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Readiness to Change and Pro-Environmental Transportation Behaviors: A Multidimensional and Gender-Sensitive Analysis

Mirko Duradoni [1,*], Marina Baroni [1], Giulia Valdrighi [1] and Andrea Guazzini [1,2]

[1] Department of Education, Literatures, Intercultural Studies, Languages and Psychology, University of Florence, 50135 Florence, Italy; marina.baroni@unifi.it (M.B.); andrea.guazzini@unifi.it (A.G.)
[2] Centre for the Study of Complex Dynamics, University of Florence, 50135 Florence, Italy
* Correspondence: mirko.duradoni@unifi.it

Abstract: The escalating climate crisis necessitates urgent and widespread behavioral change, particularly in transportation choices, given their significant contribution to greenhouse gas emissions. This study examines the relationship between dimensions of readiness to change (RTC) and pro-environmental transportation behaviors (PEB-T), exploring both linear and non-linear patterns of association. Data were collected from 807 participants via an online survey, and analyses included linear discriminant analysis (LDA) and network analysis (NA) to account for non-linear relationships and gender-specific variations. Results indicate that perceived importance of the problem consistently emerged as a critical predictor of PEB-T across all analyses and gender groups. However, other dimensions, such as motivation, effectiveness of the proposed solution, action, and perceived readiness, exhibited gender-sensitive effects. These findings advance the understanding of RTC as a determinant of PEB-T, highlighting both universal and gender-specific predictors. The study supports the hypothesis of non-linear relationships between antecedents and behaviors, emphasizing the need for tailored interventions.

Keywords: readiness to change; sustainable transportation; pro-environmental behaviors

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Academic Editor: Grigorios L. Kyriakopoulos

Received: 7 March 2025
Revised: 26 March 2025
Accepted: 27 March 2025
Published: 28 March 2025

Citation: Duradoni, M.; Baroni, M.; Valdrighi, G.; Guazzini, A. Readiness to Change and Pro-Environmental Transportation Behaviors: A Multidimensional and Gender-Sensitive Analysis. *Sustainability* **2025**, *17*, 3021. https://doi.org/10.3390/su17073021

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1. Introduction

1.1. Climate Emergency

The current climate crisis, as reported by the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [1] and the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change [2], is accelerating at an alarming rate. The measures that governments have devised and implemented worldwide are proving inadequate or insufficient. In recent years, various agreements and policies have been introduced to achieve environmentally friendly, economically sustainable goals, and promote societal well-being [3]. Nevertheless, COP28 has demonstrated that progress across all areas of climate action has been too slow. The IPCC [1] unequivocally describes the human influence on the warming of the atmosphere, oceans, and land, adding that the adverse impacts of human-caused climate change will continue to intensify.

The United Nations Regional Information Centre [2] indicates that the current global average temperature is between 0.94 and 1.03 °C higher than at the end of the nineteenth century. According to scientists, a 2 °C increase compared to pre-industrial levels would lead to dangerous, if not catastrophic, consequences for the climate, the environment, and humanity as a whole. For this reason, the international community agrees that global warming must be kept well below 2 °C. In a series of UN reports, thousands of scientists

have concurred that limiting the rise in global temperature to no more than 1.5 °C would help us avoid the worst consequences and maintain a livable climate. Nevertheless, current data suggest that due to carbon dioxide emissions, global temperatures could rise by as much as 3.2 °C by the end of the century. Warming will likely reach +1.5 °C between 2030 and 2052 if current emission rates are maintained [4].

Many people believe that climate change essentially means higher temperatures. However, the temperature rise is just a preliminary indicator. The Earth is an interconnected system; thus, changes in one area can influence changes in all others [2]. Global warming is increasingly causing dramatic consequences, including a rise in the frequency and intensity of wildfires, dust storms, hurricanes, flooding, heatwaves, and droughts [5].

Climate action requires significant investments in terms of changes, but climate inaction is enormously more costly: "The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near term" [1].

1.2. Need for Behavioral Change and Importance of Transport Behavior

Behavior change plays a central role in tackling the climate crisis [6]. Climate mitigation actions demand some degree of behavior change [7], while adaptation action also requires substantial transformations in lifestyle and society [1,8]. Mitigation strategies involve measures and approaches designed to decrease greenhouse gas emissions and minimize the repercussions of climate change [6]. In contrast, adaptation measures encompass immediate and long-term behavioral adjustments, such as readiness for extreme weather conditions [9].

Impactful mitigation actions encompass reducing air travel and driving, as well as minimizing consumption of red meat, dairy products, materials, and energy [10,11]. This highlights the significance of considering a wide range of behaviors including transport behaviors, since the transportation sector is crucial for achieving global greenhouse gas (GHG) reduction targets [12]. In the United States, for example, transportation was responsible for the largest share of total GHG emissions in 2022, accounting for 28% of the total, as reported by the Environmental Protection Agency [13]. The primary source of emissions from transportation activities is linked to road transport [14]. Although the aviation sector ranks as the second largest contributor to greenhouse gas emissions, its carbon emissions are particularly concerning due to their effects at high altitudes, as they alter atmospheric composition and exacerbate greenhouse gas concentrations and emissions at ground level. The environmental repercussions of transportation cannot be overemphasized.

The expansion of the transportation system should be meticulously planned to ensure global sustainability through what is known as green or sustainable transport [15]. Green transport can be defined as "transport services that have a lower negative impact on human health and the environment compared to existing transport services" [16]. It can be viewed as a combinatory technology that includes the optimal use of traditional fuels, efficient deployment of electric vehicle technologies, utilizing biogas as fuel for buses, and enhancing public transportation systems [17]. An effective green transport system can lead to reduced risk, decreased traffic congestion, improved energy and resource sustainability, pollution reduction, accident prevention, enhanced safety and security, and optimization of travel speed and traffic flow.

Given the positive environmental impact of green transport choices, society needs to create favorable conditions that can steer individuals toward these options. Additionally, understanding the factors that influence people's decisions to adopt sustainable transport choices is crucial.

1.3. Readiness to Change: A Recent Framework for Sustainability Behaviors

The term "readiness" is widely associated with change; however, the construct itself remains poorly understood [18]. From a psychological perspective, readiness refers to the mental and physical preparation to undertake an action [19].

Readiness can be conceptualized as a state in terms of "readiness to do something" [20] or "readiness for an event" [21]. A challenge associated with defining readiness as a state is the lack of clear criteria regarding what constitutes it [22]. Additionally, the state-based approach provides limited insight into how people reach this state. Furthermore, researchers examining readiness as a state tend to focus on the factors associated with it rather than on understanding what constitutes readiness itself.

An alternative perspective is to conceptualize readiness as a process wherein individuals become ready over time. When studied this way, readiness is typically viewed as part of a broader process [23].

Dalton et al. [18] expanded the concept of readiness by conceptualizing it as both a state and a process. This latter aspect comprises several stages: the first stage involves becoming aware of what needs to change; the second stage entails engaging in an evaluative process to analyze the costs and benefits of the change, thereby determining whether to plan for it or not; the third stage requires considering whether one possesses the necessary skills, energy, capabilities, and support to implement the desired change. The evaluative process is a critical phase, as the individual ultimately decides whether to "commit" to or "abandon" the journey toward readiness.

Armenakis et al. [24] defined readiness to change as the "beliefs, attitudes, and intentions regarding the extent to which changes are needed and the organization's capacity to successfully undertake those changes". This definition emphasizes beliefs but does not examine the affective component of readiness for change. In the study by Dalton et al. [18], becoming readily involved leads to changes in the cognitive, affective, and/or behavioral domains. Holt et al. [25] offered a definition that incorporates the emotional dimension, stating that readiness to change is "the extent to which an individual or individuals are cognitively and emotionally inclined to accept, embrace, and adopt a particular plan to purposefully alter the status quo". Crites et al. [26] assert that affect is an important component of RTC, which can encompass qualitatively diverse emotions, including love, hate, joy, sadness, happiness, annoyance, calmness, excitement, boredom, relaxation, anger, acceptance, disgust, joy, and pain. Rafferty et al. [27] propose that an individual's readiness to change is influenced overall by beliefs (that change is necessary, that they have the capacity to undertake the change successfully, and that change will yield positive outcomes) and by affect (both current and future).

In relation to environmental issues, various authors have studied the construct of readiness to change to understand its implications for pro-environmental actions. The literature indicates a scarcity of models for assessing the level of readiness to change, particularly with regard to sustainability behavior [28]. While several models have been developed to analyze environmental behavior, they do not focus on evaluating RTC. Notable examples include the Stages of Action Model [27], the Theory of Planned Behavior [29], and the Norm Activation Model [30]. Similarly, there are models of readiness to change that have been extensively implemented in various sectors yet are only marginally applicable to the environmental field. One such model is the Transtheoretical Model of Behavioral Change [31].

Consequently, it can be concluded that existing theoretical models related to pro-environmental behavior offer limited consideration of the stages of human behavioral change. In response, Duradoni et al. [32] proposed a new conceptualization of readiness to change (RTC) applied to the domain of sustainability, identifying various dimensions of

RTC involved in pro-environmental behavior. This multidimensional framework comprises seven dimensions, which are as follows:

1. Perceived Importance of the Problem/Change: The Health Action Process Approach (HAPA) [33] proposes risk perception as a predictor of behavior change, suggesting that there must be a minimum level of threat or concern before individuals begin to consider the potential benefits of actions and contemplate change. Additionally, Miller and Tonigan's SOCRATES [34] identifies other factors related to change, specifically describing "recognition" as the acknowledgment of one's problematic behavior.
2. Motivation: Cox et al. [35] identifies a positive correlation between high levels of motivation and readiness to change. Individuals exhibiting high motivation demonstrate a commitment to pursuing attainable goals, which, upon successful achievement, are expected to yield emotional satisfaction.
3. Self-Efficacy: This is defined as the individual's perception of their capability to successfully effect change [36]. The HAPA [33] identifies self-efficacy as a significant direct predictor of behavioral change. Similarly, the Health Belief Model [37], which seeks to elucidate the factors influencing behavior change, also incorporates self-efficacy as a key factor. In addition to the stages associated with the transtheoretical model of change, self-efficacy has been recently integrated as a new component of the framework [38].
4. Effectiveness of Proposed Solution: Outcome expectancies, as well as their anticipated effectiveness, are defined as the perceived consequences of an individual's behavior. More precisely, outcome expectancies pertain to the anticipation of physical, affective, and social consequences arising from one's actions [39]. In the HAPA [33], outcome expectations, which encompass both positive and negative aspects of behavior, serve as predictors of behavioral change.
5. Social Support: In the HAPA [33], the presence of this factor serves as a valuable [40] resource, while its absence can hinder the adoption or maintenance of healthy behaviors [40]. Individuals are generally more inclined to initiate change when supported by others who are helpful, encouraging, and understanding [41]. As a result, those considering a change or making early efforts to alter their behavior will particularly benefit from having supportive people around them.
6. Action and Involvement: In the transtheoretical model by Prochaska and DiClemente [42], the "action" stage refers to the stage when individuals have recently changed their behavior and intend to continue progressing with this behavioral modification. Schwarzer et al. [40] describe that when a person is inclined to adopt a specific health behavior, their "good intention" must be translated into detailed guidelines on how to carry out the desired action.
7. Perceived Readiness: This factor, understood as an individual's perceived willingness and preparedness for change, has been widely used as an indicator of RTC across general instruments primarily utilized in clinical, organizational, and social contexts, such as the Contemplation Ladder [43] and the Readiness Ruler [44]. Kwahk and Kim [45] identify four potential antecedents of readiness for change: organizational commitment, perceived personal competence, performance expectancy, and effort expectancy.

In summary, RTC represents an important and fundamental psychological construct reflecting the propensity for behavioral change and is composed of the seven dimensions mentioned above (Figure 1) [32] (Duradoni et al., 2024).

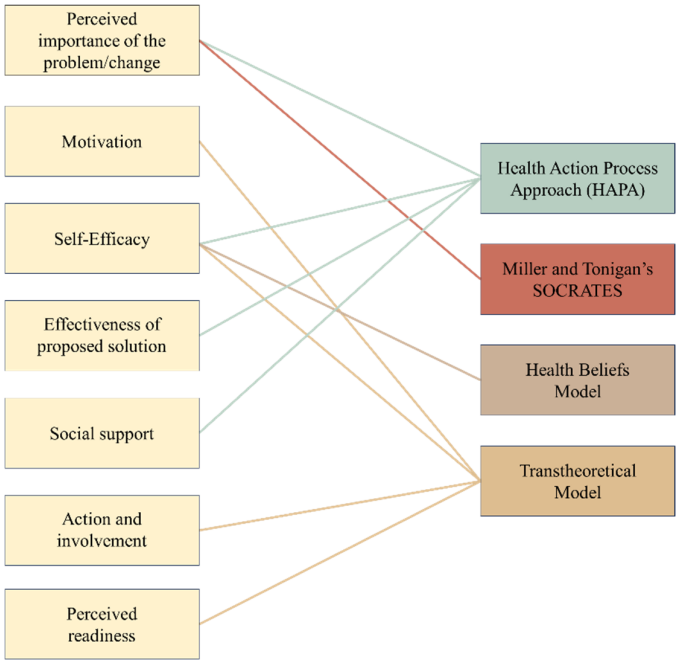


Figure 1. Conceptual framework: Theoretical models supporting readiness to change.

1.4. Readiness to Change and Transportation

Researchers from different areas of interest have examined the relationships between the seven dimensions of RTC (perceived importance of the problem/change, motivation, self-efficacy, effectiveness of proposed solution, social support, action and involvement, perceived readiness) and the adoption of environmentally friendly behaviors. This literature shows that each of these seven dimensions is related to the adoption of PEBs [9,46–51].

The study by Duradoni et al. [32] reveals a positive correlation between readiness to change, as assessed across all seven dimensions, and pro-environmental behavior: high levels of RTC are associated with elevated levels of PEBs.

Duradoni et al. [32] referred to Markle's four-cluster categorization of pro-environmental behaviors [52]: conservation, environmental citizenship, food, and transportation. Each of these clusters exhibits distinct correlations with the seven components of readiness to change. Notably, environmental citizenship within PEB demonstrates the strongest correlation with readiness to change, whereas transportation shows the weakest, showing small effect size across all seven dimensions.

In this regard, Sadeghian et al. [53] found that, contrary to their initial hypothesis that the lack of sustainable mobility practices stemmed from negligence or lack of information, fewer than 10% of participants held negative views. On the contrary, 80% of all classified statements were positive regarding sustainable mobility in general. Applying the transtheoretical model of behavior change (TTM) [42], the authors found that only a quarter of the positive statements were associated with the "action" stage or "preparation" stage, while most positive statements were in the "contemplation" stage, indicating awareness without action. This suggests that many people would consider alternatives if they were as efficient and appealing as personal transport.

The lack of sustainability in people's mobility practices could be attributed to the fact that transportation behavior, unlike the others, is characterized by an external locus of control [54]. As might be expected, the RTC construct is less sensitive in predicting behaviors over which individuals have a lower degree of control (external locus of control). Transportation choices seem to be less effectively predicted by the readiness to change (RTC) construct due to their dependence on various situational factors, including commuting

distance, public transportation availability, and economic constraints. This underscores the importance of ensuring that citizens are placed in conditions that make it more likely and advantageous for them to adopt transportation choices that are most favorable to our planet. Interventions and policies should be implemented to address these external factors, thereby promoting sustainable transportation behaviors.

1.5. Gender Differences in Pro-Environmental Behavior: A Focus on Transportation

Research has investigated the gender gap in climate change concerns and reported that women tend to express higher levels of environmental concern than men [55–57]. On a more concrete behavioral level, the literature agrees that women are generally more engaged in adopting pro-environmental behaviors compared to their male counterparts [58–60]. Previous studies consistently identify a gender gap in pro-environmental behavior; however, it is important to consider that the types of behaviors and the extent of the gap between men and women could change depending on the context [61]. It is therefore important to analyze the different clusters of PEB individually in relation to gender differences.

With regard to specific transportation behavior, several studies in the literature report that women are more likely to use public transportation then men [62], tend to use cars less often [63], and generally drive shorter distances [64]. Briscoe et al. [61] analyzed three transportation pro-environmental behaviors: car-pooling, taking public transportation, and walking or cycling. They found that women engage in more transportation-related pro-environmental behaviors than men, being more than twice as likely to carpool; however, no significant differences are observed between men and women for the other two categories of behavior. The authors proposed three possible interpretations of these results: gender socialization, safety concerns hypothesis, and ecofeminism. Gender socialization theory suggests that women are socialized into caregiving roles, which fosters an altruistic environmental perspective [65]. The safety concerns hypothesis suggests that individuals who perceive greater concern are more likely to take action to address a problem [66], which aligns with the literature indicating that women experience higher levels of concern [55–57]. The ecofeminist perspective links gender inequality in labor to environmental degradation, arguing that both the oppression of women and the destruction of nature stem from the same underlying cause: patriarchy [67]. Therefore, according to this theory, environmental responsibility has been feminized [59]. However, as suggested in the scientific literature, certain pro-environmental behaviors can be categorized as either feminine or masculine [68]. Based on this distinction, it has been observed that such categorization influences the enactment of PEBs due to the social consequences associated with gendered environmental actions [68]. Therefore, further studies are needed to better understand and explore the impact of these phenomena [68].

1.6. Aim of the Study

This study aims to analyze the relationship between readiness to change (RTC) dimensions and pro-environmental transportation behaviors, moving beyond the linear continuous approach previously discussed by Duradoni et al. [32]. Recent literature has begun to recognize that environmental antecedents and PEBs in their predictivity may follow a non-linear, potentially quadratic relationship [69]. In light of this, one approach involves discretizing PEB levels by focusing on extreme values (i.e., below the first quartile or above the third quartile), which may restore predictive capacity to RTC dimensions in relation to sustainable transportation behaviors within a linear framework. Alternatively, non-linear analytical methods, such as network analysis, may retain the continuous nature of the RTC-PEB relationship while managing its potential non-linearity. This paper will explore

both possibilities, adopting a gender-fair perspective as recommended by recent studies, recognizing that the relationship between these variables may be influenced by gender.

2. Methods

2.1. Participant Recruitment

Before the recruitment of participants, the sample needed to pursue the objectives of the present study was estimated. Regarding correlation and regression analyses, a power analysis was conducted using G*Power [70,71] to determine sample size while also preventing type I and type II errors. The power analysis pointed out that a sample composed of 616 participants (correlation analysis) and 725 participants (multiple linear regression analysis) would be necessary to achieve a statistical power of 0.80 and identify even small effect sizes (correlation analysis = 0.1; regression analysis = 0.02) by assuming a significance level of 0.05 [72]. Participants were recruited through the anonymous administration of an online survey that was developed with Google Forms and distributed through the main social networks (e.g., Facebook and Instagram) between April 2023 and July 2023. Participation in the online survey was voluntary, and the study was conducted in accordance with Italian law's privacy requirements (Law Decree DL-101/2018) and EU regulations (2016/679). The final sample comprised 807 people (30.2% cisgender men, 66.3% cisgender women, and 3.5% people belonging to the LGBTQIA+ community) with a mean age of 30.61 years (standard deviation: 12.408).

2.2. Measures

The questionnaire was composed of questions related to socio-demographic variables as well as the following instruments:

The Pro-environmental Behavior Scale (PEB) [52]: The PEB consists of a 19-item questionnaire measuring different dimensions of pro-environmental behaviors in terms of conservation, environmental citizenship, food, and transportation. Items are scored on a Likert-type scale with diverse response options. Notably, items 1 to 6 are scored on a 5-point Likert scale (1: "never"; 5: "always"), item 7 is scored on a 3-point Likert scale (1: "very high"; 3: "low"), items 8,9, and 12 are scored dichotomously (1: "yes"; 5: "no"), items 10 and 11 are scored on a 5-point Likert scale (1: never; 5: constantly), item 13 is scored on a 5-point Likert scale (1: "24 or less"; 5: "40 or more"), items 14 to 16 are scored dichotomously (1: "no"; 5: "yes"), and, finally, items 17 to 19 are scored on a 3-point Likert scale (1: "never"; 5: "frequently"). The Italian version of the scale was preliminarily validated by Duradoni and colleagues [32], who reported a good reliability index (Cronbach's $\alpha = 0.76$). The PEB scale was chosen considering its ability to consistently measure pro-environmental behaviors [52].

The Readiness to Change Scale [32]: The instrument investigates subjective readiness to change (RTC) through seven dimensions in terms of perceived importance of the problem (items 1 to 4; McDonald's $\omega = 0.78$), motivation to change (items 5 to 8; McDonald's $\omega = 0.83$), self-efficacy (items 9 to 13; McDonald's $\omega = 0.87$), effectiveness of the proposed solution (items 14 to 17; McDonald's $\omega = 0.81$), social support (items 18 to 21; McDonald's $\omega = 0.74$), action (items 22 to 25; McDonald's $\omega = 0.83$), and perceived readiness (items 26 to 29; McDonald's $\omega = 0.82$) [32]. The total scale is composed of 29 items scored on a 5-point Likert scale (1: "strongly disagree"; 5: "strongly agree"). The present instrument was used on the basis that it is the first and only scale to measure RTC in relation to pro-environmental behaviors [32]. Additional validity information for this study is available in the Supplementary Material (located in Tables S1–S3).

2.3. Data Analysis

Normality distribution was controlled by extracting skewness and kurtosis values. According to Hair [73], variables were considered normally distributed if the following criteria were met: skewness coefficient between ±2 and kurtosis coefficient between ±7. Pearson's correlation analysis was conducted to observe significant associations between PEB-transportation and RTC dimensions by also controlling for age and gender.

Moreover, RTC dimensions were included in a multiple stepwise linear regression analysis as independent variables to identify predictive dimensions of being more involved in using pro-environmental transports.

In addition, linear discriminant analysis (LDA) [74,75] was performed to distinguish by RTC dimensions whether PEB-transportation was adopted or not. Specifically, the PEB-transportation variable was divided between values below the first quartile (i.e., not involved) and above the third quartile (i.e., being involved). In addition, to provide gender-fair data information, LDA was both applied to the whole sample and disaggregated by gender by developing separated models for men and women. The LDA was not performed on the LGBTQIA+ community separately due to low sample size within the group. Among the most important advantages of using LDA is its ability to handle inhomogeneous class frequencies, to maximize the ratio between between-class and within-class variance, and to ensure maximum separability between classes [75–79].

Finally, a network analysis (NA) was performed to observe the association between PEB-transportation variables and the dimensions of RTC [80]. Notably, by assuming a putative nonlinearity between the investigated relationships [69], the NA was applied to observe whether the results of the above analysis can point out RTC outcomes that cannot be predicted by applying linear models. In line with this perspective, by adopting a network approach, the phenomena investigated in the present study can be understood as emerging from reciprocal interactions between factors [81]. Accordingly, network analysis (NA) represents a robust methodology for exploring such interactions [81]. Notably, centrality measures (e.g., betweenness, closeness, and strength) were extracted. Betweenness provides a quantitative measure of the extent to which a factor serves as a link between variables within a network [81,82]. Its value indicates the importance of the factor in maintaining connections within the network—a higher value corresponds to greater importance [81–83]. Closeness provides a quantitative index of how quickly information is transmitted between variables within the network. A high closeness value indicates that the factor has a high level of centrality within the network [81–83]. Finally, strength represents the strength with which a factor is connected to the other factors within the network [81–83]. As for LDA, the NA was applied to the whole sample and disaggregated by gender.

Statistical analyses were performed by using Statistical Package for the Social Sciences (SPSS) software (version 23) and JASP package (version 0.19.0.0).

3. Results

As displayed in Table 1, all the variables considered in the study were normally distributed. Accordingly, Pearson's correlation analysis was performed.

Correlation analysis pointed out several significant associations between PEB-transportation and RTC dimensions. In particular, in accordance with Gignac and Szodorai's thresholds [72] (small: 0.10; typical: 0.20; large: 0.30), a large and positive correlation between PEB-transportation and RCT—perceived importance ($r = 0.528$; $p < 0.001$) was found (Table 2).

Table 1. Descriptive statistics.

Variables	Min.	Max.	Mean	Sd	Skew.	Kurt.
PEB-Transportation	3	15	10.12	3.275	−0.247	−0.713
RTC—Perceived importance	5	40	25.16	8.496	−0.300	−1.324
RTC—Motivation for change	4	20	14.82	3.115	−0.708	0.930
RTC—Self-efficacy	5	25	18.31	3.400	−0.579	1.203
RTC—Effectiveness of proposed solution	4	20	14.52	2.542	−0.438	0.900
RTC—Social support	4	20	13.69	2.729	−0.203	0.483
RTC—Action	4	20	14.76	2.802	−0.651	0.891
RTC—Perceived readiness	4	20	14.92	2.673	−0.368	0.668

Notes: RTC, readiness to change; Min., minimum; Max., maximum; Sd, standard deviation; Skew., skewness; Kurt., kurtosis.

Table 2. Correlation matrix.

	RTC—Perceived Importance of the Problem	RTC—Motivation for Change	RTC—Self-Efficacy	RTC—Effectiveness of Proposed Solution	RTC—Social Support	RTC—Action	RTC—Perceived Readiness
PEB-Transportation	0.528 ***	0.113 **	0.017	0.075 *	0.007	0.116 **	0.116 **
	(0.462 ***)	(0.090 *)	(0.049)	(0.060)	(0.034)	(0.135 ***)	(0.113 **)

Notes: PEB, pro-environmental behavior; RTC, readiness to change; (. . .), correlation controlled by age and gender are reported between brackets; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

Moreover, the stepwise multiple linear regression analysis pointed out that the perceived importance dimension of RCT was significantly associated with PEB-transportation ($\beta = 0.528$; $p < 0.001$) by removing all other RTC variables entered into the model (Table 3). From a linear statistics standpoint, the result highlights that just having a perception of the importance of the problem has a totalizing effect on PEB-transportation adoption.

Table 3. Multiple linear regression analysis.

Independent Variables	Beta	t	Sig.	CI (95%)		R^2	R^2-Adjusted
				LB	UB		
RTC: Perceived importance of the problem	0.528	17.634	<0.001	0.182	0.226	0.279	0.278

Notes: RTC, readiness to change; Sig., significance; CI, confidence interval; LB, lower bound; UB, upper bound.

Concerning the LDA outputs, higher classification accuracy was observed among women only (90.3%), as well as higher precision, sensitivity, and specificity values (Table 4). However, among men and for the whole sample, moderate and good accuracy were still found, respectively. Moreover, as shown in Table 5, the RTC dimension related to the perceived importance of the problem playing a crucial role in the adoption of PEB related to means of transportation among both men and women. However, other RTC dimensions are gender specific. For example, among men, motivation for change and self-efficacy also assume great importance.

Table 4. Outputs of the linear discriminant analysis.

Groups	Accuracy (%)	Error (%)	Recall (%)	Precision (%)	Sensitivity (%)	Specificity (%)
Men and women	80.7	19.3	80.7	80.7	80.1	80.0
Men	72.0	28.0	72.0	74.1	72.8	73.1
Women	90.3	9.7	90.3	90.8	89.1	89.0

Table 5. Mean dropout loss of the linear discriminant analysis.

	Mean Dropout Loss			Linear Discriminant Coefficients		
	Men and Women	Men	Women	Men and Women	Men	Women
RTC—Perceived importance of the problem	0.491	0.476	0.508	1.415	1.109	1.508
RTC—Motivation for change	0.159	0.236	0.134	−0.265	−0.002	−0.239
RTC—Self-efficacy	0.158	0.229	0.134	−0.273	−0.269	−0.194
RTC—Effectiveness of proposed solution	0.157	0.223	0.133	0.221	0.513	0.073
RTC—Social support	0.155	0.219	0.132	−0.138	−0.255	−0.043
RTC—Action	0.154	0.212	0.132	−026	−0.219	0.105
RTC—Perceived readiness	0.151	0.194	0.131	0.203	0.371	0.083

So far, the LDA results have discriminated well between people who adopt or adopt little pro-environmental means of transportation. However, as mentioned before, the NA has been performed to observe the variable again from a non-discrete perspective, assuming the possible nonlinearity of the investigated relationships.

In keeping with this, regarding the NA performed among the whole sample, the results highlighted the presence of eight nodes with a sparsity value equal to 0.357 (Figure 2). The RTC—MC was the node with the highest centrality in the network that was positively connected with RTC—EP (r = 0.156; $p < 0.05$), RTC—A (r = 0.209; $p < 0.05$), and RTC—PR (r = 0.26; $p < 0.05$). The PEB-T was positively and strongly correlated only with RTC—PI (r = 0.482; $p < 0.05$) (Table 6; Figure 3).

Table 6. Network weight matrix and centrality measures for men and women.

Variables	Weight Matrix								Centrality Measures			
	PEB-T	RTC—PI	RTC—MC	RTC—SE	RTC—EPS	RTC—SS	RTC—A	RTC—PR	Betweenness	Closeness	Strength	Expected Influence
PEB-T	0.000								−0.930	−1.523	−1.415	−1.493
RTC—PI	0.482	0.000							0.787	0.963	0.835	0.780
RT—MC	0.000	0.146	0.000						1.931	1.281	0.431	0.458
RTC—SE	−0.014	0.000	0.092	0.000					−0.644	0.166	0.448	0.328
RTC—EPS	0.000	0.000	0.156	0.196	0.000				0.215	0.348	0.772	0.792
RTC—SS	0.000	0.000	0.000	0.166	0.273	0.000			0.930	0.860	−1.260	−1.195
RTC—A	0.013	0.000	0.209	0.104	0.208	0.110	0.000		0.644	0.674	0.893	0.910
RTC—PR	0.012	0.000	0.260	0.293	0.093	0.000	0.303	0.000	0.215	0.877	0.966	0.981

Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC social support; RTC—action; RTC—PR, RTC—perceived readiness.

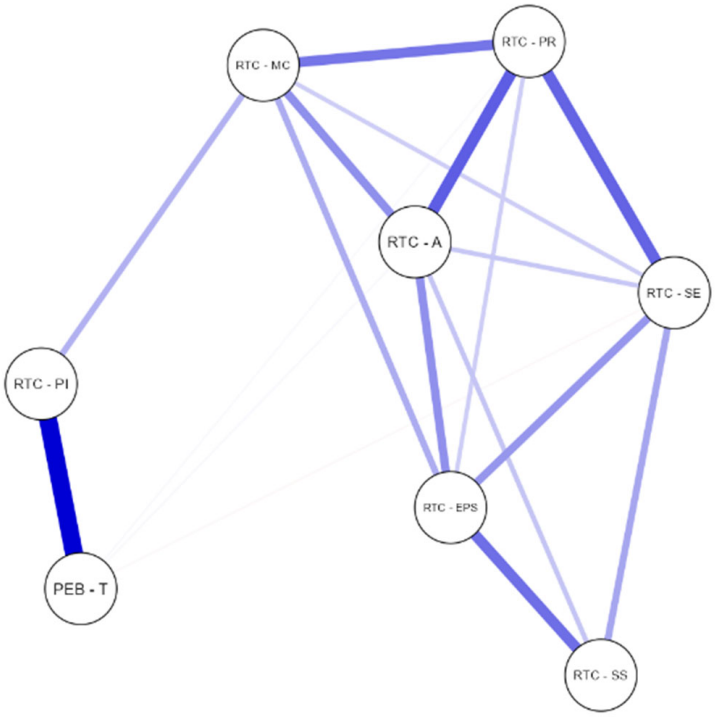


Figure 2. Whole sample network plot. Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC social support; RTC—action; RTC—PR, RTC—perceived readiness.

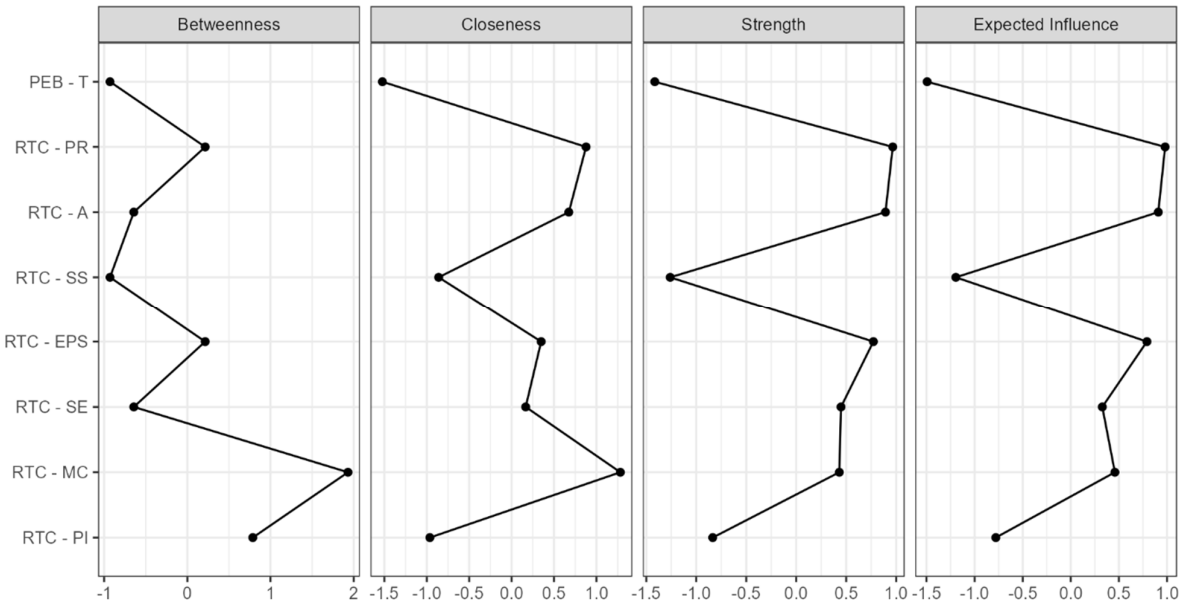


Figure 3. Whole sample centrality plot. Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC—social support; RTC—action; RTC—PR, RTC—perceived readiness.

Furthermore, by disaggregating the NA by genders, the results pointed out that although the perceived importance of the problem assumes a crucial role for men and women, different links between PEB-transportation and RTC dimensions emerged.

Regarding the results of NA among men, the analysis pointed out the presence of eight nodes with a sparsity equal to 0.357 (Figure 4). The RTC—EPS is the node with

the highest centrality in the network that was positively connected with PEB-T (r = 0.101; $p < 0.05$), RTC—SE (r = 0.111; $p < 0.05$), and RTC—MC (r = 0.143; $p < 0.05$). PEB-T was positively and negatively correlated, respectively, with RTC—PI (r = 0.330; $p < 0.05$), RTC—EPS (r = 0.101; $p < 0.05$), and RTC—SS (r = −0.40; $p < 0.05$) (Table 7; Figure 5), meaning that if the perceived importance of the problem and effectiveness of the proposed solution encourage the adoption of pro-environmental means of transportation, social support has an opposite effect.

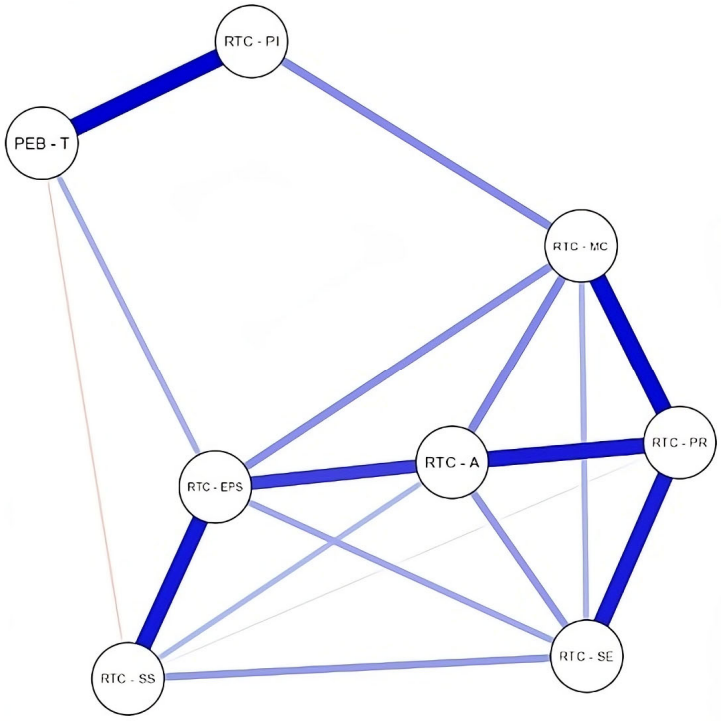


Figure 4. Men network plot. Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC—social support; RTC—action; RTC—PR, RTC—perceived readiness.

Table 7. Network weight matrix and centrality measures for men.

Variables	Weight Matrix								Centrality Measures			
	PEB-T	RTC—PI	RTC—MC	RTC—SE	RTC—EPS	RTC—SS	RTC—A	RTC—PR	Betweenness	Closeness	Strength	Expected Influence
PEB-T	0.000								−0.343	−1.355	−1.275	−1.384
RTC—PI	0.330	0.000							0.114	−1.125	−1.240	−1.036
RTC—MC	0.000	0.149	0.000						1.029	1.198	0.421	0.458
RTC—SE	0.000	0.000	0.096	0.000					−1.257	−0.248	−0.019	0.062
RTC—EPS	0.101	0.000	0.143	0.111	0.000				1.486	0.692	1.069	1.040
RTC—SS	−0.040	0.000	0.000	0.127	0.300	0.000			−1.257	−0.739	−0.809	−0.965
RTC—A	0.000	0.000	0.156	0.130	0.244	0.089	0.000		−0.343	0.533	0.656	0.669
RTC—PR	0.000	0.000	0.316	0.295	0.111	0.021	0.295	0.000	0.571	1.045	1.197	1.156

Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC social support; RTC—action; RTC—PR, RTC—perceived readiness.

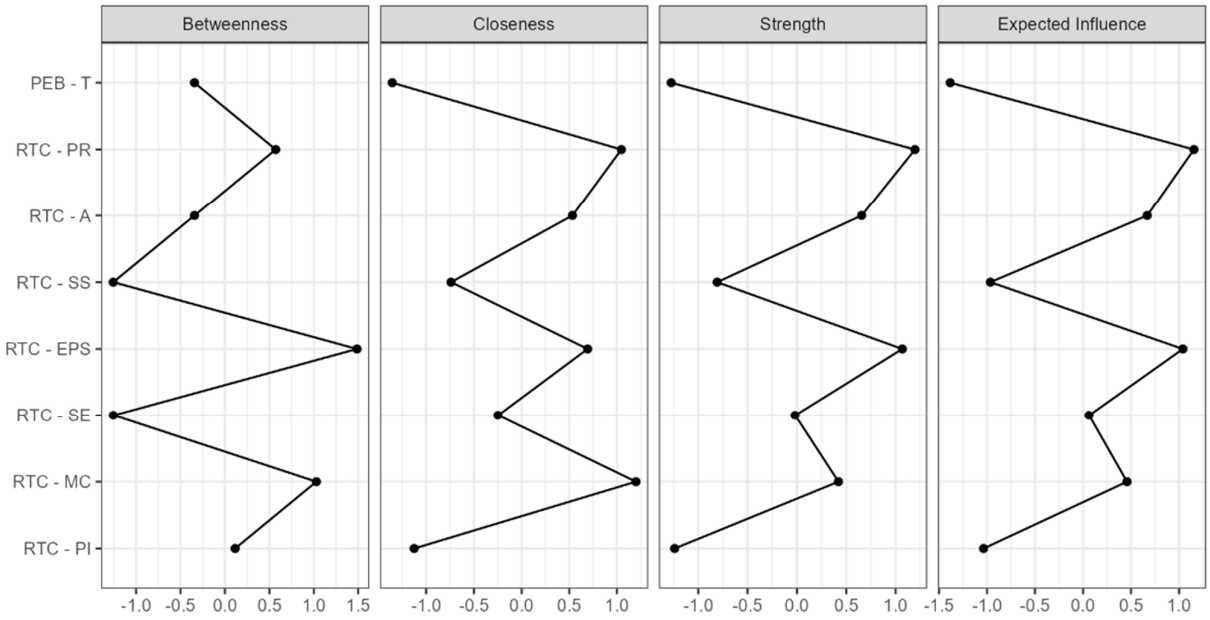


Figure 5. Men centrality plot. Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC—social support; RTC—action; RTC—PR, RTC—perceived readiness.

On the other hand, concerning the results of NA among women, the analysis pointed out the presence of eight nodes and a sparsity value of 0.393. Figures 6 and 7 display the network conformation and centrality plots, respectively. The node with the highest centrality in the network is RTC—MC, which was positively correlated with RTC—EPS (r = 0.188; $p < 0.05$), RTC—A (r = 0.211; $p < 0.05$), and RTC—PR (r = 0.229; $p < 0.05$) (Table 8). The PEB-T was positively correlated with RTC—PI (r = 0.528; $p < 0.05$) and RTC—A (r = 0.41; $p < 0.05$) while negatively correlated with self-efficacy (r = −0.29; $p < 0.05$). In summary, the results pointed out that self-efficacy affects women's non-adoption of pro-environmental means of transportation.

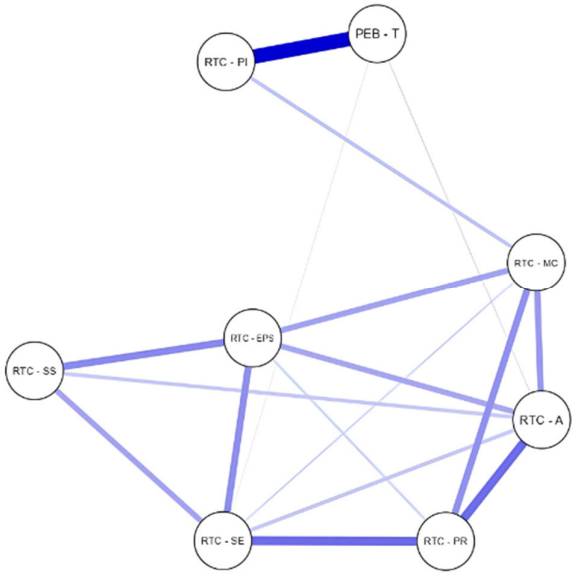


Figure 6. Women network plot. Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC—social support; RTC—action; RTC—PR, RTC—perceived readiness.

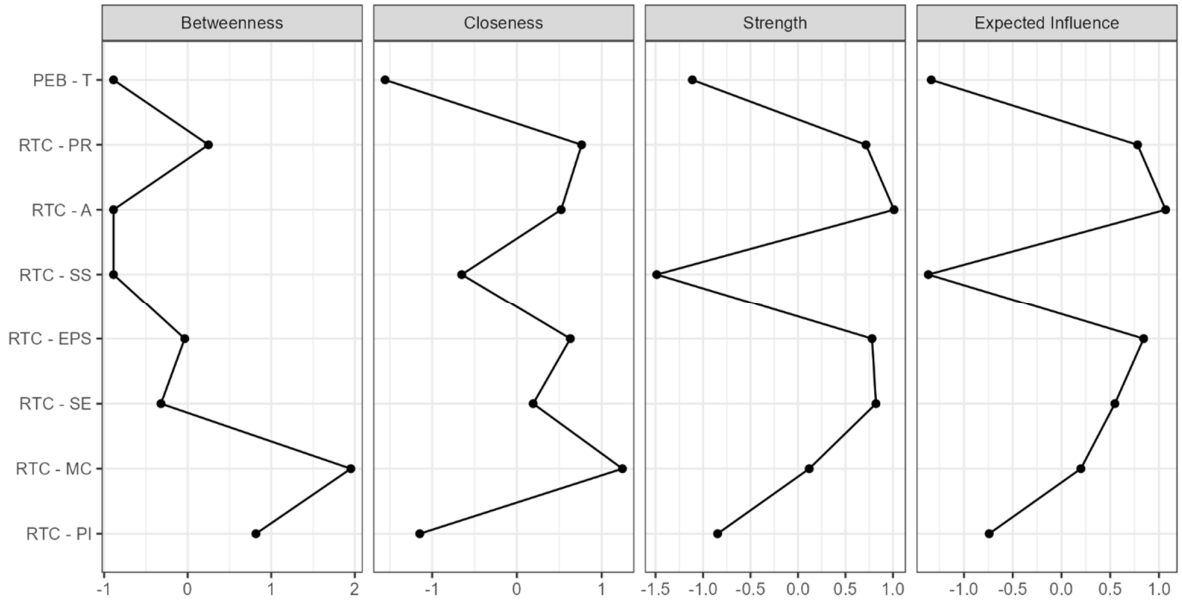


Figure 7. Women centrality plot. Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC—social support; RTC—action; RTC—PR, RTC—perceived readiness.

Table 8. Network weight matrix and centrality measures for women.

Variables	Weight Matrix								Centrality Measures			
	PEB-T	RTC—PI	RTC—MC	RTC—SE	RTC—EPS	RTC—SS	RTC—A	RTC—PR	Betweenness	Closeness	Strength	Expected Influence
PEB-T	0.000								−0.887	−1.555	−1.112	−1.335
RTC—PI	0.528	0.000							0.816	−1.147	−0.847	−0.741
RTC—MC	0.000	0.115	0.000						1.952	1.245	0.119	0.199
RTC—SE	−0.029	0.000	0.063	0.000					−0.319	0.192	0.821	0.548
RTC—EPS	0.000	0.000	0.188	0.233	0.000				−0.035	0.631	0.780	0.844
RTC—SS	0.000	0.000	0.000	0.182	0.242	0.000			−0.887	−0.652	−1.488	−1.365
RTC—A	0.041	0.000	0.211	0.111	0.181	0.111	0.000		−0.887	0.522	1.011	1.069
RTC—PR	0.000	0.000	0.229	0.305	0.073	0.000	0.300	0.000	.248	0.764	0.716	0.781

Notes: PEB-T, PEB-transportation; RTC—PI, RTC—perceived importance of the problem; RTC—MC, RTC—motivation for change; RTC—SE, RTC—self-efficacy; RTC—EPS, RTC—effectiveness of proposed solution; RTC—SS, RTC—social support; RTC—action; RTC—PR, RTC—perceived readiness.

4. Discussion

The current climate crisis is advancing at an alarming pace, and the actions implemented so far have proven insufficient to adequately address the emergency [1,2]; this clearly highlights the urgent need for large-scale behavioral change [6].

Individual transportation choices have a profound impact on climate change, as the transportation sector is one of the largest contributors to greenhouse gas emissions worldwide [12], with road transport being the primary source of these emissions [14]. It is evident that influencing individuals' transportation choices toward more sustainable alternatives requires understanding the factors that determine these choices. Going in this direction, the present study aimed to investigate the potential influence of readiness to change on transportation choices. Recently, Duradoni et al. [32] proposed a new multidimensional conceptualization of readiness to change comprising seven factors: perceived importance of the problem/change, motivation, self-efficacy, effectiveness of proposed solution, social

support, action and involvement, and perceived readiness. This new conceptualization provides an important theoretical framework for understanding the antecedents of sustainability. The authors showed that the transport cluster is among other PEBs the least effectively predicted by readiness to change.

This study aimed to examine the relationship between readiness to change (RTC) and pro-environmental transportation behaviors, moving beyond the linear continuous approach previously discussed by Duradoni et al. [32] and considering gender as a potential moderating variable in this relationship. To this end, we performed two complementary analyses: a discriminant analysis to evaluate the linear continuous relationships underlying group differentiation and a network analysis to explore potential non-linear and continuous patterns in the data. However, before proceeding with the interpretation of the results of these two analyses, it is important to note that the present study also revealed several significant correlations between PEB-T and some of the RTC dimensions examined. Notably, regarding the link between PEB-T and the perceived importance of the problem, this can be interpreted through the lens of the risk perception construct [32]. Indeed, within the field of pro-environmentalism, several authors have highlighted how a higher perception of risk is positively associated with engagement in pro-environmental behaviors [9,32,46,48]. As for the correlation between PEB-T and motivation, this is well supported by existing literature, which emphasizes the key role of this construct in shaping pro-environmental behavior [32,47,84,85]. Regarding the link between PEB-T and the effectiveness of the proposed solution, this can be interpreted in light of the response efficacy construct, which is itself potentially linked to the enactment of adaptive behaviors, including pro-environmental actions [9,32,48,86]. In relation to the association between PEB-T and action, this may be due to the fact that engagement in pro-environmental behaviors has been shown to be a key driver for the enactment of other types of PEB [32,50,87,88]. Finally, concerning the last significant correlation observed—the one between PEB-T and perceived readiness—this can be interpreted based on the notion that a perceived sense of responsibility appears to foster greater engagement in pro-environmental actions [32,51,89,90].

Concerning LDA outputs, the results supports the possible presence of a non-linear relationship between the observed variables. Specifically, considering the extremes of behavior (e.g., widespread use and non-use of pro-environmental transportation), it is found that the RTC is mainly able to predict the investigated behavior. In line with Lewin's field theory [91], it thus emerges how individual factors better predict behavioral extremes, suggesting a possible nonlinearity of the relationship. In the context of pro-environmental behaviors, the nonlinearity of relationships is also supported by several scholars, also taking into consideration that the link between attitude and behavior may mainly be nonlinear [69,92–95]. In addition, it is also observed that some dimensions are gender-invariant, while others are gender-sensitive.

In keeping with this, several scholars explored in depth the gender gap and differences in environmental concerns [55–57] by highlighting how gender appears to be an important factor in the determinants of pro-environmental behaviors [61,62]. By focusing on the results of the present study, it has been observed that if the perceived importance of the problem and self-efficacy assume a positive and negative key role concerning using more sustainable means of transportation in both men and women, other dimensions are more gender sensitive. Concerning the latter, among men, the dimensions of the effectiveness of the proposed solution and perceived readiness have a positive relationship with the adoption of pro-environmental means of transportation. In contrast, among women, the dimension of motivation for change appears to be particularly important in the negative direction. Thus, it is observed that different parameters assume different levels of

importance among men and women. In summary, with regard to the perceived importance of the problem, there are thus parameters that are particularly gender sensitive.

Regarding the network analysis outputs [80], the continuous patterns allowed us to better investigate the interrelationship between the observed dimensions by highlighting how the perceived importance of the problem continues to matter among both men and women by representing the strongest link between the RTC dimensions and PEB-transportation. Furthermore, it is observed that motivation for change is the central and connecting node among all RTC dimensions.

Concerning men only, the effectiveness of the proposed solution is maintained as a crucial element in the adoption of sustainable means of transportation by also representing the central and connecting node of RTC dimensions.

On the other hand, regarding women, in addition to the perceived importance of the problem, the dimension most negatively linked with the use of sustainable transportation is the action dimension.

In general, the results are in line with the literature data. In fact, by taking into consideration the most robust findings of the present study, it is well established in the literature that the perceived importance of the problem in terms of perceived risk, the effectiveness of the proposed solution in terms of response effectiveness, and perceived readiness are related to the implementation of pro-environmental behaviors [9,32,46,48,89]. Conversely, the findings concerning RTC dimensions in terms of self-efficacy need further investigation. In keeping with this, our results are partially supported by literature data [96]. Indeed, only some scholars have investigated the role of dispositional self-efficacy in the engagement of pro-environmental behaviors, considering that most studies have focused on the so-called environmental self-efficacy [96]. Based on the findings of the study by Kosic and colleagues [96], the role of dispositional self-efficacy in the context of pro-environmental behaviors needs further investigation, considering that this factor does not seem to be closely related to the above behaviors. It has been observed how self-efficacy (dispositional or collective) may affect pro-environmental behaviors differently based on the behavior investigated [97]. As suggested by Chen [98], the results that emerged may depend on the fact that although dispositional self-efficacy plays a crucial role in engaging useful behaviors to address individual problems, this factor would seem to be less relevant to taking collective actions, such as those needed to counter the climate crisis [98,99]. Future studies are still needed to clarify and define the role of dispositional self-efficacy in sustainable behaviors.

Moreover, by taking into consideration only the variables that differentiate men and women, we attempted to interpret the results that emerged by gender. Compared to women, it was observed that higher RTC—EPS scores among men are associated with greater use of environmentally sustainable transportation. As previously noted, this RTC dimension is also related to social consequences, a construct that is particularly relevant in the context of pro-environmentalism, given that the literature has highlighted how the enactment of public-sphere pro-environmental behaviors can result in social benefits [32,68,100]. Considering that the use of eco-sustainable transportation may involve public visibility [101] and that men appear more likely to engage in public rather than private PEBs in countries where traditional gender-role beliefs are prevalent, such as Italy [102,103], our result may be explained through the construct of social consequences. Furthermore, as perceived readiness is related to behavioral willingness, the positive relationship between this RTC dimension and the use of public transportation among men may also be interpreted as being linked to the perceived social consequences of such behaviors. Specifically, prior research has shown that the social consequences of PEBs can be associated with the enactment of public-sphere behaviors (e.g., using public transportation) [68,100]. Regarding

women, it was observed that a greater motivation to change and self-efficacy are associated with lower use of public transportation. Although this result may seem counterintuitive, it might be explained by the fact that RTC represents a general measure of readiness for behavioral change, whereas PEB-T reflects a highly specific behavior. In this context, for example, Biassoni and colleagues [104] found that men are more likely than women to use bicycles, an environmentally friendly mode of transportation. Among the various explanations offered, the authors suggest that this difference may be due to greater concerns about personal safety, which tend to be more prevalent among women than men [104–106]. Additionally, in line with previous studies [107,108], women appear to be more tied to family responsibilities that often involve car use (e.g., grocery shopping or transporting children) [107,108]. However, this finding warrants further investigation due to the contradictory evidence in the existing literature [109]. On the other hand, as Li et al. [109] suggest, the relationship between RTC—A and PEB-T may also be interpreted in light of the greater environmental concern often exhibited by women, which may underlie a stronger intention to engage in pro-environmental behaviors [109–111]. In fact, this aligns with the safety concerns hypothesis, which suggests that individuals who express greater concern are also more likely to take action to address a given issue [66]. Furthermore, from an ecofeminist perspective, environmental responsibility has been symbolically linked to the female figure [112].

In terms of implications, the observed results reinforce the putative presence of non-linearity among the dimensions and relationships investigated. As suggested by Byrne [113], human behavior would seem to be better predicted by nonlinear antecedents [95,113], underscoring how complex behavior change processes are [114]. Specifically, the linear approach often conceptualizes behavioral change as a gradual process over time, relying on assumptions that often disregard reality complexities [114,115]. In contrast, examining behavioral change through a nonlinear perspective may provide a more robust and insightful comprehension of the phenomenon [114,115]. On this basis, adopting a complex perspective regarding the links between attitude and behavior would enable scholars to better understand pro-environmental behaviors and attitudes [114]. Referring to the present work, the findings shed light on how certain RTC dimensions are gender-= sensitive. This aspect can play a crucial role in the development of gender-sensitive policies. Indeed, in line with Kabeer's assumptions [116,117], considering gender differences in policy development—including in the field of sustainability—not only enables the design of more equitable interventions but also enhances their effectiveness and inclusivity [118,119]. In summary, the results can play a key role in policy implementation by supporting the development of tailored actions and expanding knowledge about gender differences in the context of pro-environmental behaviors.

This study is not without its limitations. Its cross-sectional design does not allow for causal inferences to be drawn. Furthermore, the use of self-administered questionnaires may be subject to social desirability bias, particularly given the topic under investigation. However, this bias is likely mitigated by the completely anonymous nature of the survey. Additionally, the non-random recruitment process could limit the generalizability of the findings.

To address these limitations, future research should aim to replicate or extend this study in different socio-cultural and demographic contexts to test the robustness of the results. Beyond this, future studies could also explore the applicability of the proposed model across various forms of sustainable mobility, such as carpooling, electric scooters, bicycles, public transportation, shared electric vehicles, pedestrian-friendly urban areas, ride-hailing services, shared micromobility systems (e.g., e-bikes, hoverboards), or even innovative options like autonomous vehicles integrated into eco-friendly networks. Dif-

ferent levels of attractiveness and accessibility that individuals may associate with these modes of transport could result in distinct usage patterns, as well as varying influences of the dimensions of readiness to change on predicting their adoption.

5. Conclusions

In conclusion, the present work adds significant data about a topic still being investigated in the scientific literature, such as the use of sustainable means of transportation [60]. Notably, the work supported the putative non-linear links between attitudes and pro-environmental behaviors by also highlighting how some RTC dimensions are gender sensitive. In summary, the findings may represent the groundwork for future studies and sensibilization interventions about environmental concerns. Notably, further research is needed to apply the RTC scale in different cultural contexts. In this regard, it would be particularly interesting to examine potential differences between individualistic and collectivistic countries [120–122]. Finally, future applications could involve testing environmental interventions based on the RTC model, including the promotion of environmentally sustainable means of transportation.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su17073021/s1, Table S1: CFA Outputs; Table S2: Factor loadings; Table S3: Factor Covariance.

Author Contributions: Conceptualization, M.D. and A.G.; Data curation, A.G.; Formal analysis, M.D. and M.B.; Investigation, G.V.; Methodology, M.D. and A.G.; Supervision, M.D. and A.G.; Writing—original draft, M.D., M.B. and G.V.; Writing—review & editing, M.D., M.B., G.V. and A.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was approved by the Comissão de Ética do Centro de Estudos Sociais (CE-CES) (University of Coimbra; date: 24 october 2022; protocol number: 02319461).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: We thank the European Union's Horizon 2020 Project "PHOENIX: The Rise of Citizen Voices for a Greener Europe" (grant agreement No 101037328) for supporting and promoting this systematic review.

Conflicts of Interest: The authors declare no conflicts of interest.

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