evidence endorsing the relationships between cycling behaviour and CV1 – Road risk perception (e.g., Sanders, 2015; Kummeneje, Ryeng & Rundmo, 2019), same as with CV2 – Cycling crashes (e.g., O'Hern, Stephens, Young & Koppel, 2020; Zheng et al., 2019). Therefore, these two constructs were used as criterion variables. For this purpose, CVs were dichotomised, as follows: (*i*) scores on CV1 were divided by the 50th percentile of the distribution, in order to compare the risky and positive cycling behaviours of riders with lesser/greater degrees of road risk perception; and (*ii*) cyclists who had reported suffering at least one riding crash were split from those who said they had not suffered any in the last five years. Since the assumption of normality was not met, robust (Brown-Forsythe) mean tests were used for mean comparisons, given the ordinal nature of the analysed variables.

The comparative tests have shown that there are significant differences in terms of all the CBQ factors according to cyclists' road risk perception degree, as well as the fact of having (or not) suffered cycling crashes. Coherently to the theoretically expectable, the self-reported frequencies of both cycling errors and traffic violations are greater among cyclists with a lesser risk perception (CV1) and having suffered cycling crashes (CV2). The detailed robust test coefficients and their descriptive values and significance levels are shown in Table 6.

3.4. CBQ's cross-cultural validity and descriptive outcomes

With the goals of, respectively, testing the cross-cultural validity and the descriptive outcomes of the CBQ, it was followed a two-step process: firstly, the fit of the structure of the psychometrically endorsed model was assessed through a region-based approach (i.e., testing the fit of the data from each continent to the model). Secondly, and as it can be assumed that cycling behaviour might considerably vary among countries (even within the same regions), the descriptive scores of the questionnaire were calculated for each country.

In regard to the first, the data fit shown by the CBQ can be considered adequate throughout all regions covered by the study, even though (and exceptionally) the Normed Fit Index (NFI) and Tucker-Lewis Index (TLI) of the Asian sample were slightly under 0.900, in addition to an RMSEA of 0.093, something marginally over the "optimal" 0.080 criterion. Nonetheless, the other two ordinal indexes established to assess the goodness-of-fit of the three-factorial solution used (Confirmatory Fit Index – CFI and Incremental Fit Index – IFI) were over 0.900, thus considered adequate, as shown in Table 7.

In a second step, the three CBQ dimensions (i.e., traffic violations, errors, and positive behaviours) were descriptively analysed under a country-based approach. Mean scores, standard deviations, and confidence intervals for the three cycling behavioural scales composing the questionnaire are represented in Table 8.

Overall, the descriptive scores found across the five regions covered in this application of the CBQ across 19 countries suggest that:

Factor 1 – Traffic violations: The highest rate of self-reported traffic violations corresponds to Cameroon ($M = 1.660$), followed by Germany ($M = 0.890$), and China ($M = 0.854$). On the other hand, the lowest scores correspond to the following countries: the United Kingdom ($M = 0.445$), Spain ($M = 0.492$), and Australia ($M = 0.532$).

Factor 2 – Errors: The greatest scores on riding errors have been found in the case of Cameroonian cyclists ($M = 1.709$), with a great difference if compared with by Chinese ($M = 0.801$), and Dominican ($M = 683$) riders. As for the lowest self-reported error rates, these means were found among cyclists from Denmark ($M = 0.317$), the United Kingdom ($M = 0.321$), and Finland ($M = 0.336$).

Factor 3 – Positive behaviours: The greatest means scores of self-reported positive behaviours (safe riding habits) were found, respectively, in Malaysia ($M = 3.409$), Brazil ($M = 3.369$), and Mexico ($M = 3.325$). Regarding the lowest scores found (even though all country-based means were noticeably high), these outcomes corresponded to cyclists from Belgium ($M = 2.462$), China ($M = 2.696$) and Russia ($M = 2.729$).

4. Discussion

This research aimed to cross-culturally validate the Cycling Behaviour Questionnaire, examining its psychometric properties, reliability indexes, validity insights and descriptive scores in 19 countries in five regions: Europe, America, Asia, Africa, and Oceania.

Approaching the CBQ from a psychometric perspective, the outcomes of this study provide insightful information on its dimensional structure, reliability, and validity as a self-report questionnaire for assessing cycling safety from a behavioural perspective. Next, we will discuss these fundamental points considering previous evidence (including some applications of the CBQ worldwide), underlying theories, psychometric findings and descriptive outcomes of the current study.

Table 6
Robust mean comparisons (Brown-Forsythe tests) for CBQ scales between cyclists: self-reporting higher/lower road risk perception rates (CV1); and having suffered or not cycling crashes in the last five years (CV2).

CV1: Risk Perception [a]						
CBQ Scale	**Mean (SD)**		**Statistic** [b]	**df1**	**df2**	**Sig.**
	<=P50	**>P50**				
F1: Traffic violations	0.811(0.643)	0.562(0.494)	331.485	1	6594.712	<0.001
F2: Errors	0.612(0.608)	0.393(0.430)	304.857	1	6336.861	<0.001
F3: Positive behaviours	2.759(0.812)	3.252(0.692)	746.137	1	6845.462	<0.001
CV2: Traffic crashes						
CBQ Scale	**Mean (SD)**		**Statistic** [a]	**df1**	**df2**	**Sig.**
	Yes	**No**				
F1: Traffic violations	0.801(0.631)	0.596(0.531)	207.122	1	5978.122	<0.001
F2: Errors	0.607(0.584)	0.421(0.480)	203.830	1	5884.074	<0.001
F3: Positive behaviours	2.94(0.711)	3.05(0.850)	37.107	1	6496.504	<0.001

Notes: [a] The variable was dichotomised on the basis of percentile 50; [b] Brown-Forsythe test score - asymptotically F distributed.

Table 7
Fit indexes for the general CBQ confirmatory model (above) and across all regions incorporated in the study (below).

Region	X^2	df[1]	*p*	RMSEA[2]	90 % CI[3]		CFI[4]	NFI[5]	TLI[6]	IFI[7]
					Lower	Upper				
Full Sample	**4739.771**	**248**	**<0.001**	**0.051**	**0.050**	**0.052**	**0.942**	**0.940**	**0.906**	**0.943**
Europe	2300.412	248	<0.001	0.051	0.049	0.053	0.946	0.941	0.963	0.947
Latin America	1440.152	248	<0.001	0.051	0.048	0.053	0.947	0.937	0.914	0.948
Asia	1680.742	248	<0.001	0.093	0.089	0.097	0.906	0.876	0.853	0.901
Africa	378.204	248	<0.001	0.067	0.053	0.080	0.950	0.904	0.918	0.953
Oceania	842.794	248	<0.001	0.047	0.043	0.050	0.925	0.901	0.876	0.926

Notes: [1]df = Degrees of freedom; [2]RMSEA = Root Mean Square Error of Approximation; [3]Confidence Interval for RMSEA (α = 0.010); [4]CFI = Confirmatory Fit Index; [5]NFI = Normed Fit Index; [6]TLI = Tucker-Lewis Index; [7]IFI = Incremental Fit Index.

Table 8
Descriptive CBQ factor scores in the 19 different countries.

Country	N	Violations				Errors				Positive Behaviours			
		M[a]	SD[b]	95 % CI[c]		M	SD	95 % CI		M	SD	95 % CI	
				LB[d]	UB[e]			LB	UB			LB	UB
Australia	1104	0.532	0.419	0.507	0.557	0.432	0.356	0.411	0.453	3.183	0.535	3.152	3.215
Austria	131	0.724	0.466	0.644	0.805	0.402	0.373	0.338	0.466	2.926	0.642	2.815	3.037
Belgium	342	0.772	0.440	0.725	0.819	0.472	0.296	0.440	0.503	2.462	0.542	2.404	2.519
Brazil	226	0.767	0.469	0.706	0.829	0.362	0.372	0.313	0.411	3.369	0.595	3.291	3.447
Cameroon	119	1.660	0.995	1.479	1.840	1.709	0.950	1.536	1.881	2.716	0.735	2.582	2.849
Chile	303	0.685	0.468	0.632	0.738	0.407	0.368	0.365	0.448	3.172	0.591	3.105	3.239
China	541	0.854	0.510	0.811	0.897	0.801	0.432	0.765	0.838	2.696	0.791	2.629	2.763
Colombia	603	0.798	0.688	0.743	0.853	0.597	0.560	0.553	0.642	2.965	0.868	2.896	3.035
Denmark	576	0.646	0.418	0.611	0.680	0.317	0.315	0.291	0.343	3.131	0.684	3.075	3.187
Dominican Republic	386	0.678	0.781	0.600	0.756	0.683	0.823	0.601	0.765	2.864	1.160	2.748	2.981
Finland	213	0.662	0.431	0.604	0.720	0.336	0.383	0.284	0.387	2.912	0.615	2.829	2.995
Germany	458	0.890	0.561	0.839	0.942	0.451	0.415	0.413	0.489	2.930	0.668	2.869	2.992
Malaysia	183	0.570	0.449	0.504	0.635	0.436	0.467	0.368	0.504	3.409	0.802	3.292	3.526
Mexico	330	0.686	0.446	0.638	0.735	0.460	0.395	0.417	0.503	3.325	0.526	3.268	3.382
Poland	116	0.519	0.614	0.406	0.632	0.421	0.581	0.314	0.528	3.111	0.743	2.974	3.247
Russia	374	0.740	0.998	0.638	0.841	0.670	0.980	0.571	0.770	2.729	1.343	2.593	2.866
Slovakia	233	0.608	0.491	0.545	0.672	0.475	0.458	0.416	0.534	3.119	0.571	3.046	3.193
Spain	335	0.492	0.510	0.437	0.547	0.381	0.395	0.339	0.424	2.921	1.015	2.812	3.030
UK	428	0.445	0.370	0.410	0.480	0.321	0.303	0.292	0.350	3.069	0.517	3.020	3.118
Global sample	7001	0.688	0.587	0.674	0.701	0.503	0.538	0.491	0.516	3.003	0.795	2.984	3.022

Notes: [a]M = Mean; [b]SD = Standard deviation; [c]95% CI = Confidence interval at the level 95 %; [d]LB = Lower Bound; [e]UB = Upper Bound.

CBQ dimensionality: Beyond "risky" or "positive" behaviours

Firstly, apart from the most theoretically sensitive, the three-dimensional composition of the CBQ has shown to be the one fitting better to the data compared with a hypothesised bifactorial composition jointly analysing all risky behaviours. Regarding numbers, all items (in its three scales) have shown relatively high factor loadings (all $\lambda > 0.400$), the CBQ was satisfactorily adjusted to a parsimonious structure consisting of a three-factorial latent variable model, composed of the following dimensions: *Traffic Violations (F1), Errors (F2)*; and *Positive Behaviours (F3)*.

Furthermore, one of the theoretical advantages of making such taxonomical differentiation is being coherent with recent evidence provided by other studies following the Behavioural Questionnaire (BQ) paradigm applied to non-motorised users' road behaviour. Overall, this evidence suggests that a distinction between risky behaviours is necessary to properly understand behavioural risks among 'active' transport users, such as cyclists and pedestrians (Hezaveh et al., 2018; Useche et al., 2021b; Useche & Llamazares, 2022).

This taxonomical discussion started three decades ago, while analysing motor vehicle drivers' behavioural contributors to road risks (Reason et al., 1990). However, there is still little empirical evidence among cyclists. Precisely, the results of this study are in line with this assumption and support previous studies assuming a differential impact of deliberate and undeliberate risky road behaviours over cyclists' safety (O'Hern, Stephens, Young, & Koppel, 2020; Puchades, Pietrantoni, Fraboni, De Angelis, & Prati, 2018; Wang, Zhang, Feng, Wang, & Gao, 2020).

In addition, to the best of our knowledge, the CBQ is the first widely validated behavioural questionnaire incorporating positive cycling behaviours as a core factor. This addition, analogous to the contribution of Özkan & Lajunen (2005) to the study of behavioural crash contributors of four-wheel drivers, might help to further understand the role of protective behaviours over cyclists' crash outcomes (O'Hern et al., 2021). However, many subsequent studies in further contexts and with other designs (e.g., multi-measure and longitudinal research) are needed to support this assumption accurately. In other words, the present contribution should be interpreted as preliminary.

CBQ reliability and internal consistency indexes

Secondly, the CBQ was found to be an internally reliable and consistent scale, provided with good-to-optimal coefficients from different logics and natures. While in previous applications using small sample sizes, the CBQ scales reported Cronbach's alphas ranging between $\alpha = [0.603 - 0.851]$, the coefficients found for this wider cross-cultural sample of cyclists increase up to $\alpha = [0.768 - 0.914]$. Moreover, the errors (F2) scale is the one having a greater alpha coefficient, most likely because it comprises a larger number of items, which inevitably inflates the value of alpha (Tavakol & Dennick, 2011).

Complementarily, and given the aforementioned shortcomings of Cronbach's coefficients (Peterson & Kim, 2013), both McDonald's omegas ($\omega > 0.770$) and consistency indexes (CRI > 0.981) support the internal stability of the scale. Indeed, it seems methodologically interesting that CRI coefficients are large and they keep a strong coherence with the other two measures, given that, unlike Cronbach's coefficients (grounded on the exploratory correlation of each item with the total score for each observation), composite reliability calculation is mathematically based on the analysis of factor loadings and residuals seen in the results of SEM-based confirmatory analyses (CFAs; Padilla & Divers, 2016; Peterson & Kim, 2013).

However, as a fundamental limitation, it should be mentioned that test–retest reliability indexes cannot be estimated through the retrieved data, as this is a cross-sectional study (Zenk et al., 2007). The nature and sampling method used in this research (being anonymous) makes it extremely difficult to retrieve/correlate the data of a given user for a second time. However, it would still be valuable if a further study could test the reliability between measures of the CBQ, even with a smaller sample, as suggested in previous studies addressing risk-related behavioural issues, whose trajectories along the time can be an interesting object of study (Nasaescu et al., 2020).

CBQ concurrence and cross-cultural validity insights

A first inspection of the concurrent validity of the CBQ analysed its capability to differentiate cycling behavioural trends of individuals with clear differences in terms of two highly-supported criterion variables (CVs): risk perception and self-reported cycling crashes.

On the one hand, road risk perception (CV1) has consistently shown to be negatively associated with risk-taking behaviours among several groups of road users, including motor vehicle drivers (Ventsislavova et al., 2021), pedestrians (McIlroy, Useche, & Gonzalez-Marin, 2022; Useche, Hezaveh, Llamazares, & Cherry, 2021c; Yu et al., 2020), e-scooter riders (Fonseca-Cabrera et al., 2021) and, of course, bicycle riders (López, Arroyo, & García, 2021; O'Hern, Stephens, Young, & Koppel, 2020). Accordingly, the results of Brown-Forsythe tests have shown how, whilst riding behaviours (F1 and F2) uniformly tend to be worse among cyclists with lesser risk perception, scores on positive behaviours (F3) are significantly greater among riders over the 50th percentile of the distribution.

On the other, self-reported cycling crashes, even though previously argued as a multivariate outcome (e.g., a result of many factors), have been shown to be predictable by risky road behaviours of bicycle riders to a considerable extent (Li et al., 2021; Useche, Alonso, Sanmartin, Montoro, & Cendales, 2019b; Zheng, Ma, Li, & Cheng, 2019). Coherently, comparative tests have proved that those individuals who self-report having suffered at least one cycling crash during the last five years, also report significantly greater scores on the traffic violations (F1) and errors (F2) scales, as well as tending to be low-scorers on positive behaviours (F3).

Other interesting strengths shown so far by the CBQ are: (*i*) its structural stability across regions, similar to the one shown by the previous transculturally observed behavioural questionnaires such as the Pedestrian Behaviour Scale (PBS; Solmazer et al., 2020) and the Behaviour of Young Novice Drivers Scale (BYNDS; Oviedo-Trespalacios & Scott-Parker, 2017); and (*ii*) the consistency of the age-based trends found with the CBQ (Useche, Alonso, Montoro, & Esteban, 2019a; Useche, Alonso, Sanmartin, Montoro, & Cendales, 2019) and those provided by the PBS and BYNDS among other groups of users, where younger users have uniformly shown to be commonly performing risky behaviors with a greater frequency and, at the same time self-reporting getting involved in more crashes. These can also be interpreted as discriminant and convergent validity insights of the CBQ as, consistently across its different applications, its results remain coherent with both age-based road risk profiles and other similar tools' findings.

This wide application also adds useful data about the Goodness-of-Fit (GoF) of the measurement model proposed by the CBQ (see Table 7), but this time under a cross-cultural approach, showing how fit indexes of the confirmatory model retained reports good-to-optimal values across all regions. Specifically, the model meets all basic fit index cut-off points in all regions, except for Asia, where three out of the five indexes present slight (although not substantial) deviations from the Goodness-of-Fit criteria.

This can be interpreted in two ways: first, that cycling behavioural trends between the countries composing the Asian sample (China and Malaysia) were substantially heterogeneous, or presenting several specificities, as suggested by previous behavioural studies in the region, such as Li (Li et al., 2021) and Zheng et al. (2019). Secondly, it is possible (although not verifiable) that common method biases could influence data collection, often observable in contexts where participants may perceive that fair data handling cannot be guaranteed or remain beyond all potential efforts and rigour of researchers (Robinson & Tannenberg, 2018; Ruiz-Hernandez et al., 2020; Li, Shi & Zhu, 2018). Regardless, this lack of fit in the case of the Asian sample remains very slight. In contrast, CBQ factors qualitatively remain reasonably fitted to the dimensional composition of the questionnaire since no extreme values were observed in descriptive analyses.

Therefore, and in addition to its item composition (addressing only universally recognizable behaviours), dimensionality, reliability, and concurrent validity insights – as previously presented in this section, the idea that the CBQ constitutes an efficiently suitable method for assessing both risky and positive road behaviours across regions can be supported. It also represents an essential progression in understanding behavioural contributors to road safety, whose different stakeholders might benefit from this validation study's evidence and insights.

Country-based differences and trends

Finally, this paper also presents the raw scores on cycling behaviour obtained across the 19 countries covered in our study. While this constitutes only a first approach to assessing riding behavioural trends in these regions (in this case, from a merely descriptive approach), there are some relevant outcomes worth discussing:

Firstly, the fact that risky cycling factors (i.e., traffic violations and errors) tended to score considerably low mean values, while the positive behaviour scale (F3) tends to be noticeably higher in all cases, as also observed in previous studies dealing with drivers' (Özkan & Lajunen, 2005), cyclists' (Feenstra et al., 2011; Hezaveh, Zavareh, Cherry & Nordfjærn, 2018) and pedestrians' (McIlroy et al., 2020; Useche & Llamazares, 2022) road behaviour.

While this is not an isolated fact in behavioural questionnaire-based research, and the trend is (in fact) consistent with previous literature, two issues should be considered. On the one hand, and beyond the fact that online surveys were uniformly used in all countries, there could be bias (e.g., social desirability and other common method issues) potentially influencing study participants. On the other, behavioural questionnaires should also be 'behaviourally' and qualitatively interpreted, making sense that -outside stereotypes- most road users (including cyclists) do not commit violations and errors on a highly regular basis, for which it is difficult to find (e.g.) normally distributed behavioural data or intermediate scores. Instead, non-normal and asymmetric distributions requiring statistical corrections are rather frequent, a key reason for using bias-corrected scores, as performed in this large-scale research (Pek, Wong & Wong, 2018; Ruiz-Hernandez et al., 2020).

Moreover, the descriptive outcomes show key differences across countries, being it possible to overview certain patterns, such as finding that African and Asian riders tend to be high-scorers in both risky behavioural (i.e., traffic violations and errors) subscales. In this regard, and although at first glance it could be interpreted that, added to a substantial lack of previous research, a combination of reduced cycling infrastructure, training, and tradition (Larouche et al., 2014; Timpabi et al., 2021) might drive low-income countries to report 'worse' behavioural outcomes, this relationship seems not sheer. For instance, it draws attention that Germany, a high-income economy with high investments in infrastructure, road safety education, and an undisputable urban cycling tradition, remains one of the top scorers in terms of self-reported traffic violations, coherently with issues highlighted by previous researchers such as cycling anger (Oehl et al., 2019), secondary task engagement (Huemer et al., 2022), alcohol-intoxicated riding (Bothorn et al., 2022), crowding and road conflicts in urban scenarios (Von Stülpnagel et al., 2022).

All in sum, and beyond the usefulness of the questionnaire as a primary analysis tool (which, in any case, is limited to raw scores), these outcomes suggest the need to thoroughly analyse the dynamics and contextual particularities of these cases to depict the 'why' and formulate further hypotheses and explanations. As such, understanding cyclists' riding-related experiences, attributions and habits is fundamental to both increase both functional and contextual understanding of riding risky and positive behaviours (Kalra et al., 2022).

5. Limitations of the study and further research

Although, to the best of our knowledge, this study involved the most extensive sample of cyclists gathered so far for applying a riding behaviour questionnaire in many countries, and despite many strengths that have been described throughout the manuscript, there are some key limitations worth acknowledging.

First of all, recruiting processes were dissimilar across countries. Some regions (especially Africa) remain underrepresented due to the poor coverage of research networks, the reduced number of cyclists allocated for partaking in the study, and many disparities that potentially influence the behavioural outcomes of our participants. Accordingly, one of the key shortcomings of this paper seems to be highly gendered cyclists' quotas gathered from both emerging and culturally more conservative countries. Said otherwise, while High-Income Countries (HICs) show very balanced gender distributions, most Low- and Middle-Income Countries (LMICs) show considerably greater proportions of male cyclists. Given that previous research has demonstrated how 'gender matters' as for self-reported riding, driving and walking behaviour (Hezaveh, Zavareh, Cherry, & Nordfjærn, 2018; Useche, Montoro, Alonso, & Tortosa, 2018b; Ventsislavova, Crundall, Garcia-Fernandez, & Castro, 2021), this could be a factor to consider when interpreting data. Indeed, a further paper addressing these matters (e.g., country-based indexes, inequities, and social issues) is currently being developed by our research team.

Secondly, the sampling strategy could not be (for obvious reasons) totally uniform across countries. Beyond all feasible analytical corrections, this may have introduced a bias in the sampling, as a combination of social media, varied mailing lists, student recruitment, and press releases were used.

Thirdly, our strategy for grouping countries was rather geographical (i.e., by continents). Although it entails the advantage of easily segmenting the sample under a widely agreed criterion, we are aware that key differences might be present amongst countries from the same region, e.g., comparing southern and northern Europe. However, this number of possible combinations is very long to be discussed in this paper, but in the upcoming months, researchers will have full access to our data in order to allow them to perform these analyses.

Fourthly, common method biases (CMBs) and social issues (into which we will not delve since they are outside the scope of this paper) could likely influence our participants' self-reported behavioural outcomes. While all the efforts depending on us were made to reassure participants of the anonymity of their responses, we cannot ensure all responses were unbiased.

As for further research, this validated version of the CBQ encourages international researchers to perform further demographic comparisons. Also, researchers are encouraged to involve this tool in their cycling safety-related actions performed from the perspective of behavioural assessment, using new samples, study designs and incorporating it into further research questions and dynamics.

6. Conclusion

The present investigation constitutes a new cross-cultural perspective on the Cycling Behaviour Questionnaire, suggesting that its 29-item version represents a suitable tool for assessing riding behaviour in a three-factorial approach worldwide. In addition, it offers reasonable psychometric properties, validity and reliability insights, and the potentiality of being applied in an electronic environment. This allows adapting to the new technological trends and the shortcomings of social distancing dynamics.

Also, this study supports the assumption that cyclists' behaviours share both similarities and key differences across regions. Still, the application of the CBQ would benefit from complementary research techniques (e.g., naturalistic observations, experimental designs) to support its usefulness to develop country- or city-based case studies. Moreover, practical actions and policies aimed at improving cycling safety from the human factors perspective might get benefited from the insights provided by this measurement tool.

CRediT authorship contribution statement

Sergio A. Useche: Visualization, Conceptualization, Supervision, Investigation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Validation, Writing - original draft, Writing - review & editing. **Francisco Alonso:** Investigation, Resources. **Aleksey Boyko:** Investigation. **Polina Buyvol:** Investigation. **Isaac Castañeda:** Investigation. **Boris Cendales:** Investigation. **Arturo Cervantes:** Investigation. **Tomas Echiburu:** Investigation. **Mireia Faus:** Investigation. **Zuleide Feitosa:** Investigation. **Javier Gene:** Investigation. **Adela Gonzalez-Marin:** Investigation. **Jozef Gnap:** Investigation. **Mohd K. Ibrahim:** Investigation. **Kira H. Janstrup:** Investigation. **Arash Javadinejad:** Investigation. **Irijna Makarova:** Investigation. **Rich McIlroy:** Investigation. **Miroslava Mikusova:** Investigation. **Mette Møller:** Investigation. **Sylvain Ngueuteu-Fouaka:** Investigation. **Steve O'Hern:** Investigation. **Mauricio Orozco-Fontalvo:** Investigation. **Ksenia Shubenkova:** Investigation. **Felix Siebert:** Investigation. **Jose Soto:** Investigation. **Amanda N. Stephens:** Investigation. **Yonggang Wang:** Investigation. **Ellias Willberg:** Investigation. **Phillip Wintersberger:** Investigation. **Linus Zeuwts:** Investigation. **Zarir H. Zulkipli:** Investigation. **Luis Montoro:** Supervision, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

The authors would like to thank the participants and countless institutional stakeholders supporting the "Bike-Barometer 2020-2021" project that framed the data collection of this study, and Sara Pascual for proofreading the final manuscript.

References

Aldred, R. (2016). Cycling near misses: Their frequency, impact, and prevention. *Transportation Research Part A: Policy and Practice, 90*, 69–83. https://doi.org/10.1016/j.tra.2016.04.016

Aldred, R., Elliott, B., Woodcock, J., & Goodman, A. (2017). Cycling provision separated from motor traffic: A systematic review exploring whether stated preferences vary by gender and age. *Transport Reviews, 37*(1), 29–55. https://doi.org/10.1080/01441647.2016.1200156

Banerjee, A., Łukawska, M., Jensen, A. F., & Haustein, S. (2021). Facilitating bicycle commuting beyond short distances: Insights from existing literature. *Transport Reviews, 1–25*. https://doi.org/10.1080/01441647.2021.2004261

Beck, B., Stevenson, M., Newstead, S., Cameron, P., Judson, R., Edwards, E. R., Bucknill, A., Johnson, M., & Gabbe, B. (2016). Bicycling crash characteristics: An in-depth crash investigation study. *Accident Analysis & Prevention, 96*, 219–227. https://doi.org/10.1016/j.aap.2016.08.012

Bothorn, J. B., Schwender, H., Graw, M., Kienbaum, P., & Hartung, B. (2022). Cycling under the influence of alcohol-criminal offenses in a German metropolis. *International Journal of Legal Medicine, 136*(4), 1121–1132. https://doi.org/10.1007/s00414-022-02828-8

Büchel, B., Marra, A. D., & Corman, F. (2022). COVID-19 as a window of opportunity for cycling: Evidence from the first wave. *Transport Policy, 116*, 144–156. https://doi.org/10.1016/j.tranpol.2021.12.003

Buehler, R., & Pucher, R. (2021). COVID-19 Impacts on Cycling, 2019–2020. *Transport Reviews, 41*(4), 393–400. https://doi.org/10.1080/01441647.2021.1914900

Fonseca-Cabrera, A. S., Llopis-Castelló, D., Pérez-Zuriaga, A. M., Alonso-Troyano, C., & García, A. (2021). Micromobility Users' Behaviour and Perceived Risk during Meeting Manoeuvres. *International Journal of Environmental Research and Public Health, 18*(23), 12465. https://doi.org/10.3390/ijerph182312465

de Hartog, J. J., Boogaard, H., Nijland, H., & Hoek, G. (2010). Do the health benefits of cycling outweigh the risks? *Environmental Health Perspectives, 118*(8), 1109–1116. https://doi.org/10.1289/ehp.0901747

Doğru, O. C., Webb, T. L., & Norman, P. (2021). What is the best way to promote cycling? A systematic review and meta-analysis. *Transportation Research Part F: Traffic Psychology and Behaviour, 81*, 144–157. https://doi.org/10.1016/j.trf.2021.06.002

Feenstra, H., Ruiter, R. A., Schepers, J., Peters, G. J., & Kok, G. (2011). Measuring risky adolescent cycling behaviour. *International Journal of Injury Control and Safety Promotion, 18*(3), 181–187. https://doi.org/10.1080/17457300.2010.540334

Green, S., Sakuls, P., & Levitt, S. (2021). Cycling for health: Improving health and mitigating the climate crisis. *Canadian Family Physician, 67*(10), 739–742. https://doi.org/10.46747/cfp.6710739

Handy, S., Van Wee, B., & Kroesen, M. (2014). Promoting cycling for transport: Research needs and challenges. *Transport Reviews, 34*(1), 4–24. https://doi.org/10.1080/01441647.2013.860204

Hezaveh, A. M., Zavareh, M. F., Cherry, C. F., & Nordfjærn, T. (2018). Errors and violations in relation to bicyclists' crash risks: Development of the Bicycle Rider Behavior Questionnaire (BRBQ). *Journal of Transport & Health, 8*, 289–298. https://doi.org/10.1016/j.jth.2017.11.003

Huemer, A. K., Banach, E., Bolten, N, Helweg, S., Koch, A., & Martin, T. (2022). Secondary task engagement, risk-taking, and safety-related equipment use in German bicycle and e-scooter riders – An observation. *Accident Analysis & Prevention, 172*, Article 106685. https://doi.org/10.1016/j.aap.2022.106685

Iwińska, K., Blicharska, M., Pierotti, L., Tainio, M., & de Nazelle, A. (2018). Cycling in Warsaw, Poland - Perceived enablers and barriers according to cyclists and non-cyclists. Transportation research. *Part A, Policy and Practice, 113*, 291–301. https://doi.org/10.1016/j.tra.2018.04.014

Kalra, A., Lim, T., Pearson, L., & Beck, B. (2022). Methods used to capture subjective user experiences in adults while riding bicycles: A scoping review. *Transport Reviews*. https://doi.org/10.1080/01441647.2022.2123064

Kahlmeier, S., Boig, E. A., Fernandez A, C., Smeds, E., Benvenuti, F., Eriksson, U., Iacorossi, F., Nieuwenhuijsen, M. J., Int Panis, L., Rojas-Rueda, D., Wegener, S., & de Nazelle, A. (2021). Assessing the Policy Environment for Active Mobility in Cities-Development and Feasibility of the PASTA Cycling and Walking Policy Environment Score. *International Journal of Environmental Research and Public Health*, *18*(3), 986. 10.3390/ijerph18030986.

Kummeneje, A. M., Ryeng, E. O., & Rundmo, T. (2019). Seasonal variation in risk perception and travel behaviour among cyclists in a Norwegian urban area. *Accident Analysis & Prevention, 124*, 40–49. https://doi.org/10.1016/j.aap.2018.12.021

Kummeneje, A. M., & Rundmo, T. (2020). Attitudes, risk perception and risk-taking behaviour among regular cyclists in Norway. *Transportation Research Part F: Traffic Psychology and Behaviour, 69*, 135–150. https://doi.org/10.1016/j.trf.2020.01.007

Larouche, R., Oyeyemi, A. L., Prista, A., Onywera, V., Akinroye, K. K., & Tremblay, M. S. (2014). A systematic review of active transportation research in Africa and the psychometric properties of measurement tools for children and youth. *The International Journal of Behavioral Nutrition and Physical Activity, 11*, 129. https://doi.org/10.1186/s12966-014-0129-5

Li, X., Shi, W., & Zhu, B. (2018). The face of internet recruitment: Evaluating the labor markets of online crowdsourcing platforms in China. *Research and Politics, 2018*, 1–8. https://doi.org/10.1177/2053168018759127

Li, X., Useche, S. A., Zhang, Y., Wang, Y., Oviedo-Trespalacios, O., & Haworth, N. (2021). Comparing the cycling behaviours of Australian, Chinese and Colombian cyclists using a behavioural questionnaire paradigm. *Accident Analysis & Prevention, 164*, Article 106471. https://doi.org/10.1016/j.aap.2021.106471

López, G., Arroyo, R., & García, A. (2021). Structural Equation Approach to Analyze Cyclists Risk Perception and Their Behavior Riding on Two-Lane Rural Roads in Spain. *Sustainability, 13*(15), 8424. https://doi.org/10.3390/su13158424

Marsh, H. W., Hau, K.-T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cut-off values for fit indexes and dangers in over generalizing Hu and Bentler's (1999) findings. *Structural Equation Modeling, 11*, 320–341. https://doi.org/10.1207/s15328007sem1103_2

McIlroy, R., Useche, S. A., & Gonzalez-Marin, A. (2022). To what extent do our walking and cycling behaviours relate to each other, and do we cycle as well as we think we do? Piloting the Walking and Cycling Behaviour Questionnaires in the UK. *Accident Analysis & Prevention, 168*, Article 106597. https://doi.org/10.1016/j.aap.2022.106597

McIlroy, R. C., Nam, V. H., Bunyasi, B., Jikyong, U., Kokwaro, G. O., Wu, J., Hoque, M. S., Plant, K. L., Preston, J. M., & Stanton, N. A. (2020). Exploring the relationships between pedestrian behaviours and traffic safety attitudes in six countries. *Transportation Research Part F-traffic Psychology and Behaviour, 68*, 257–271.

Møller, M., & Haustein, S. (2017). Anger expression among Danish cyclists and drivers: A comparison based on mode specific anger expression inventories. *Accident Analysis & Prevention, 108*, 354–360. https://doi.org/10.1016/j.aap.2017.09.016

Nasaescu, E., Zych, I., Ortega-Ruiz, R., Farrington, D. P., & Llorent, V. J. (2020). Longitudinal Patterns of Antisocial Behaviors in Early Adolescence: A Latent Class and Latent Transition Analysis. *The European Journal of Psychology Applied to Legal Context, 12*(2), 85–92. https://doi.org/10.5093/ejpalc2020a10

Özkan, T., & Lajunen, T. (2005). A new addition to DBQ: Positive driver behaviours scale. *Transportation Research Part F: Traffic Psychology and Behaviour, 8*(4), 355–368. https://doi.org/10.1016/j.trf.2005.04.018

O'Hern, S., Estgfaeller, N., Stephens, A. N., & Useche, S. A. (2021). Bicycle Rider Behavior and Crash Involvement in Australia. *International Journal of Environmental Research and Public Health, 18*(5), Article 2378. https://doi.org/10.3390/ijerph18052378

O'Hern, S., Stephens, A. N., Young, K. L., & Koppel, S. (2020). Personality traits as predictors of cyclist behaviour. *Accident Analysis & Prevention, 145*, Article 105704. https://doi.org/10.1016/j.aap.2020.105704

Oehl, M., Brandenburg, S., & Huemer, A. K. (2019). German bike messengers' experiences and expressions of cycling anger. *Traffic Injury Prevention, 20*(7), 753–758. https://doi.org/10.1080/15389588.2019.1616179

Oviedo-Trespalacios, O., & Scott-Parker, B. (2017). Transcultural validation and reliability of the Spanish version of the behaviour of young novice drivers scale (BYNDS) in a Colombian young driver population. *Transportation Research Part F: Traffic Psychology and Behaviour, 49*, 188–204. https://doi.org/10.1016/j.trf.2017.06.011

Padilla, M. A., & Divers, J. A. (2016). Comparison of Composite Reliability Estimators: Coefficient Omega Confidence Intervals in the Current Literature. *Educational and Psychological Measurement, 76*(3), 436–453. https://doi.org/10.1177/0013164415593776

Pek, J., Wong, O., & Wong, A. (2018). How to address non-normality: A taxonomy of approaches, reviewed, and illustrated. *Frontiers in Psychology, 9*, 2104. https://doi.org/10.3389/fpsyg.2018.02104

Peterson, R. A., & Kim, Y. (2013). On the relationship between coefficient alpha and composite reliability. *Journal of Applied Psychology, 98*(1), 194–198. https://doi.org/10.1037/a0030767

Prati, G., De Angelis, M., Marín Puchades, V., Fraboni, F., & Pietrantoni, L. (2017). Characteristics of cyclist crashes in Italy using latent class analysis and association rule mining. *PloS One, 12*(2), e0171484.

Puchades, V. M., Pietrantoni, L., Fraboni, F., De Angelis, M., & Prati, G. (2018). Unsafe cycling behaviours and near crashes among Italian cyclists. *International journal of Injury Control and Safety Promotion, 25*(1), 70–77. https://doi.org/10.1080/17457300.2017.1341931

Pucher, J., & Buehler, R. (2007). Making Cycling Irresistible: Lessons from The Netherlands. *Denmark and Germany. Transport Reviews, 28*(4), 495–528. https://doi.org/10.1080/01441640701806612

Reason, J., Manstead, A., Stradling, S., Baxter, J., & Campbell, K. (1990). Errors and violations on the roads: A real distinction? *Ergonomics, 33*(10–11), 1315–1332. https://doi.org/10.1080/00140139008925335

Robinson, D., & Tannenberg, M. (2018). Self-Censorship in Authoritarian States: Response Bias in Measures of Popular Support in China. *V-Dem Working Paper, 2018*, 66. 10.2139/ssrn.3161915.

Ruiz-Hernandez, J. A., Pina, D., Puente-López, E., Luna-Maldonado, A., & Llor-Esteban, B. (2020). Attitudes towards school violence questionnaire, revised version: CAHV-28. *The European Journal of Psychology Applied to Legal Context, 12*(2), 61–68. https://doi.org/10.5093/ejpalc2020a8

Sanders, R. L. (2015). Perceived traffic risk for cyclists: The impact of near miss and collision experiences. *Accident Analysis & Prevention, 75*, 26–34. https://doi.org/10.1016/j.aap.2014.11.004

Solmazer, G., Azık, D., Fındık, G., Üzümcüoğlu, Y., Ersan, O., Kaçan, B., Özkan, T., Lajunen, T., Öz, B., Pashkevich, A., Pashkevich, M., Danelli-Mylona, V., Georgogianni, D., Krasniqi, E. B., Krasniqi, M., Makris, E., Shubenkova, K., & Xheladini, G. (2020). Cross-cultural differences in pedestrian behaviors in relation to values: A comparison of five countries. *Accident Analysis & Prevention, 138*, Article 105459. https://doi.org/10.1016/j.aap.2020.105459

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education, 2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

Thomas, B., & DeRobertis, M. (2013). The safety of urban cycle tracks: A review of the literature. *Accident Analysis & Prevention, 52*, 219–227. https://doi.org/10.1016/j.aap.2012.12.017

Timpabi, A. P., Osei, K. K., & Adams, C. A. (2021). Bicycle ownership and utilization in Tamale Metropolis; influencing factors and impacts to sustainable transport. *Heliyon, 7*(6), e07133.

Tirachini, A., & Cats, O. (2020). COVID-19 and public transportation: Current assessment, prospects, and research needs. *Journal of Public Transportation, 22*(1), 1–21. https://doi.org/10.5038/2375-0901.22.1.1

Useche, S. A., & Llamazares, J. (2022). The Guilty, the Unlucky, or the Unaware? Assessing self-reported behavioral contributors and attributions on pedestrian crashes through Structural Equation Modeling and Mixed Methods. *Journal of Safety Research, 82*, 329–341. https://doi.org/10.1016/j.jsr.2022.06.009

Useche, S. A., Montoro, L., Tomas, J. M., & Cendales, B. (2018a). Validation of the Cycling Behavior Questionnaire: a tool for measuring cyclists' road behaviors. *Transportation Research Part F: Psychology and Behaviour*, 1021–1030. https://doi.org/10.1016/j.trf.2018.08.003
Useche, S. A., Montoro, L., Alonso, F., & Tortosa, F. (2018b). Does gender really matter? A structural equation model to explain risky and positive cycling behaviors. *Accident Analysis & Prevention, 118*, 86–95. https://doi.org/10.1016/j.aap.2018.05.022
Useche, S. A., Alonso, F., Montoro, L., & Esteban, C. (2018c). Distraction of cyclists: How does it influence their risky behaviors and traffic crashes? *PeerJ, 6*, Article e5616. https://doi.org/10.7717/peerj.5616
Useche, S. A., Alonso, F., Montoro, L., & Esteban, C. (2019a). Explaining self-reported traffic crashes of cyclists: An empirical study based on age and road risky behaviors. *Safety Science, 113*, 105–114. https://doi.org/10.1016/j.ssci.2018.11.021
Useche, S. A., Alonso, F., Sanmartin, J., Montoro, L., & Cendales, B. (2019b). Well-being, behavioral patterns and cycling crashes of different age groups in Latin America: Are aging adults the safest cyclists? *PLoS ONE, 14*(8), e0221864.
Useche, S. A., Alonso, F., Montoro, L., & Sanmartin, J. (2019c). Healthy but risky: A descriptive study on cyclists' encouraging and discouraging factors for using bicycles, habits and safety outcomes. *Transportation Research Part F: Psychology and Behaviour, 62*, 587–598. https://doi.org/10.1016/j.trf.2019.02.014
Useche, S. A., Esteban, C., Alonso, F., & Montoro, L. (2021a). Are Latin American cycling commuters "at risk"? A comparative study on cycling patterns, behaviors, and crashes with non-commuter cyclists. *Accident Analysis & Prevention, 150*, Article 105915. https://doi.org/10.1016/j.aap.2020.105915
Useche, S. A., Philippot, P., Ampe, T., Llamazares, J., & de Geus, B. (2021b). "Pédaler en toute sécurité": The Cycling Behavior Questionnaire (CBQ) in Belgium – a validation study. *Transportation Research Part F: Psychology and Behaviour, 80*, 260–274. https://doi.org/10.1016/j.trf.2021.04.014
Useche, S. A., Hezaveh, A. M., Llamazares, F. J., & Cherry, C. (2021c). Not gendered… but different from each other? A structural equation model for explaining risky road behaviors of female and male pedestrians. *Accident Analysis & Prevention, 150*, Article 105942. https://doi.org/10.1016/j.aap.2020.105942
Useche, S. A., Gene-Morales, J., Siebert, F. W., Alonso, F., & Montoro, L. (2021d). "Not as Safe as I Believed": Differences in Perceived and Self-Reported Cycling Behavior between Riders and Non-Riders. *Sustainability, 13*(4), Article 1614. https://doi.org/10.3390/su13041614
Ventsislavova, P., Crundall, D., Garcia-Fernandez, P., & Castro, C. (2021). Assessing willingness to engage in risky driving behaviour using naturalistic driving footage: The role of age and gender. *International Journal of Environmental Research and Public Health, 18*(19), 10227. https://doi.org/10.3390/ijerph181910227
Von Stülpnagel, R., Petinaud, C., & Lißner, S. (2022). Crash risk and subjective risk perception during urban cycling: Accounting for cycling volume. *Accident Analysis & Prevention, 164*, Article 106470. https://doi.org/10.1016/j.aap.2021.106470
Vuori, I. (2011). Promoting cycling: A review of interventions. *Clinical Journal of Sport Medicine, 21*(6), 542–544. https://doi.org/10.1097/01.jsm.0000407931.13102.0b
Walker, I. (2007). Drivers overtaking bicyclists: Objective data on the effects of riding position, helmet use, vehicle type and apparent gender. *Accident Analysis & Prevention, 39*(2), 417–425. https://doi.org/10.1016/j.aap.2006.08.010
Wang, C., Zhang, W., Feng, Z., Wang, K., & Gao, Y. (2020). Exploring factors influencing the risky cycling behaviors of young cyclists aged 15–24 years: A questionnaire-based study in China. *Risk Analysis, 40*(8), 1554–1570. https://doi.org/10.1111/risa.13499
Yu, S., Wu, Y., Mrug, S., Wang, H., Ridley, S., Hu, G., & Schwebel, D. C. (2020). Pedestrian-vehicle crashes: Risk perception and responsibility attribution among children, adolescents and adults. *Journal of Injury & Violence Research, 12*(1), 29–38. https://doi.org/10.5249/jivr.v12i1.1243
Zenk, S. N., Schulz, A. J., Mentz, G., House, J. S., Gravlee, C. C., Miranda, P. Y., Miller, P., & Kannan, S. (2007). Inter-rater and test-retest reliability: Methods and results for the neighborhood observational checklist. *Health & Place, 13*(2), 452–465. https://doi.org/10.1016/j.healthplace.2006.05.003
Zheng, Y., Ma, Y., Li, N., & Cheng, J. (2019). Personality and behavioral predictors of cyclist involvement in crash-related conditions. *International Journal of Environmental Research and Public Health, 16*(24), 4881. https://doi.org/10.3390/ijerph16244881