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French Adaptation and Validation of the Pedestrian Receptivity Questionnaire for Fully Autonomous Vehicles (F-PRQF)

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ABSTRACT

This research is based on the adaptation and validation in French of the Pedestrian Receptivity Questionnaire for Fully Autonomous Vehicles (PRQF). Faced with the emergence of numerous issues related to interactions between pedestrians and fully autonomous vehicles (FAV), this questionnaire is a reliable and scientifically valid means of collecting pedestrian experiences when they cross a road in front of an autonomous vehicle. The translation methodology of the PRQF was based on a committee approach, which consisted of asking several bilingual experts to come to an agreement on a consensual translation. The validation of the French PRQF (F-PRQF) was based on the completion of 584 questionnaires. Different psychometric tests were carried out, including an accuracy analysis, a principal component factor analysis (PCA) and a confirmatory factor analysis (CFA). Our results show that the F-PQRF displays satisfactory psychometric qualities, in particular in terms of internal consistency ($\alpha = 0.932$ and $\omega = 0.935$). We also find a scale with five components, which confirms the theoretical model structure of the original scale. The F-PRQF showed good psychometric qualities, which should thus facilitate research in fully autonomous vehicles among French-speaking audiences.

1. Introduction

Technological developments to make the fully autonomous vehicles (FAV) continue from year to year. Besides road tests organized by the different vehicle manufacturers (Bagloee et al., 2016), the first fully autonomous vehicles could be in circulation and accessible to the general public from 2025, with deployment to more than 90% of the market by 2055 (Nieuwenhuijsen et al., 2018). However, these predictions must be qualified by considering the progress of technological developments (Ahmed et al., 2022), and the policy for integrating autonomous vehicles into the market (Alvarez León & Aoyama, 2022; Wang et al., 2022). Indeed, numerous governments support research and development into FAV, not only from an economic point of view, but also by preparing the massive infrastructure adaptations that would be necessary for FAV and non-autonomous vehicles to share the road (Alsalman et al., 2021).

1.1. What is a fully autonomous vehicle?

Fully autonomous vehicles (FAV) are vehicles where driving is managed entirely by an automated system, which is equipped with detectors and capable of reacting to all situations the vehicle finds itself in. The U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) defines autonomous vehicles as follows: "Automated vehicles are those in which at least some aspects of a safety-critical control function (e.g., steering, throttle, or braking) occur without direct driver input."

FAV constitute the highest level of autonomy for autonomous vehicles defined by the Society of Automotive Engineers (SAE), which distinguishes six levels, detailed in Table 1. The first three levels (0, 1 and 2) are considered driver support systems, where the driver remains the main actor in the driving process. The next three levels (3, 4 and 5) delegate part or all of the driving to the automated system. FAV correspond to level 4 or even 5.

Often, the vehicle must be connected in order for it to be autonomous. A connected vehicle incorporates wireless telecommunication systems allowing it to collect information that it can save, process, use and relay to other vehicles or send to the road infrastructure. In this way, a fully autonomous vehicle continuously exchanges information with other FAV and the systems that manage the infrastructure. For example, a connected vehicle can better manage intersections by communicating with other vehicles to know their position and the state of the traffic (vehicle-to-vehicle: V2V), but also with the infrastructure (vehicle-to-infrastructure: V2I) in order to determine the safest and fastest route, taking into account areas under construction or accidents on the road (Gholamhosseinian & Seitz, 2022). In this

Table 1. Autonomy level of the vehicles, according to the SAE classification.

Level	Name	Definition
The driver monitors the driving environment		
0	No automation	The driver is fully in charge of driving, however, he/she may have warning mechanisms available, like audible lane departure or obstacle proximity signals, etc.
1	Driver assistance	The driver retains the responsibility for the manoeuvres at all times, but delegates part of the tasks to the system, typically for the longitudinal control of the vehicle, for example via an adaptive cruise control system. The driver must be capable of taking over the complete control of the driving if required by the situation.
2	Partial automation	Responsibility for the manoeuvres is delegated entirely to the system but everything is done under the constant supervision of the driver, who may decide to resume control at any time, for example, where there is an automatic change of lane.
The automated driving system monitors the driving environment		
3	Conditional automation	The driver may delegate driving along the two guiding dimensions (longitudinal and lateral) and may lower his/her level of vigilance to briefly carry out other tasks. The intelligent steering system is then responsible for positioning and keeping the vehicle in lane while maintaining a speed adapted to traffic and speed conditions.
4	High automation	This is a highly automated level at which the driver no longer intervenes and can turn his/her attention to other things. However, this level only concerns certain driving modes, in certain conditions. The driver activates and deactivates the automated mode.
5	Full automation	This is the ultimate automation: there is no longer any intervention by humans, whether in the control or supervision of the driving or navigation. The system is responsible for and controls everything. Even the presence of a human at the controls is no longer necessarily required.

purpose, the acronym CAV is also used, signifying connected and autonomous vehicles.

In this article, we also favor the term FAV over CAV likewise the original PRQF study by Deb et al. (2017).

1.2. Expectations and interests concerning FAV

The reason for the FAV being the subject of so much attention since the beginning of the 2000s is that they promise numerous social changes and significant improvements in the transport domain. In 2005, a report on intelligent vehicle safety systems (IVSS) (Abele et al., 2005) predicted that the development of vehicles with numerous assistance technologies, such as ABS (Antilock Braking System), ACC (Adaptive Cruise Control) or ESP (Electronic Stability Programme), would lead to a significant reduction in the number of road accidents, the seriousness of the accidents and traffic congestion. Since then, Advanced Driver Assistance Systems (ADAS) have been widely developed and are increasingly integrated into modern vehicles. A study of road accident conditions in the UK estimated that the systematic deployment of certain assistance systems would reduce accidents by 23.8% (Masello et al., 2022). As FAV would systematically include all available driving assistance technologies, they would be fully in line with the combat for road safety. In a report on the societal impact of autonomous vehicles on tomorrow's world, Bagloee et al. (2016) highlight a number of advantages and expectations concerning FAV, in particular as they relate to road safety, traffic congestion car-sharing, electricity, optimal use of road capacities, transport costs, freeing up time for users, land use, development of business in third-world countries and the decrease in greenhouse gases. Freight transport would also benefit from the advantages of automation. Sindi and

Woodman (2021) have identified several impacts of the use of autonomous goods vehicles (AGVs) in interviews with professionals in the logistics industry. Certain obstacles were highlighted, such as the difficulty of completely replacing the driver, who is not only responsible for driving the vehicle but also, for example, for securing the load on board. On the other hand, AGVs could facilitate manoeuvres at the quay and thus avoid many accidents, but above all reduce operating costs.

We will expand on the main expectations and advantages of FAV in the subsequent sections. Nevertheless, we emphasize that our objective is neither to draw up an exhaustive list of the advantages of FAV compared to traditional vehicles nor to plead in favour of FAV, but rather to illustrate why FAV are the subject of so much research today and why it is important that ergonomic psychology shows interest.

1.2.1. Improvement of road safety
FAV should considerably improve road safety. In addition to the conclusions drawn from the report on IVSS relative to the technologies on board the FAV, it is also recognized that mistakes made by drivers are responsible for three-quarters of road accidents (Imprialou & Quddus, 2019). Furthermore, FAV are considered a reliable means of reducing the number of accidents, since on one hand, they would include all the driving technologies necessary to prevent accidents, and on the other, they would eliminate all human intervention in controlling the vehicle.

However, this technocentric approach still needs to be moderated, since certain research works into ergonomics maintain that the best human-system performance is based on a cooperation that is distributed fairly between humans and machines, in an anthropocentric approach (Rabardel & Beguin, 2005).

1.2.2. Reducing road traffic congestion

Projections concerning the impact of FAV for reducing road congestion are contradictory.

On one hand, certain projections indicate that FAV will be capable of reducing traffic congestion, in particular, with the adoption of new travel habits and the adoption of car-sharing (Minelli et al., 2015). After observing different scenarios and situations taking into account several degrees of traffic density and different FAV penetration ratios, Lu et al. (2020) measured that FAV would be capable of increasing traffic density without impacting its fluidity. In this way, FAV would improve congestion by better exploiting road infrastructures and providing better coordination between vehicles. Furthermore, since FAV would be safer than vehicles driven by humans and would reduce the number of accidents, which are the cause of many traffic jams, this would also relieve traffic congestion (Bagloee et al., 2016).

On the other hand, expectations regarding congestion reduction are more modest. In a survey of six countries that could be highly impacted by FAV (China, Japan, India, United States of America, United Kingdom and Australia), opinions on the ability of FAV to better manage traffic and road decongestion vary greatly from one country to another: Indians are optimistic (72.3% of respondents estimate that FAV will have a positive impact on traffic congestion) while on the other hand, the British are much more sceptical (47.3% of respondents have positive expectations), as are the Japanese, Americans and Australians (Schoettle & Sivak, 2014). Several authors also estimate that the arrival of FAV would result in high demand for this means of transport, which would be made available for a large population that currently does not have access to individual transport: people that are visually impaired, that have a physical or mental handicap, the elderly or those without a driving licence. This rebound effect would significantly increase the number of vehicles on roads and would contribute to an increase in traffic congestion (Bissell et al., 2020; Metz, 2018; Minelli et al., 2015).

Whatever the predictions, all the research agrees that the introduction of FAV will require a thorough and global overhaul of transport methods. FAV will have to coordinate more with other forms of public transport (train, metro, aeroplane, bus, etc.) in order to offer users a global mobility service (Alessandrini et al., 2015; Buehler, 2018), commonly known as "Mobility as a Service."

1.2.3. Environmental benefits

The introduction of FAV is expected to bring many environmental benefits. In a literature review, Shiwakoti et al. (2020) noted that the reduction of greenhouse gases was the subject most addressed by research into autonomous vehicles since 2018. By combining several factors relating to FAV, such as a reduction in vehicle size, the optimization of road journeys and the use of electrical rather than thermal energy, (Sanguesa et al., 2021), Greenblatt and Saxena (2015) estimate that greenhouse gases could be reduced by 87–94% compared to current vehicle emissions.

In another study on the benefits of FAV for the environment, Jones and Leibowicz (2019) list the principal factors that would favour the reduction of greenhouse gases. Since individual vehicle are responsible for 60–75% of emissions in the transport sector, there are high expectations that FAV will improve this situation. Indeed, the change in the mobility model, which would go from individual mobility to mobility on demand (Pavone, 2015), where no single person (or single household) would have precedence over a vehicle, but they would be shared with on-demand access (Golbabaei et al., 2021), would be one of the most important factors for the conservation of the environment. In this case, FAV fleets would manage their parking themselves and take into account traffic flows in order to avoid congestion (Tu et al., 2019).

Finally, it is expected that FAV would be programmed to drive in an ecological way, thus limiting brusque and erratic accelerating and braking, which use excessive energy. A simulation of traffic entirely managed by autonomous vehicles saw a 45% reduction in energy consumption to be measured compared to a fleet of conventional vehicles (Chen et al., 2019).

1.2.4. Life quality improvement and social benefits

There is a general consensus that FAV will offer the possibility for numerous categories of society to improve their quality of life. The main perceived advantages of FAV are: a reduction of driving-related stress; the opportunity to relax during long journeys and to spend time with other activities, such as reading (Thomopoulos & Givoni, 2015); the reduction of accidents and therefore, the preservation of the physical health of users; a reduction in insurance costs; and the possibility to travel whenever users want (Pettigrew, 2017; Pettigrew et al., 2018; Pettigrew & Cronin, 2019).

Young people, the elderly and those with a handicap are those that suffer the most from restrictions on their mobility. A study by The Society of Morot Manufacturers and Traders Limited (Hawes, 2017) indicates that these three groups identified FAV as a potential solution for improving their mobility and quality of life. The study shows that more than 50% of those surveyed estimate that their mobility is limited, whereas 48% of them declare that the reduction in driving-related stress would be the main advantage of FAV. In this way, FAV favour social inclusion by offering more freedom of mobility to categories of people excluded from current transport models (Pettigrew, 2017). According to Crayton and Meier (2017), these advantages would however not be effective without a new global policy put in place by the authorities.

1.3. Interaction issues between pedestrians and FAV

Although FAV offer numerous opportunities for tomorrow's companies, they face many challenges in terms of design. Besides technical aspects related to the technologies they would have on board (autonomous driving systems, artificial intelligence, inter-vehicle communications, etc.), FAV must

also take the human factor into account. As with any innovative product, their design must be centred on the human in order to offer the best user experience possible (ISO 9241-210:2010,210:2010, 2010).

One of the challenges of human-centred design concerns interaction between pedestrians and FAV. Indeed, certain situations require the vehicles to transmit information to pedestrians, in particular when pedestrians begin to cross the road. In this part, we describe pedestrian behaviour observed when they cross the road, then, we present several pedestrian-FAV interaction solutions proposed in the literature.

1.3.1. Behaviour of pedestrians when they cross the road

Much research has focused on the observation of pedestrian behaviours when they cross the road, and the explicit and implicit interactions that are involved between pedestrians and motorized vehicles. From experience, all pedestrians know to what extent the signals transmitted by vehicle drivers are important when deciding whether or not to cross the road: the perceived attention of the driver, hand or head gestures, the flashing of headlights or eye contact, are all indications that allow pedestrians to know whether or not they can cross safely. Furthermore, the approach speed of the vehicle is also an important parameter in decision-making (Bella & Silvestri, 2015; Liu & Tung, 2014; Várhelyi, 1998).

The study of Sucha et al., (2017) enabled the quantification of pedestrian behaviours when they crossed a road at a zebra crossing without traffic lights. For example, 46% of pedestrians observed wait until the vehicles stop before crossing; 18% wait until the vehicles slow down, 2% do not wait for a reaction from the vehicles and cross spontaneously; and in 34% of observations, the vehicles do not give way at the zebra crossing, forcing the pedestrians to cross after them. Most pedestrians also declared that they tried to signal their intention to cross to the approaching vehicles using different behaviours: 84% of pedestrians try to make eye contact with the drivers, 9% indicated their intention to cross by stepping into the road, 4% made a hand gesture. Another study, this time concentrating on drivers, indicate that they try to make eye contact with pedestrians in order to assure them that they have seen them (Ren et al., 2016). Therefore, in the absence of eye contact, drivers approach the pedestrian crossing faster and with a less progressive deceleration than when eye contact is made. Eye contact is thus perceived by the drivers as the pedestrians expressing their intention to cross, which then incites them to better anticipate stopping.

Pedestrians adopt other strategies when they cross outside of zebra crossings. For example, Dey and Terken (2017) observed that if there is a lot of traffic on the road where the pedestrians want to cross, they generally stay on the kerb and wait for the cars to go by and the road to be completely clear before they begin to cross. Where the traffic is less dense, 61.3% of pedestrians estimate the trajectory of a vehicle in order to adjust their own movements and largely bypass the vehicle or leave a lot of space between themselves and the traffic. A smaller proportion of pedestrians (37.7%) wait until all the vehicles have gone by.

Finally, it is interesting to note that pedestrians do not expect explicit communication from drivers. Lee et al. (2021) highlight that less than 1% of the vehicles indicate to pedestrians that they are letting them cross, for example by flashing their headlights or sounding their horn. Approximately 4% of drivers make a hand gesture when they let pedestrians cross.

These studies thus indicate that a pedestrian-vehicle interaction, whether explicit or implicit, is initiated when the pedestrian tries to cross the road, with or without a zebra crossing. Certain drivers behaviours, including eye contact and the visual attention they pay to their environment, enable them to indicate to the pedestrians whether they can cross safely. For FAV without drivers, new forms of interaction must be implemented. Certain manufacturers and researchers propose alternative solutions in the absence of a driver, and we will introduce some of them in the next section.

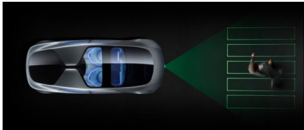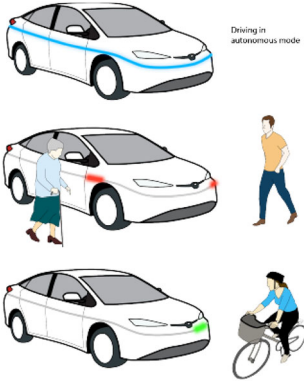### 1.3.2. Selected FAV pedestrian interaction solutions

The issue of the potential absence of a driver in the FAV, which would mean that pedestrian-driver interactions are no longer possible when crossing the road, has been taken into account since the middle of the 2010s. Remedial solutions are proposed in the form of human-machine interfaces integrated into the external elements of the vehicle, and these have the acronym eHMI (external Human-Machine Interface) (Bazilinskyy et al., 2019).

Several types of eHMI have been developed. Dey, Habibovic, et al. (2020) identify four main categories of visual eHMI:

- Anthropomorphic, that use human or anthropomorphic communication elements, such as facial expressions (eyes, smile) or gestures;
- Textual, that display an explicit text, such as "Stop," "Drive," "Please cross" or any other variant that uses text to communicate the state of the vehicle or instructions for pedestrians;
- Symbolic, that use recognizable traffic signals, such as stop signs, pedestrian crossing lines, the walking pedestrian symbol, arrows or other forms of iconic symbols;
- Abstract, which take on abstract visual forms, subject to the pedestrian's interpretation, or any other form of light-based or non-light-based communication devices, that are neither anthropomorphic, textual or symbolic.

28 eHMIs, developed by automotive manufacturers and parts suppliers or by research centres, were referenced by Bazilinskyy et al. (2019). However, there are many others, such as those proposed by Liu et al. (2021), Dey et al. (2020), Chang et al. (2017) or even de Clercq et al. (2019). As an illustration, in Table 2 we present an example of visual eHMI for each of the four categories of Dey et al. (2020).

Table 2. Examples of visual eHMI.

Category of the eHMI	Illustration	Functioning	Source
Anthropomorphic		The FAV have two friendly-looking eyes. They keep watching them while they cross in front of them.	Palmer (2018)
Textual		The FAV displays the message "Go Ahead" on its grille in order to inform the pedestrian that he/she can cross.	Vorsteher (2017)
Symbolic		The FAV projects a pedestrian crossing in front of it in order to inform the pedestrian that he/she can cross.	Mercedes Benz (2015)
Abstract		The FAV displays three states to pedestrians: 1. A blue band indicates that the FAV continues its path; 2. A red light indicates to pedestrians that they have been detected but that they do not have right of way; 3. A green light indicates to the pedestrian that he/she may cross.	Dey et al. (2018)

1.4. Presentation of the Pedestrian Receptivity Questionnaire for Fully autonomous vehicles (PRQF)

Research into autonomous vehicles and pedestrian behaviours shows to what extent pedestrian-FAV interactions are a fundamental issue that must be investigated. In a more targeted way on autonomous vehicles than the trust in automation scale (Jian et al., 1998), the Pedestrian Receptivity Questionnaire for Fully autonomous vehicles (PRQF), designed and validated by Deb et al. (2017), allows pedestrian perception of autonomous vehicles to be measured. The PRQF was defined by focusing in particular on the main technology acceptance models, such as the Technology Acceptance Model (TAM) (Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), as well as the first acceptation models of autonomous vehicles as drivers, such as the Car Technology Acceptance Model (CTAM) (Osswald et al., 2012).

The theoretical model of the PRQF is centred around five subscales, resumed in the questionnaire, which allow a prediction of the behavioural intention of the respondent to
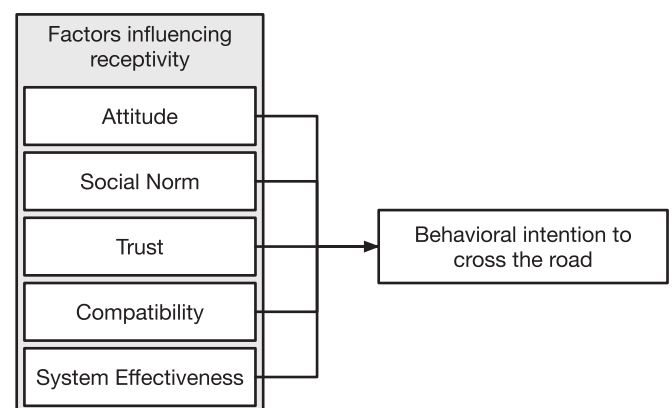
Figure 1. Conceptual model of the PRQF (according to Deb et al., 2017).

cross the road in front of an FAV (Figure 1). These subscales are:

- The attitude of the pedestrian towards FAV (the acronym used is AT). It describes the positive or negative feelings towards FAV in general, as well as the specific technologies on board the vehicles;

- Social norms (S). They concern the feelings of the respondents concerning what people that are important and influential for their think;
- Trust (T). This registers to what extent FAV are perceived as capable of successfully detecting pedestrians and other obstacles on the road, stopping for them and letting them cross safely;
- Compatibility (C). This describes the degree to which an FAV is perceived as being compatible with the existing transportation system;
- System effectiveness (EF). This describes the individual conviction that an FAV will accomplish its tasks highly effectively.

In its definitive version, the PRQF comprises 16 items in the form of affirmative phrases. The respondents are asked to respond to each of them on a 7-point Likert scale going from 1 (strongly disagree) to 7 (strongly agree). Item 7 is reversed. Each subscale of the conceptual model is used by several items: attitude (AT) comprises 5 items; social norms (S) 3 items, of which one is reversed; trust (T) 3 items, compatibility (C) 3 items, of which it has one in common with effectiveness; and effectiveness (EF) comprises 3 items, including one in common with trust.

A high score on the PRQF represents a higher receptivity to FAV and a higher behavioural intention to cross in front of an FAV.

2. Objectives

The present study aims at testing the validity of a French version of the Pedestrian Receptivity Questionnaire for Fully Autonomous Vehicles. The first objective is to adapt in French the PRQF according to the proposed methodology by Vallerand (1989) and Gana et al. (2021). The second objective is to verify the psychometric properties of the French version of the PRQF, through the measure of internal consistency with Cronbach's alphas and McDonald's omega (Hayes & Coutts, 2020), principal factor analysis (PCA), confirmatory factor analysis (FCA) and the measure of convergent validity.

3. Method

3.1. Procedures and participants

It is recognized that the minimum size of the sample necessary for psychometric tests is at least five participants per item, which corresponds to 80 participants for the 16 items of the PRQF (Nunnally, 1978).

For the psychometric evaluation of the French adaptation of the PRQF, we disseminated an online survey. The participants were not compensated and were recruited through the investigator's social networks using online advertisements or email. We worked with a convenience sample, obtained without any particular method. Age was the only inclusion criterion; participants had to be at least 18 years old. All information that could have been used to

Table 3. Demographic characteristics of the sample questioned.

Demographic characteristics	n (%)
Sex	
Female	366 (62.67)
Male	208 (35.61)
Don't want to say	10 (1.71)
Age	
Average	32.06
Minimum	18
Maximum	87
25th percentile	19
50th percentile	25.5
75th percentile	42
Victim of a road accident	
No, never	247 (58.95)
Yes, as a pedestrian	11 (2.63)
Yes, as a vehicle passenger	161 (38.42)
Driving licence-holder	
No	137 (23.46)
Yes, for less than 3 years	123 (21.06)
Yes, for more than 3 years	324 (55.48)

identify individuals was deleted as soon as the second data collection was initiated, such as the email addresses. Thereafter, all of the data was treated with complete anonymity and confidentiality.

Of the 627 participants that completed the survey, 584 questionnaires were able to be used, in light of the incomplete and incoherent responses. Our sample was made up of 366 women and 208 men, with an average age of 32.07 years old ($SD = 15.566$), 30.26 for women ($SD = 14.72$) and 35.31 for men ($SD = 16.13$). 10 people preferred not to comment on their gender ($M = 30.80$; $SD = 23.41$). Additional questions dealt with sociodemographic characteristics such as driving licence holder or having been involved in a road accident.

All the demographic characteristics collected are resumed in Table 3.

3.2. Measures

3.2.1. The French version of the Pedestrian Receptivity Questionnaire for Fully Autonomous Vehicles

In order to provide a French adaptation of the PRQF, we followed the methodological framework proposed by Vallerand (1989) and Gana et al. (2021) for the transcultural translation and validation of psychological questionnaires in English into French. N.B. To make this article easier to read, the French version of the PRQF will be referred to as F-PRQF.

The first step consisted of preparing a preliminary version of the original questionnaire in French. Several methods are possible, including traditional translation where the researchers do the translation on their own, the committee method and the back translation method. For our study, and in order to minimize the bias of traditional translation cited by Vallerand (1989), we opted for a committee translation.

Translation by a committee requires several experts in the domain of the questionnaire to agree upon a preliminary version, which is subsequently validated. For our study, two French native speakers, bilingual experts in human elements,

were asked to propose a translation of the 16 items of the PRQF.

First, each translator did their own individual translation. The translators were able to write one or more translation propositions per item. Then, in a second phase, the researchers presented their translations and began discussing the content of their translations. The experts were then asked to reach a consensus on the formulation of the translations for each item. This individual translation work and subsequent debate was done virtually but in a synchronous way with the help of the Miro© tool.

Table 4 resumes the individual translations of each expert, then the consensual translation that resulted from their discussions. It was therefore indeed the consensual translation that was selected for the following validation steps.

It is interesting to note that, for many items, the consensual version is a complete reformulation of the individual translations. For example, for item 15 (FAV is compatible with all aspects of transportation system in my area), the consensual translation selected by the experts "Les VEA vont pouvoir fonctionner avec tous les types de transport et leur infrastructure de ma région" is different to the two individual translations ("Le véhicule autonome est compatible avec tous les types de transport de ma région" et "Les CAV sont compatibles avec tous les aspects du système de transport dans ma région/mon quartier"), although it uses some elements from them.

As for the PRQF, we kept the 7-point Likert scale going from 1 (strongly disagree—"Pas du tout d'accord") to 7 (strongly agree—"Tout à fait d'accord").

3.2.2. The Pedestrian Behavior Questionnaire

In order to proceed with a concurrent validation of the F-PRQF, we proceeded with the same comparison as Deb et al. (2017) of the PRQF with the Pedestrian Behavior Questionnaire (PBQ) (Deb et al., 2017). The PBQ enables the frequency of pedestrian high-risk behaviour to be measured. The long version contains 50 items and the shorter version 20 items. The PBQ is a self-administered questionnaire made up of affirmative phrases describing different pedestrian behaviours when crossing the road. For each phrase, the participant is asked to respond on a 6-point Likert scale depending on the frequency of the behaviour adopted (1 = very infrequently or never; 6 = very often or always).

The PBQ has five subscales:

- Violations (V), that correspond to behaviours that infringe traffic rules;
- Errors (E), that describe deviant or inappropriate behaviour, but that do not infringe the law;
- Lapses (L), that correspond to behaviours adopted due to forgetfulness or a lack of vigilance by the pedestrian;
- Aggressive behaviours (A) that are directed both at vehicle drivers and other pedestrians or any other road user;

- Positive behaviours (P) towards vehicle drivers or any other road users. It should be noted that all items in this subscale are reverse-scaled items.

The global score of the PBQ reports on the general behaviour of the pedestrian when he/she crosses the road. The higher the score, the more high-risk the behaviour.

For the purpose of our study, the PQB has been adapted into French (Appendix A). The French PBQ (F-PBQ) has a good general internal consistency with a Cronbach's alpha of 0.800. The Violations subscale has an alpha of 0.801 (compared to 0.84 in the original English version of the PBQ), 0.525 for the Errors subscale (compared to 0.73 for the PBQ), 0.818 for the Lapses subscale (compared to 0.87), 0.629 for the Aggressive behaviours subscale (compared to 0.83) and 0.606 for the Positive behaviours subscale (compared to 0.58).

3.3. Statistical analyses

We followed the psychometric analysis approach proposed by Gronier (2022) for the transcultural adaptation of scales. All statistical analyses were conducted using SPSS 26 and JASP 0.16.3.

Exploratory analyses were conducted using principal factor analysis (PCA) with an orthogonal Varimax rotation.

The internal consistency was measured with Cronbach's alphas and McDonald's omega (Hayes & Coutts, 2020). According to Nunnally (1978), the minimum acceptable coefficient should not be less than .70. For descriptive statistics and in order to evaluate a possible age and gender effects, Student's t-test and repeated measures ANOVAs were performed.

We also tested the dimensional model of the PRQF using confirmatory factor analyses (CFA). For these analyses, goodness of fit was tested with Chi^2 test. Moreover, according to Schweizer (2010), we choose four other adjustment indices for the analysis: Standardised Root Mean square Residual (SRMR), Root Mean Square Error of Approximation (RMSEA), Tucker-Lewis index (TLI) and Comparative Fit Index (CFI). It is assumed that the model could be considered satisfactory when the Chi^2/df was lower than 3, SRMR and RMSEA respectively lower than .06 and .08, TLI higher than .95 and CFI higher than .90 (Hu & Bentler, 1999; Steiger, 2007).

Convergent validity was measured by comparing the F-PRQF with the French adaptation of the Pedestrian Behavior Questionnaire (F-PBQ) (Deb et al., 2017).

4. Results

4.1. Exploratory study

4.1.1. Principal factor analysis
In line with the analyses carried out by Deb et al. (2017) to test the construct validity of the PRQF, we replicate a principal component factor analysis (PCA) on the F-PRQF.

Table 4. Translations of the PRQF items by experts, with the consensual translation selected for the psychometric validation phases.

PRQF items	Expert translation 1	Expert translation 2	Consensual translation
1. FAVs will enhance the overall transportation system (AT1).	Les véhicules autonomes vont améliorer le transport dans son ensemble.	Les CAV vont améliorer le système de transport global. / Les CAV vont améliorer globalement le transport.	Les VEA vont améliorer le transport dans son ensemble.
2. FAVs will make the roads safer (AT2).	Les véhicules autonomes vont rendre les routes plus sûres.	Les CAV vont rendre les routes plus sûres.	Les VEA vont rendre les routes plus sûres.
3. I would feel safe to cross roads in front of FAVs (AT3).	Je me sentirais plus confiant(e) pour traverser la route en présence de véhicules autonomes.	Je me sentirais en sécurité lorsque je traverse une route face à un CAV.	Je me sentirais en sécurité si je traversais la route devant des VEA.
4. It would take less effort from me to observe the surroundings and cross roads if there are FAVs involved (AT4).	S'il y a des véhicules autonomes sur la route, cela me demandera moins d'efforts pour vérifier le carrefour et ses abords.	Cela me demandera moins d'effort pour observer la route autour de moi et les carrefours en présence de CAV. / Si je me trouvais au milieu des CAV, cela me demandera moins d'effort pour observer la route autour de moi et les carrefours.	Si je veux traverser en présence de VEA, ça me demandera moins d'effort pour vérifier la route.
5. I would find it pleasant to cross the road in front of FAVs (AT5).	Ca me plairait de traverser la route devant des véhicules autonomes.	Je trouverais plaisant/amusant de traverser la route face à un CAV. / Je trouverais agréable de traverser la route face à un CAV.	Je trouverais cela plaisant de traverser la route devant des VEA.
6. People who influence my behavior would think that I should cross roads in front of FAVs (S1).	Les personnes ayant un impact sur mon attitude auront tendance à penser que je dois traverser devant les véhicules autonomes.	Les gens qui influencent mon comportement/qui me sont influents penseraient que je dois traverser la route face à un CAV. / Les personnes en qui je fais confiance/qui me sont toujours de bons conseils penseraient que je dois traverser la route (même) en face d'un CAV.	Les gens que j'ai l'habitude d'écouter pensent que je peux traverser la route devant des VEA.
7. People who are important to me would not think that I should cross roads in front of FAVs (S2).	Les gens qui comptent à mes yeux n'auront pas tendance à penser que je dois traverser devant des véhicules.	Les gens qui comptent pour moi penseraient que je ne dois pas traverser la route face à un CAV. / Les gens qui me sont chers penseraient que je ne dois pas traverser la route face à un CAV.	Les gens qui comptent pour moi vont plutôt penser qu'il ne faut pas traverser la route devant des VEA.
8. People who are important to me and/or influence my behavior trusts FAVs (or has a positive attitude towards FAVs) (S3).	Les gens qui comptent à mes yeux et qui ont un impact sur mon comportement ont confiance dans les véhicules autonomes (ou ont une bonne opinion de ceux-ci).	Les gens qui comptent pour moi ou les gens qui me sont influents font confiance aux CAV.	Les gens qui comptent pour moi et/ou que j'ai l'habitude d'écouter ont confiance dans les VEA ou en ont une bonne opinion.
9. Interacting with the system would not require a lot of mental effort (EF1).	L'interaction avec le système ne demande pas beaucoup de concentration.	Interagir avec le système ne me demanderait pas de gros efforts de réflexion/cognitif.	Interagir avec le système ne me demanderait pas de beaucoup réfléchir.
10. FAV can correctly detect pedestrians on streets (EF2).	Les véhicules autonomes détectent correctement les piétons sur la route.	Les CAV peuvent détecter correctement les piétons dans les rues.	Les VEA vont pouvoir détecter correctement les piétons dans les rues.
11. I would feel comfortable if my child, spouse, parents—or other loved ones—cross roads in the presence of FAVs (T1).	Je me sentirais à l'aise si mon enfant, épouse ou parent - ou autre proche - traversait la rue en présence de véhicules autonomes.	Je me sentirais confortable/rassuré si mes enfants, mon épouse, mes parents ou les autres personnes que j'aime traversaient la rue en présence de CAV.	Je me sentirais serein-e si mon enfant, partenaire, parent, ou autre proche, traversait la route en présence de VEA.
12. I would recommend my family and friends to be comfortable while crossing roads in front of FAVs (T2).	Je dirais à ma famille et à mes amis qu'ils peuvent être confiants lorsqu'ils traversent la rue en présence de véhicules autonomes.	Je recommanderais à ma famille et à mes amis de rester confortable/serein/en confiance quand ils traversent la rue face à un CAV.	Je dirais à ma famille et à mes amis qu'ils peuvent avoir confiance quand ils traversent la route en présence de VEA.
13. I would feel more comfortable doing other things (e.g., checking emails on my smartphone, talking to my companions) while crossing the road in front of FAVs (T3).	Je me sentirais plus tranquille/serein à faire autre chose quand je traverse la route (ex : regarder mes emails sur mon téléphone, ou discuter avec des amis) si je traverse face à des véhicules autonomes.	Je me sentirais plus serein/en confiance/rassuré à faire d'autres tâches (vérifier mes mails sur mon smartphone ou parler à mes amis par exemple) quand je traverse une rue face à un CAV.	Je me sentirais plus serein-e de faire autre chose quand je traverse la route devant des VEA (par exemple regarder mes emails sur mon téléphone, ou discuter avec des amis).
14. The traffic infrastructure supports the launch of FAVs (C1).	Les installations de la route prennent en compte le déploiement des véhicules autonomes.	L'infrastructure routière convient au lancement des CAV. / L'infrastructure routière est prête pour le lancement des CAV.	L'infrastructure routière est prête pour le lancement des VEA.
15. FAV is compatible with all aspects of transportation system in my area (C2).	Le véhicule autonome est compatible avec tous les types de transport de ma région.	Les CAV sont compatibles avec tous les aspects du système de transport dans ma région/ mon quartier.	Les VEA vont pouvoir fonctionner avec tous les types de transport et leur infrastructure de ma région.
16. FAVs will be able to effectively interact with other vehicles and pedestrians (EF3, C3).	Les véhicules autonomes seront capables d'interagir efficacement avec les autres véhicules et les piétons.	Les CAV seront capables d'interagir efficacement/correctement avec les autres véhicules et les piétons.	Les VEA seront capables d'interagir de manière efficace avec les autres véhicules et les piétons.

AT = Attitudes; S = Social norms; EF = Effectiveness; T = Trust; C = Compatibility.
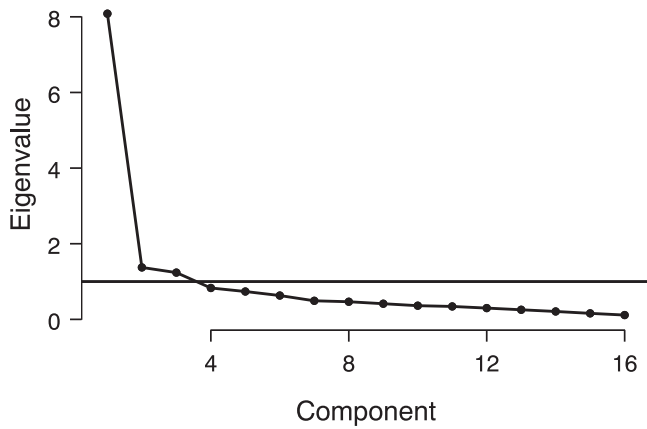
Figure 2. Scree plots for the F-PRQF, which suggests a three-component structure.

First, we obtain a Kaiser-Meykin-Olkin (KMO) measure of .924; Bartlett's test of sphericity was highly significant ($p < 0.000$). As a first step, this allows us to ensure that the items in the F-PRQF are highly correlated with each other.

Cattell's scree test (1966) (Eigenvalues) suggest a 3-component structure for the F-PRQF, each with an eigenvalue above 1. The first component accounts for 50.520% of the variance, the second 8.584% and the third 7.729% (Figure 2).

Table 5 presents the scores following a three-component Varimax rotation for the 16 items of the F-PRQF, comprising items ATT1, AT2, AT3, AT4, AT5, EF1, EF2, T1, T2 and T3 for the first component, items S1, S2 and S3 for the second, and items C1, C2 and EF3-C3 for the third.

Thus, the principal component analysis of the F-PRQF does not make it possible to find a factorial structure identical to that of the original scale, since the five dimensions do not differ completely. Only social norm (items S1, S2 and S3) and compatibility (C1, C2 and EF3-C3) appear in separate components. Attitude, efficacy and confidence items are grouped in the same component. It can be noted, however, that these items are the ones that directly ask participants about their interactions with VEAs, whereas the social norms items are concerned with what the respondent's social environment thinks of VEAs, and the compatibility items are concerned with the external elements of VEAs (infrastructure, ability of VEAs to interact).

4.1.2. Internal consistency

To measure the reliability of the F-PRQF, we calculated Cronbach's alpha and McDonald's omega, which forms the most widely used reliability measurement tests in human and social sciences. The Cronbach coefficient alpha of the F-PRQF confirms adequate reliability, with a score of 0.932, considerably superior to the threshold of .70 recommended by Landauer (1997) or Kline (2005). The McDonald's omega coefficient is 0.935.

There is no significant advantage to deleting an item. Only item 7 (S2) would enable an alpha of 0.933 and an

Table 5. 3-Component Varimax rotation for the 16 items of the F-PRQF.

F-PRQF items	Components		
	C1	C2	C3
1. Les VEA vont améliorer le transport dans son ensemble (AT1).	0.764		
2. Les VEA vont rendre les routes plus sûres (AT2).	0.818		
3. Je me sentirais en sécurité si je traversais la route devant des VEA (AT3).	0.823		
4. Si je veux traverser en présence de VEA, ça me demandera moins d'effort pour vérifier la route (AT4).	0.683		
5. Je trouverais cela plaisant de traverser la route devant des VEA (AT5).	0.664		
6. Les gens que j'ai l'habitude d'écouter pensent que je peux traverser la route devant des VEA (S1).		0.803	
7. Les gens qui comptent pour moi vont plutôt penser qu'il ne faut pas traverser la route devant des VEA (S2).		0.863	
8. Les gens qui comptent pour moi et/ou que j'ai l'habitude d'écouter ont confiance dans les VEA ou en ont une bonne opinion (S3).		0.721	
9. Interagir avec le système ne me demanderait pas de beaucoup réfléchir (EF1).	0.601		
10. Les VEA vont pouvoir détecter correctement les piétons dans les rues (EF2).	0.737		
11. Je me sentirais serein·e si mon enfant, partenaire, parent, ou autre proche, traversait la route en présence de VEA (T1).	0.755		
12. Je dirais à ma famille et à mes amis qu'ils peuvent avoir confiance quand ils traversent la route en présence de VEA (T2).	0.764		
13. Je me sentirais plus serein·e de faire autre chose quand je traverse la route devant des VEA (par exemple regarder mes emails sur mon téléphone, ou discuter avec des amis) (T3).	0.585		
14. L'infrastructure routière est prête pour le lancement des VEA (C1).			0.836
15. Les VEA vont pouvoir fonctionner avec tous les types de transport et leur infrastructure de ma région (C2).			0.855
16. Les VEA seront capables d'interagir de manière efficace avec les autres véhicules et les piétons (EF3-C3).			0.578

omega of 0.936 to be obtained, but to us, this gain seems too small to justify the deletion of this item. It must be noted that item 7 is the only reversed item in the questionnaire. The deletion of all the other items reduces the Cronbach's alpha and McDonald's omega scores.

Therefore, our translation shows good internal consistency overall.

We also calculated the reliability scores for the five factors of the PRQF. The results are presented in Table 6.

4.1.3. Associations between the F-PRQF scores and demographic variables

Several sensitivity analyses were undertaken and comparisons were drawn with the results obtained for the PRQF. In this way, like Deb et al. (2017), we first obtain a significant

difference to the general receptivity score depending on gender ($F(2, 581) = 7.227$, $p < 0.001$). On the other hand, there are no significant difference in terms of age (Pearson coefficient correlation $r = 0.076$, $p = 0.068$).

Our other comparisons allowed us to analyse the influence of variables other than those studied by Deb et al. (2017). The possession of a driving licence has a significant influence on receptivity ($F(2, 581) = 5.437$, $p = 0.005$). Conversely, having been the victim of a road accident does not seem to have an impact on the receptivity score ($F(2, 581) = 0.137$, $p = 0.872$).

4.2. Confirmatory study

4.2.1. Confirmatory factor analysis
We did a confirmatory factor analysis (CFA) using the original organization by factor of the items of the PRQF. The objective here is to verify that the structure of the F-PRQF is sufficiently close to the structure of the original questionnaire, even if the results of the PCA were a little different concerning the items grouped together in each component. We used the weighted least squares (WLS) criterion for optimal estimation (Figure 3).

We also tested the three-factor structural model of the F-PRQF, found above by the PCA that we applied, and the three-factor structural model of the PRQF found by Deb et al. (2017). The fit index values are presented in the Table 7.

Table 6. Cronbach's alphas and McDonald's omegas for each factor of the PRQF.

Factor	F-PRQF Cronbach's alpha	F-PRQF McDonald's omega
Attitude	0.889	0.891
Social Norms	0.809	0.814
Effectiveness	0.771	0.783
Trust	0.876	0.893
Compatibility	0.785	0.799

4.2.2. Convergent validity
Like Deb et al. (2017), we compared the results to the scores of each subscale of the French version of the Pedestrian Behavior Questionnaire (F-PBQ) and each subscale of the F-PRQF. The Pearson correlation coefficients and p-values are indicated in Table 8.

The results reveal that there is no significant correlation between the F-PBQ and the F-PRQF, whether for the global scores for each of the two scales or for each subscale. This partly corresponds to the results obtained by Deb et al. (2017), even if we did not find significant links between the Errors and Interaction, or Aggressive behaviours and Interaction subscales, contrary to the results found with the original scale.

5. Discussions

The French version of the PRQF displays numerous psychometric qualities that tend to show that this questionnaire can be used by the French-speaking public. However, several points deserve to be discussed that could improve the current version of the F-PRQF.

5.1. Validation of the original structure of the PRQF

When designing and validating the PRQF, Deb et al. (2017) created a 5-factor scale based on theoretical elements from a literature review. They proposed a conceptual model integrating attitudes, social norms, system effectiveness, trust and compatibility (Figure 1). However, the PCA and CFA did not find and confirm the theoretical model. The authors then proposed a three-factor scale named Safety (including items AT1, AT2, S3 and EF2), Interaction (items T1, T2, T3, AT3, AT4, AT5, S1 and S2) and Compatibility (items EF3-C3, C1 and C2). The EF1 effectiveness item was removed from the CFA because it was too weakly associated with any of the three factors.
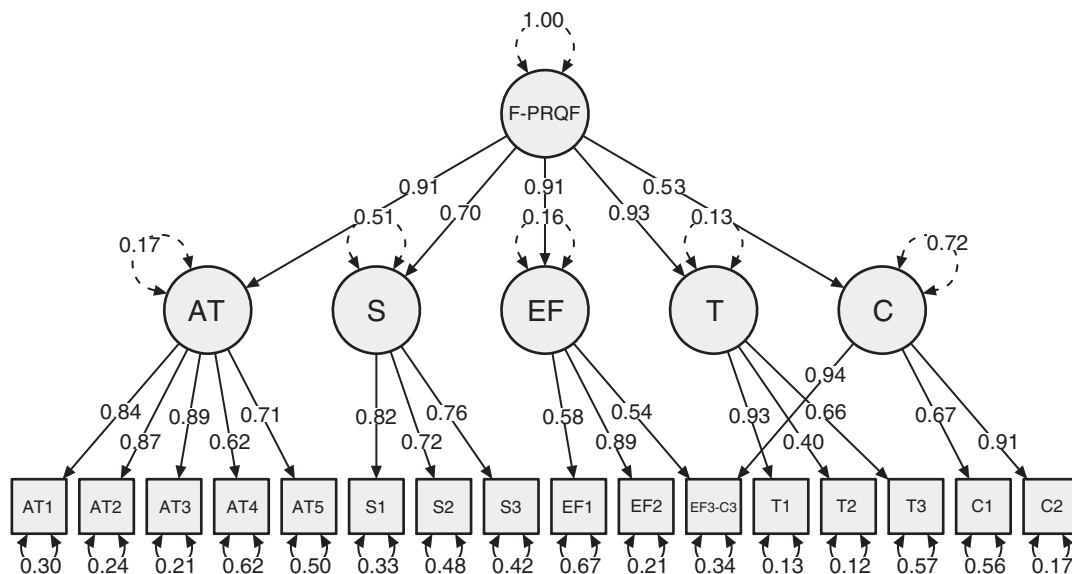

Figure 3. Standardized solution of the confirmatory factor analysis of the F-PRQF, using the original structure of the PRQF. Correlation among factors and standard regression weights were all statistically significant, with $p < 0.001$ (AT: Attitudes; S: Social norms; EF: Effectiveness; T: Trust; C: Compatibility).

Table 7. Fit index values for the three different tested models.

Model	Chi^2	p	ddl	Chi^2/ddl	CFI	TLI	SRMR	RMSEA
PRQF original structural model (Deb et al., 2017)	477.017	< 0.001	98	4.867	0.940	0.951	0.046	0.079
F-PRQF (three-factors)	926.337	< 0.001	101	9.172	0.868	0.843	0.055	0.118
PRQF three-factor structural model (Deb et al., 2017)	1063.779	< 0.001	87	12.227	0.839	0.805	0.073	0.139

Table 8. Results of the correlations between the subscales of the F-PBQ and those of the F-PRQF.

			F-PBQ					
			Violations	Errors	Lapses	Aggressive behaviours	Positive behaviours	Global score
F-PRQF	Attitude	Pearson's r	0.044	0.025	−0.014	0.004	−0.059	0.003
		p-Value	0.296	0.560	0.749	0.920	0.160	0.940
	Social norms	Pearson's r	0.025	0.050	0.017	−0.013	0.006	0.029
		p-Value	0.552	0.234	0.693	0.764	0.884	0.497
	Effectiveness	Pearson's r	0.064	0.031	0.020	−0.058	−0.075	0.003
		p-Value	0.127	0.469	0.641	0.171	0.075	0.945
	Trust	Pearson's r	0.099	0.059	0.014	−0.022	−0.039	0.045
		p-Value	0.019	0.164	0.734	0.610	0.357	0.289
	Compatibility	Pearson's r	0.054	0.017	0.008	−0.048	−0.017	0.014
		p-Value	0.198	0.684	0.845	0.253	0.687	0.747
	Global score	Pearson's r	0.068	0.043	0.008	−0.026	−0.046	0.022
		p-Value	0.106	0.306	0.843	0.532	0.281	0.597

Our study on the psychometric validation of the French adaptation of the PRQF shows different results. Although the PCA also identified three factors, these did not include the same items as the PRQF. More importantly, the CFA that we conducted on the different models of the F-PRQF (Table 7) validate the original theoretical model of the PRQF. Indeed, most of the fit index values are above the validity thresholds (CFI > .90; TLI > .95; SRMR < .06 and RMSEA < .08). Only the Chi^2/df is greater than 3 (4.867).

We therefore recommend using and analysing the F-PRQF on the basis of its theoretical 5-factor model, keeping the theoretical distribution of items within these factors.

5.2. Reformulation of the reversed item

The calculation of the Cronbach's alpha coefficient for the F-PRQF showed that a higher score, going from 0.927 to 0.932, could only be obtained by deleting item 7 (S2). However, we considered that this gain was not significant and that the F-PRQF already displayed a sufficiently high consistency ($\alpha = 0.927$).

We also highlighted that item 7 was the only reversed item in the questionnaire, which brought us to consider the usefulness of this reversed item. Sauro and Lewis (2011) carried out a survey on the reformulation of reversed items of the System Usability Scale (SUS) questionnaire, of which 1 item is reversed. The authors particularly highlight that the reversed items, formulated negatively, are less well understood by respondents than the other items, and are the cause of more errors in their completion. Even if the results are not all significant, Sauro and Lewis consider that the advantages of including reversed items (for example, to avoid certain completion biases) do not compensate for the disadvantages. Later, the same authors (Lewis & Sauro, 2017) re-evaluated the factor structure of the SUS according to several models. The structure that proved to be the most robust statistically is the one that distinguishes the reversed items (negative formulation) from the non-reversed items

(positive formulation). Once again, these results prove that for the SUS, which aspires to be a single-factor scale, the use of reversed items disrupts the full understanding of these items.

Concerning the F-PRQF, it seem to us that item 7 ("Les gens qui comptent pour moi vont plutôt penser qu'il ne faut pas traverser la route devant des VEA") would benefit from being reformulated in a way that avoids it being differentiated from the others simply because of its negative formulation. In this way, this item could be reformulated for example in the following way: "Les gens qui comptent pour moi vont plutôt penser que l'on peut traverser la route devant des VEA."

5.3. Concurrent validation

The concurrent validation that we applied consisted, in keeping with Deb et al. (2017), of measuring the links between the Pedestrian Behavior Questionnaire (PBQ) and the PRQF. To do this, we had to create a French version of the PBQ. The results did not show significant links between the two scales. It is thus possible that high-risk pedestrian behaviours are not directly related to receptivity towards FAV. Indeed the behaviours adopted when a pedestrian crosses the road do not systematically make reference to the manner in which he/she would be ready to accept autonomous vehicles. These two issues do not seem to us to be strongly correlated and could explain why we do not find significant links between the two questionnaires in their French versions.

In order to apply a concurrent validation that makes more sense, we could for example cross the F-PRQF with other questionnaires that also relate to the acceptance of technologies. Questionnaires like the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) seem to us to be more suitable for a cross analysis. In particular, the UTAUT has some subscales that are comparable to those of the PRQF, including attitude towards

technology, social influence and perceived effectiveness. Although the UTAUT was designed more to evaluate acceptance of a technology in the area of work, it has been applied several times in other contexts, in particular, technologies intended for the general public (Hsu, 2012; Williams et al., 2015). Consequently, it could also be proposed to evaluate the acceptance of FAV, in order to be compared to the F-PRQF.

5.4. Limitations

Although this study proposed a first psychometric validation of a French version of the PRQF that meets a number of criteria, several limitations should be overcome. First of all, the validation of the F-PRQF focused on the dissemination of a survey without a specific study context. Indeed, participants were simply asked to express their perception of autonomous and connected vehicles as a pedestrian, without any situational proposition. The situations that could be proposed could be varied: position the participants in the street (or on a simulator) in front of a pedestrian crossing; display the image of a person (an adult, a child, an elderly person) crossing a street; or for example, ask the participants to express their receptivity according to the eHMIs integrated into the vehicles.

It would also be interesting to study the impact of other socio-demographic factors on the perception of fully autonomous vehicles. For example, the context of the participant's habitat, urban or rural, may be an important factor in the global acceptance of autonomous vehicles. Personality is also an important element in the adoption of risky pedestrian behaviour (Herrero-Fernández et al., 2016). Furthermore, numerous studies have already shown that technological acceptance varied depending on the culture and country of residence (Al-Gahtani et al., 2007; Burton-Jones & Hubona, 2005). It would therefore be interesting to concentrate our efforts on recruiting respondents where we take into account where they live, and for example, compare several populations according to the French-speaking country. For example, we could expect to find cultural differences between the Quebecois population with its north American culture and the French population with its European culture. Differences could also be observed between certain European French-speaking countries, like between France, Belgium, Luxembourg and Switzerland.

Finally, the sample of respondents could be expanded to strengthen the psychometric analyses for the validation of the F-PRQF.

6. Conclusion and research perspectives

The aim of this study was to translate and validate a French version of the PRQF, developed by Deb et al. (2017). This questionnaire with 16 items elicits the perception of pedestrians regarding autonomous vehicles, in particular in situations where the pedestrian has to cross a road where there is an FAV.

This translation appears important for the international French-speaking community, where French is the native

language or one of the official languages. There are 29 states in the world where French is the everyday language, including France, Belgium, Luxembourg, Switzerland and Canada. These five countries are particularly active in research into autonomous vehicles. For example, France has several research institutes dedicated to transport and automation. The Institute of Energy Transition (ITE) VEDECOM develops numerous solutions as part of the New Industrial France (NFI) Autonomous Vehicle Plan, an Invest for the Future (PIA) programme supported by the Government. Other institutes such as IFSTTAR (French Institute of Science and Technology for Transport, Development and Networks), INRIA (National Institute for Research in Digital Science and Technology), Cerama (Centre for Studies on Risks, the Environment, Mobility and Urban Planning) or the LS2N (Nantes Laboratory of Digital Sciences) also focus part of their research on autonomous and connected vehicles and the related human issues. The F-PRQF could therefore also be a methodological tool that would be useful to them.

We also find several publications in French that used the PRQF translated freely (Dommes et al., 2020). A validated version would reinforce the robustness of these studies.

In agreement with Deb et al. (2017) and Deb et al. (2017), it seems interesting to us, although limited (see Section 5.3), to associate a measurement of high-risk pedestrian behaviours when they are crossing the road (as measured in the PBQ) with a measurement of receptivity of the pedestrians concerning FAV (as measured in the PRQF). For the concurrent validation of the F-PRQF, we therefore did a French translation of the PBQ. From this point on, we would need to continue with the psychometric validation of the F-PBQ, on one hand by disseminating it to a larger sample of respondents, while paying attention to the intercultural dimensions as stated above, and on the other, by intensifying the statistical analyses by a principal component and confirmatory factor analysis.

In this way, with a validated version of the F-PBQ available, we would be able not only to cross it with the F-PRQF in a more relevant way, but we would also further contribute to the methodological enrichment of the French-speaking community working on pedestrian safety.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix A. Committee translation of the PBQ items

PBQ items	French translation (F-PBQ)
1. I cross the street even though the pedestrian light is red (V).	Je traverse la rue même si le feu piéton est rouge.
2. I cross diagonally to save time (V).	Je traverse en diagonale pour gagner du temps.
3. I cross outside the pedestrian crossing even if there is one (crosswalk) less than 50 meters away (V).	Je traverse en-dehors des passages piétons même s'il y en a un qui se trouve à moins de 50 mètres.
4. I take passageways forbidden to pedestrians to save time (V).	J'emprunte les passages interdits aux piétons pour gagner du temps.
5. I cross between vehicles stopped on the roadway in traffic jams (E).	Je traverse entre les véhicules à l'arrêt dans les embouteillages.
6. I cross even if vehicles are coming because I think they will stop for me (E).	Je traverse devant des véhicules en approche, car je pense qu'ils vont s'arrêter pour me laisser passer.
7. I walk on cycling paths when I could walk on the sidewalk (E).	Je marche sur les pistes cyclables alors que je pourrais marcher sur le trottoir.
8. I run across the street without looking because I am in a hurry (E).	Je traverse la rue en courant sans regarder quand je suis pressé·e.
9. I realize that I have crossed several streets and intersections without paying attention to traffic (L).	Il m'arrive de traverser plusieurs rues et carrefours sans faire attention au trafic.
10. I forget to look before crossing because I am thinking about something else (L).	J'oublie de regarder avant de traverser quand je pense à autre chose.
11. I cross without looking because I am talking with someone (L).	Je traverse sans regarder quand je discute avec quelqu'un.
12. I forget to look before crossing because I want to join someone on the sidewalk on the other side (L).	J'oublie de regarder avant de traverser quand je veux rejoindre quelqu'un sur le trottoir d'en face.
13. I get angry with another road user (pedestrian, driver, cyclist, etc.), and I yell at him (A).	Je m'énerve contre d'autres usagers de la route (piétons, conducteurs, cyclistes, etc.) et je leur crie dessus.
14. I cross very slowly to annoy a driver (A).	Je traverse très lentement pour embêter les automobilistes.
15. I get angry with another road user (pedestrian, driver, cyclist, etc.), and I make a hand gesture (A).	Je m'énerve contre d'autres usagers de la route (piétons, automobilistes, cyclistes, etc.) et je leur fais des gestes grossiers.
16. I have gotten angry with a driver and hit their vehicle (A).	Il m'est déjà arrivé de m'énerver contre un automobiliste et de donner un coup dans son véhicule.
17. I thank a driver who stops to let me cross (P).	Je remercie les automobilistes qui s'arrêtent pour me laisser traverser.
18. When I am accompanied by other pedestrians, I walk in single file on narrow sidewalks so as not to bother the pedestrians I meet (P).	Quand je marche en compagnie d'autres personnes sur un trottoir étroit, je me mets en file indienne pour ne pas gêner les piétons que je croise.
19. I walk on the right-hand side of the sidewalk so as not to bother the pedestrians I meet (P).	Je marche du côté droit du trottoir pour ne pas gêner les piétons que je croise.
20. I let a car go by, even if I have the right-of-way, if there is no other vehicle behind it (P).	Je laisse passer une voiture même si j'ai la priorité, s'il n'y a pas d'autre voiture derrière elle.

V = Violations; E = Errors; L = Lapses; A = Agressive behaviours; P = Positive behaviours.