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The assessment of drivers' acceptance of automated vehicles in Italy: Development and initial validation of a short self-report measure

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ABSTRACT. I veicoli a guida autonoma hanno un enorme potenziale di modifica della viabilità; pertanto, la valutazione dei fattori che possono influenzare i guidatori nel loro utilizzo riveste un ruolo centrale. Lo scopo di questo studio consisteva nello sviluppo di una misura finalizzata alla valutazione dei seguenti aspetti: (a) disposizione positiva nei confronti della tecnologia (*Technology Optimism Scale; TOS*); (b) disposizione positiva nei confronti dei veicoli a guida autonoma (*Perception of Automated Vehicles; PAV*) e (c) attitudine nei confronti della mobilità sostenibile (*Sustainable Mobility Attitudes; SMA*). Il campione reclutato per lo studio ha incluso 730 soggetti adulti italiani (61% di sesso femminile; età media = 36.39 anni). Sono state condotte analisi bivariate e multivariate, oltre all'utilizzo della exploratory graph analysis al fine di esaminare le proprietà di misurazione delle scale. TOS, PAV e SMA hanno mostrato adeguata affidabilità e relazioni significative con specifiche variabili demografiche e personologiche. Nel complesso, i risultati dello studio suggeriscono la possibilità di utilizzare questi strumenti nell'ambito della ricerca sui veicoli a guida autonoma.

SUMMARY. Autonomous vehicles (AVs) have the potential to transform mobility. Exploring factors influencing driver' acceptance of AVs has become crucial. We aimed at developing a short measure assessing: (a) positive dispositions towards technology (Technology Optimism Scale; TOS); (b) positive dispositions towards automated vehicles (Perception of Automated Vehicles; PAV); and (c) sustainable mobility attitudes (Sustainable Mobility Attitudes; SMA) in Italy. A sample of 730 Italian community-dwelling adult participants (mean age = 36.39 years; 61.1% female), was administered the TOS, PAV, and SMA items. Bivariate and multivariate item analyses were carried out; moreover, exploratory graph analysis was conducted to examine the structure of the measure. Internal consistency estimates of the TOS, PAV and SMA total scores were computed; associations between TOS, PAV, and SMA total scores, and demographic variables and personality traits, respectively, were assessed. The TOS, PAV, and SMA total scores were provided with adequate reliability and showed meaningful relationships with selected demographic variable and personality traits. Our findings may represent a useful contribution to the available literature on AVs providing researchers a short measure to assess different aspects contributing to the perception of AVs, at least among Italian community-dwelling participants.

Keywords: *Autonomous vehicles, Driver' acceptance, Perception of Automated Vehicles, Technology Optimism Scale, Sustainable Mobility Attitudes*

INTRODUCTION

Autonomous vehicles (AVs) are vehicles that could monitor the driving environment and work in automated driving (Society of Automotive Engineers, 2018). AVs have the potential to transform mobility and improve efficiency on roads, while reducing traffic accidents and minimizing environmental impact (e.g., Ryan, 2020; Stone, Santoni de Sio & Vermaas, 2020). Despite these positive factors, it should be observed that these benefits will be accessible depending upon the acceptance of AVs. Indeed, negative publicity around AVs (e.g., because of the accidents they have caused) has been spread (e.g., Ryan, 2020), and public skepticism over safety represent key barriers to AVs acceptance (e.g., Zhang et al., 2019).

Notably, Tennant and colleagues (2019) carried out an extensive review on the perception of AVs and performed a large survey (N = 11,827) across 11 European countries examining attitudes towards AVs. Confirming and extending previous European data (European Commission, 2017), Tennant, Stares and Howard (2019) showed that more respondents were uncomfortable with the prospect of AVs. Against this background, exploring factors influencing driver' acceptance of AVs has become crucial (e.g., Liu, Yang & Zu, 2019). Indeed, the efforts to understand public acceptance of AVs are still relatively limited and its psychological correlates remain largely unknown (e.g., Xu et al., 2018).

Up to now, different studies examined the role of demographic variable and the perception of AVs (e.g., Penmetsa, Adanu, Wood, Wang & Jones, 2019). These research findings suggested that public acceptance of AVs may vary according to geographic location and gender (KPMG, 2013), but results have been quite debated. For instance, some results suggested female to be more interested in AVs than male participants (e.g., KPMG, 2013), and other studies showed male to manifest greater acceptance to AVs than female participants (e.g., Hulse, Xia & Galea, 2018).

Although results are still controversial (e.g., Hartwich, Witzlack, Beggiato & Krems, 2019; Nielsen & Haustein, 2018), selected socio-economic characteristics (e.g., Becker & Axhausen, 2017) were found to be associated with the willingness to use AVs. For example, Nikitas, Vitel and Cotet (2021) carried out an international study and found that respondents studying or working in the information technology and financial industries thought that automation of the transport industry will follow the path of other automated industries, suggesting that job may play a role in the perception of the changes related to the mobility. Similarly, Hudson, Orviska and Hunady (2019) found that individuals' degree of comfort with AVs decreased if they were unemployed or retired. Notably, educational level (e.g., Hudson et al., 2019), and dispositions towards technology (e.g., Tennant et al., 2019), have been found to influence the willingness to use AVs.

Up to now, few studies examined the associations between trust in AVs and driver's personality traits (Li et al., 2020). For instance, Kyriakidis, Happee and de Winter (2015) found that participants scoring higher on neuroticism were slightly less comfortable about AVs data transmitting, while Charness, Yoon, Souders, Stothart and Yehnert (2018) found that emotional stability (i.e., low neuroticism) and openness to experience were positive predictors of eagerness to adopt AVs.

One of the limitations of the available literature on the acceptance of AVs is related to the variability of the measures used (e.g., Adell, Varhelyi, & Nilsson, 2014; Zoellick, Kuhlmey, Schenk, Schindel & Blüher, 2019). Moreover, a recent study (Kacperski, Kutzner & Vogel, 2021) conducted in a sample of 529 participants from France, Germany, Italy and the United Kingdom showed that responses varied substantially between countries, with the most positive views being from Italy. As a whole, Kacperski and colleagues (2021) provided insight into the respondents' general reticence about their intention to use AVs, while suggesting future research to focus on larger samples to study between-country differences to provide specific insights into AVs acceptance, to make them accessible for a variety of populations and their cultural demands. From this perspective, the availability of a short measure to examine the acceptance of AVs in Italy would allow for future studies to recruit larger samples of Italian participants.

The present study

Against this background, we aimed at developing a short measure providing 1) a scale to assess positive dispositions towards technology (i.e., T*echnology Optimism Scale; TOS*); 2) a scale measuring positive dispositions towards automated vehicles (*Perception of Automated Vehicles; PAV*), and 3) a scale assessing sustainable mobility attitudes (*Sustainable Mobility*

Attitudes; SMA). Thus, we designed the preset study as the first attempt at providing item validity, internal consistency reliability estimates, and dimensionality assessment of this short new measure.

Furthermore, preliminary validity data with respect to demographic characteristics and personality traits were considered. Indeed, previous data showed the relevance of these variables for the perception of AVs, dispositions towards technology and sustainable attitudes. For instance, personality traits were found to be associated with these constructs (e.g., Weigl, Nees, Eisele & Riener, 2022), and Barnett, Pearson, Pearson and Kellermanns (2015) found that while conscientiousness was positively associated with perceived and actual use of technology, neuroticism showed negative relationships with these variables.

Initial bivariate (i.e., item-total *r* coefficients corrected for part-whole overlap) and multivariate item analyses (i.e., item cluster analysis; Revelle, 1978) were conducted. Relying on factor analysis for dimensionality and latent structure assessment of the TOS, PAV, and SMA items may represent a sub-optimal choice. Indeed, scale item were likely to represent cause indicators rather than effect indicators (i.e., observable variables which reflects the effect of the latent construct; Bollen, 1989). Indeed, variation in the opinions expressed on the technology optimism scales are likely to produce a variation in the overall level of technological optimism; rather, it seems unlikely that participant's answers to technological optimism items reflect different manifestations of a latent variable. In a sense, it is a situation similar to socio-economic status assessment; a variation in observable indicators (e.g., income, home property, education level, etc.) produces a variation the socio-economic status (i.e., the construct) level, whereas manipulating the values of socio-economic status does not change participant's income, home properties or educational level (i.e., the observable indicators).

Recent psychometric approaches may provide useful alternatives to factor analysis when the existence of latent constructs causing the variation in the observable indicators is called into question (Golino & Epskamp, 2017). Exploratory graph analysis (EGA) is a recently developed technique from the field of network psychometrics (Golino & Epskamp, 2017); in this approach, items are considered to directly affect each other rather than being caused by an unobserved latent construct; accordingly, items that share strong connections and are in close proximity to each other can form any number of communities (Christensen, Gross, Golino, Silvia & Kwapil, 2019; Fried & Cramer, 2017).

After examining the structure of TOS, PAV and SMA items, we focused on their reliability and validity in order to provide support to the hypothesis that they represent useful assessment instruments. To this aim, we firstly assessed the reliability of the TOS, PAV, and SMA total scores, which were expected to be provided with adequate internal consistency estimates. After that, we evaluated their association with demographic variables (i.e., gender, educational level, civil status, job) which showed to be useful in assessing public acceptance of AVs (e.g., Hohenberger, Spörrle & Welpe, 2016). Specifically, we hypothesized to observe higher TOS scores for male participants (e.g., Kacperski et al., 2021; Tennant et al., 2019), as well higher score on the PAV scales for participants with a higher educational level (e.g., Bansal, Kockelman & Singh, 2016). Based on previous data on the relationships between employment status and AVs perception (e.g., Hudson et al., 2019), a possible effect of job on PAV scores was expected. Because adoption of novel technology may be influenced by the characteristics of the adopter (e.g., Hegner, Beldad & Brunswick, 2019), we examined the associations between personality and TOS, PAV, and SMA total scores. Based on previous data on the relationships between personality traits and AVs perception (Kacperski et al., 2021; Kyriakidis et al., 2015), we hypothesized to observe significant associations between PAV total score and openness to experience and neuroticism scales, respectively. Finally, we hypothesized a positive association between TOS total score and conscientiousness, and a negative relationship between TOS total score and neuroticism (e.g., Barnett et al., 2015).

METHOD

Participants

The sample was composed of 730 Italian community-dwelling adult participants, with a mean age of 36.39 years (*SD* = 15.65 years; age range: 18 years-82 years); 4 (.5%) participants refused to disclose their age. In our sample 446 (61.1%) participants were female and 276 (37.9%) participants were male, 4 (.5%) participants identified their gender outside the gender binary, whereas 4 (.5%) participants refused to disclose their gender. Four thousand five hundred fifteen

(56.8%) participants were unmarried, 282 (38.6%) were married, 24 (3.3%) participants were divorced, and 6 (.8%) participants were widow/-er; 3 (.4%) participants refused to disclose their civil status. Twenty-six (3.6%) participants had junior high school degree, 301 (41.2%) participants had high school degree, 354 (48.5%) participants had university degree, and 48 (6.6%) participants had doctoral degree; one (.1%) participant refused to disclose his/her educational level. Eighteen (2.5%) participants were unemployed, 26 (3.6%) participants were retired, whereas 686 (94.0%) were active community members; 6 (.8%) participants refused to report their job. To be included in the sample, participants had to have been in possession of a car driver's license; on average participants held driving license from 17.21 years (*SD* = 15.12 years).

Procedures

Participants completed the study online using Online Surveys Jisc, an online survey tool designed for academic research (https://www.onlinesurveys.ac.uk/); participants volunteered to take part in the study receiving no economic incentive or academic credit for their participation. To be included in the sample, participants had to document that they were of adult age (i.e., 18 years of age or older), been in possession of a car driver's license, and to agree to online written informed consent in which the study was extensively described. The TOS, PAV and SMA items were randomly included in a single questionnaire on "Attitudes towards technology and environment".

Measure translation procedure

The TOS, PAV and SMA items were independently translated into Italian by two psychologists who were fluent in both English and Italian languages. After reaching a first consensus, an English mother-tongue professional translator translated the Italian version back into English, and this English back-translation (e.g., van de Vijver & Hambleton, 1996) was compared with the original English version of the items. If the latest version differed from the English original, the translators came to an agreement on the definitive Italian translation. The final TOS, PAV and SMA items are provided in the Supplementary material.

Measures

- *Technological Optimism Scale* (*TOS*; see also Tennant et al., 2019). The TOS is a 7-item measure assessing participants' general views on technology; items are rated on a 5-point Likert scale ranging from *1* (Strongly disagree) to *5* (Strongly agree). Items were summed and averaged to yield the TOS total score, the higher the TOS total score, the higher the driver's trust in technology. Previous data suggested the usefulness of the TOS scale in assessing driver's dispositions towards technology (Tennant et al., 2019).
- *Perception of Automated Vehicles Scale* (*PAV*; see also Tennant et al., 2019). The PAV is a 12-item scale purportedly assessing driver's positive disposition towards automated vehicles. In the present study, each PAV item was rated on a 5-point Likert scale ranging from *1* (Strongly disagree) to *5* (Strongly agree). Items were summed and averaged to yield the PAV total score, the higher the PAV total score, the higher the driver's positive disposition towards automated vehicles. Previous data suggested the usefulness of the PAV scale in assessing driver's dispositions towards technology (Tennant et al., 2019).
- *Sustainable Mobility Attitudes* (*SMA*; see also Kaiser & Wilson, 2000). The SMA is a three-item measure of driver's sensitivity to ecological considerations in mobility planning. In the present study, each SMA item was rated on a 5-point Likert scale ranging from *1* (Strongly disagree) to *5* (Strongly agree). Items were summed and averaged to yield the SMA total score, the higher the SMA total score, the higher the driver's sensitivity to sustainable mobility considerations. The SMA items were selected from the *General Ecological Behavior Scale*, which showed to be provided with adequate psychometric properties (Kaiser & Wilson, 2000).
- *Big Five Inventory* (*BFI*; John & Srivastava, 1999). The BFI consists of 44 items which are rated on a five-point Likert scale from *1* (disagree a lot) to *5* (agree a lot). The BFI items are assigned to five scales measuring Extraversion (8 items), Agreeableness (9 items), Conscientiousness (9 items), Neuroticism (8 items), and Openness to experience (10 items). The BFI showed adequate psychometric properties also in its Italian translation (Fossati, Borroni, Marchione & Maffei, 2011).

Data analysis

Item-total correlations corrected for part-whole overlap ($r_{i\text{-}t}$) between each item and the total score of the scale to which the item was assigned were computed for each item scale. Multivariate item analyses were carried out relying on the Item Cluster Analysis (ICLUST; Revelle, 1979) algorithm, which allows to hierarchically cluster items to form composite scales. ICLUST is meant to do item cluster analysis using a hierarchical clustering algorithm specifically asking questions about the reliability of the clusters (Revelle, 1979); clusters are combined if coefficients α (average slip-half reliability) and β (minimum split-half reliability) increase in the new cluster. Cluster fit and pattern fit indices were used as cluster fit statistics (Revelle, 1979).

In the present study, we relied on exploratory graph analysis (EGA; Golino & Epskamp, 2017) to assess whether three dimensions could be identified for the TOS, PAV, and SMA items. EGA is a dimensionality assessment method which produces a visual guide (i.e., network plot) that indicates the number of dimensions to retain (Golino & Epskamp, 2017). EGA combines the Gaussian graphical model (Lauritzen, 1996), with the Walktrap algorithm (Pons & Latapy, 2006) for community detection on weighted networks to assess the dimensionality. In EGA models, nodes (i.e., circles) represent items and edges (i.e., lines) represent associations between the nodes. The EGA approach currently uses two network estimation methods (for a review, see Golino et al., 2020), namely, graphical least absolute shrinkage and selection operator (GLASSO; Friedman, Hastie & Tibshirani, 2008) and triangulated maximally filtered graph (TMFG; Previde Massara, Di Matteo & Aste, 2016). In the present study, in line with the results of Golino and colleagues' (2021) simulation study, we relied on Von Neumman Entropy (EFI.vn) to compare the results of graphical least absolute shrinkage and selection operator EGA (EGA_{GLASSO}) and triangulated maximally filtered graph EGA (EGA_{TMFG}); specifically, we selected the model with the lowest TEFI.vn (Golino et al., 2021). Moreover, to estimate the stability of dimensions identified by EGA, we relied on Bootstrap Exploratory Graph Analysis (bootEGA; Christensen & Golino, 2021), which allows to evaluate the stability of EGA results across bootstrapped EGA results. In the present study, we relied on the non-parametric bootEGA procedure that is implemented by resampling with a replacement from the empirical dataset; in particular, we relied on 1,000 bootstrap samples. Bootstrap EGA results allowed us to estimate the number of times each item was estimated to belong to the same dimension.

Although their usefulness is controversial (Hallquist, Wright & Molenaar, 2021), in line with previous network applications (e.g., Epskamp, Borsboom & Fried, 2018), we relied on centrality measures to assess the importance of individual nodes in the network. In particular, we examined three nodal centrality measures: strength, closeness, and betweenness (Epskamp et al., 2018). The strength of a node is defined as the sum of its edge weights (i.e., partial correlations) to other nodes; closeness is the sum of the shortest path lengths between a specific node and all other nodes; finally, betweenness quantifies how often the shortest paths among all nodes traverse a given node (e.g., Hallquist et al., 2021).

Cronbach's α coefficient and mean inter-item correlation (MIC) coefficient were used to evaluate the internal consistency reliability of the scales (Clark & Watson, 1995). Pearson r coefficient was used to assess the relationships between continuous variables.

RESULTS AND DISCUSSION

Descriptive statistics and item-total correlations corrected for part-whole overlap for the TOS, PAV, and SMA items are summarized in Table 1, Table 2, and Table 3, respectively. All $r_{i\text{-}t}$ coefficient values were suggestive of adequate discriminatory power for all items of the three scales. Accordingly, all items were retained for further analyses.

When ICLUST was used to formally assess whether the groups of TOS, PAV, and SMA items could be considered as fairly homogenous clusters, a single cluster solution was identified for TOS (cluster fit = .70; pattern fit = .97), PAV (cluster fit = .78; pattern fit = .97), and SMA (cluster fit = .70; pattern fit = .99) items, respectively. The rooted dendritic structure of the TOS, PAV, and SMA items are displayed in Figure 1, Figure 2, and Figure 3, respectively. These finding suggested that each set of items represented a homogeneous system of observable indicators purportedly assessing driver's technological optimism (i.e., TOS scale score), propensity towards automated vehicles (i.e., PAV scale score), and sensitivity to sustainable mobility (i.e., SMA scale score), respectively.

- *Exploratory Graph Analysis*. When the TEFI.vn index was used to compare different dimensionality structures between GLASSO and TMFG EGA methods (Golino et al.,

Table 1 – Technological Optimism Scale item analyses: descriptive statistics and bivariate item-total correlations corrected for part-whole overlap in Italian community-dwelling adult participants (N = 730)

Technological Optimism Scale items	*M*	*SD*	r_{i-t}
TECH1	2.57	1.09	.42
TECH2	3.89	1.01	.44
TECH3	3.56	.92	.45
TECH4	3.69	1.01	.50
TECH5	3.02	.91	.52
TECH6	3.06	1.10	.64
TECH7	2.85	1.11	.45

Note. r_{i-t}: Item-total *r* coefficient corrected for part-whole overlap.

Table 2 – Perception of Automated Vehicles Scale item analyses: descriptive statistics and bivariate item-total correlations corrected for part-whole overlap in Italian community-dwelling adult participants (N = 730)

Perception of Automated Vehicles Scale items	*M*	*SD*	r_{i-t}
PAV1	3.19	.97	.63
PAV2	2.48	1.02	.64
PAV3	2.34	.85	.36
PAV4	2.19	.92	.51
PAV5	3.57	.90	.42
PAV6	2.62	.95	.43
PAV7	3.12	.98	.52
PAV8	2.17	1.19	.34
PAV9	2.27	.98	.67
PAV10	3.07	1.22	.54
PAV11	2.30	1.00	.66
PAV12	3.05	1.04	.59

Note. r_{i-t}: Item-total *r* coefficient corrected for part-whole overlap.

Table 3 – Sustainable Mobility Attitudes Scale item analyses: descriptive statistics and bivariate item-total correlations corrected for part-whole overlap in Italian community-dwelling adult participants (N = 730)

Sustainable Mobility Attitudes items	*M*	*SD*	r_{i-t}
SMA1	2.30	1.25	.38
SMA2	2.48	1.23	.58
SMA3	2.92	1.48	.53

Note. r_{i-t}: Item-total *r* coefficient corrected for part-whole overlap.

Figure 1 – Rooted dendritic structure of the Technological Optimism Scale items (N = 730)

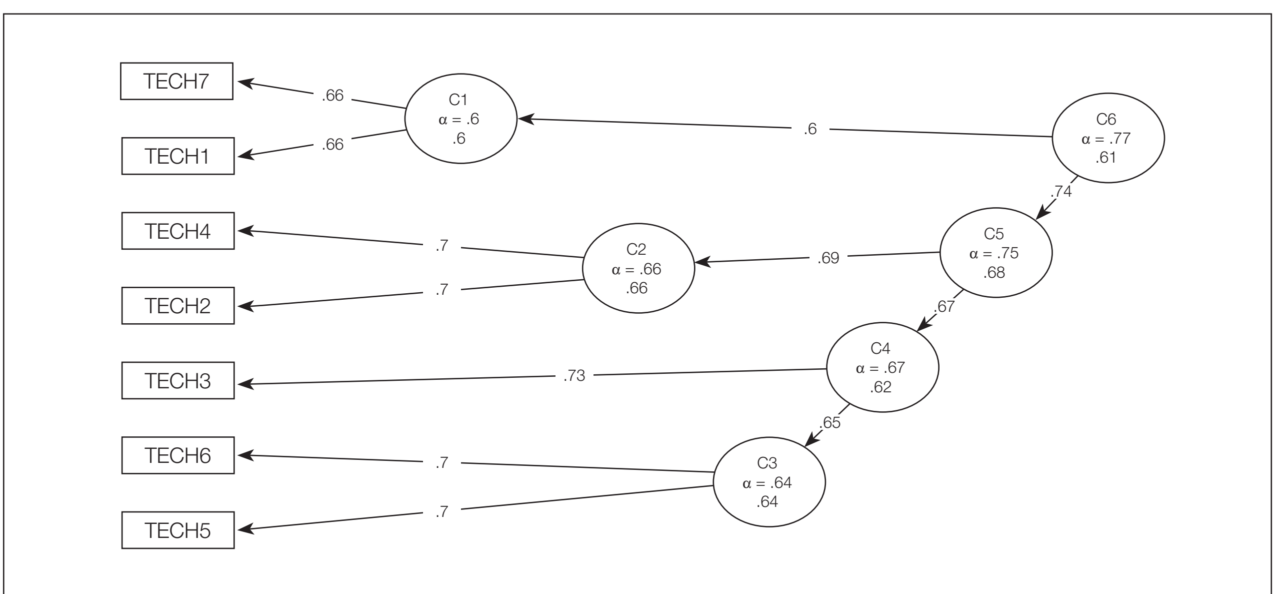


Figure 2 – Rooted dendritic structure of the Perception of Automated Vehicles items (N = 730)

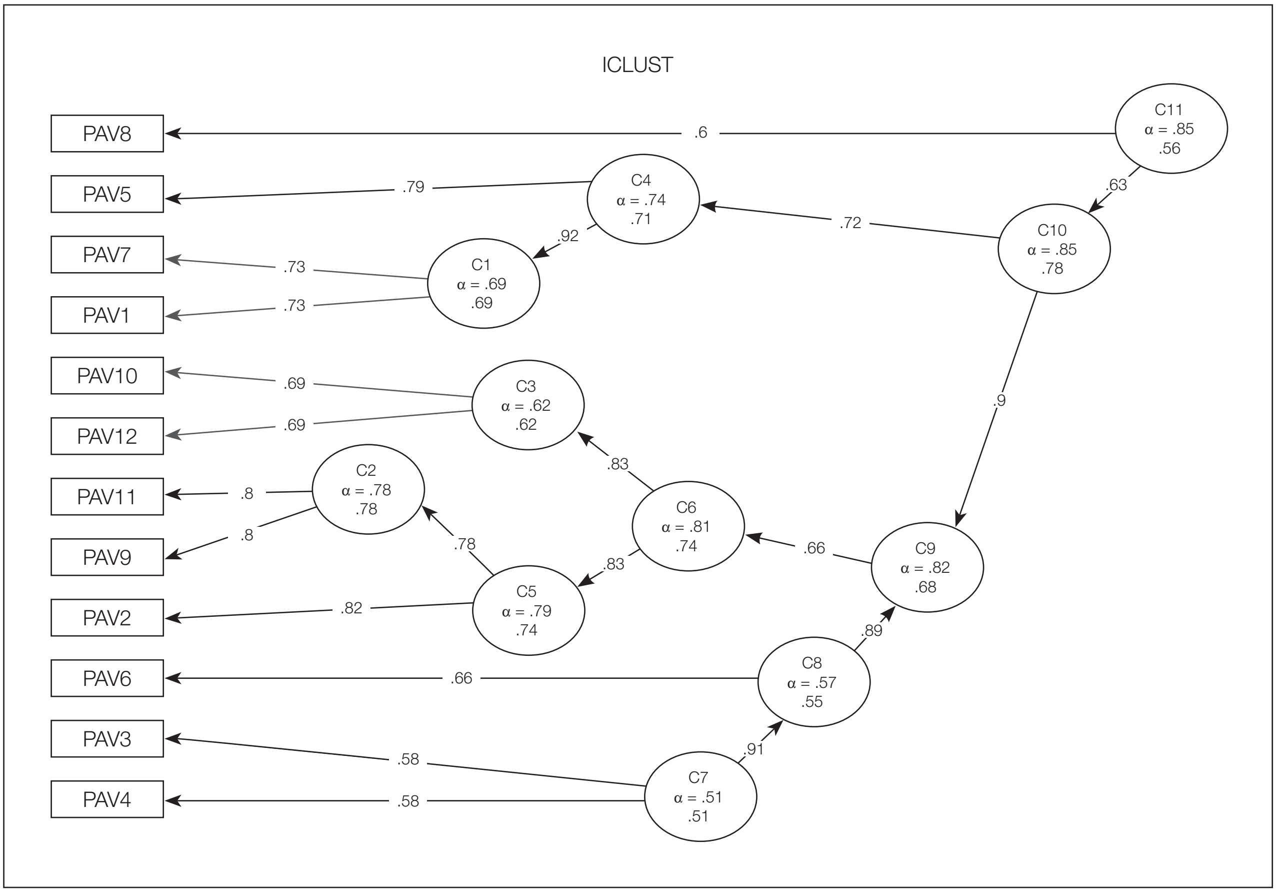
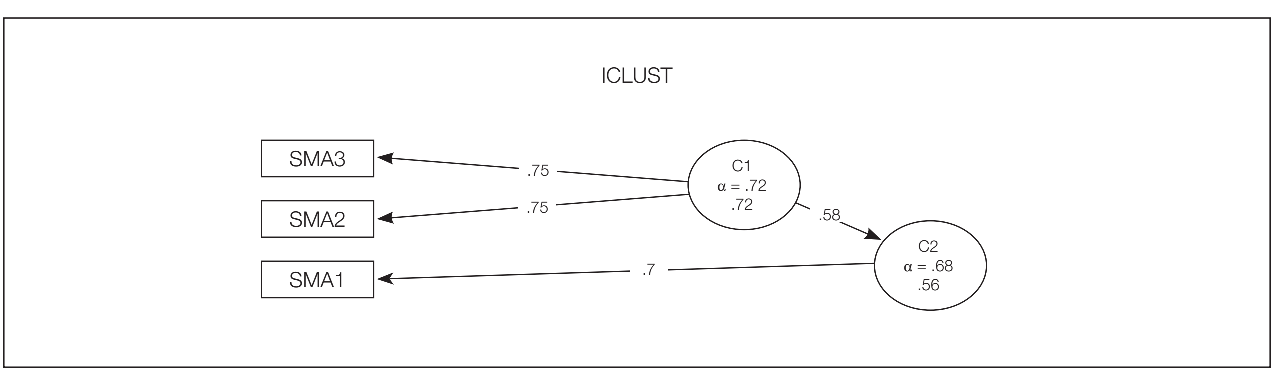


Figure 3 – Rooted dendritic structure of the Sustainable Mobility Attitudes items (N = 730)



2021), the structure estimated via EGA_{GLASSO} suggested three dimensions and presented the lowest TEFI.vn value (−21.11). Rather, the value of the TEFI.vn obtained with EGA_{TMFG} was higher (−20.21), and suggested to retain three dimensions. According to TEFI.vn index value, the EGA_{GLASSO} three-dimensions model was retained as best fitting model. This finding was consistent with our expectations, while confirming and extending bivariate r_{i-t} analysis findings and ICLUST multivariate item analysis results.

Bootstrap EGA was used to estimate and evaluate the stability of dimensions identified by EGA_{GLASSO}; specifically, we carried out 1,000 non-parametric bootstrap (i.e., sampling with replacement) iterations. According to bootstrap EGA results, 3 dimensions were highly stable, median across the replica = 3, *SE* = .50, and 95% confidence intervals = 2.00, 3.99. The distribution of the proportion of times that a certain number of dimensions was replicated, confirms that 3 dimensions were the most stable dimensional organization of the data, being replicated 728 times (a unidimensional solution was found one time, four dimensions were replicated 248 times, five dimensions were replicated 23 times).

Figure 4 represents the EGA_{GLASSO} network, whereas Figure 5 provides a graphical summary the number of times each item was estimated in the same dimension according to bootstrap EGA_{GLASSO} results. The importance of individual nodes in the network was assessed by computing node centrality measures (Epskamp et al., 2018; Opsahl, Agneessens, & Skvoretz, 2010); the results of the visual analysis of centrality are displayed in Figure 6. As to the structure of the measure, EGA results supported the three-cluster model as the best-fitting solution, thus suggesting that the item pool that was administered in our survey could be safely assigned on the expected scales (i.e., TOS, PAV, and SMA scales).

– *Reliability and validity*. Based on univariate and multivariate item analysis, as well as on EGA_{GLASSO} results, we computed mean scores for the TOS, PAV, and SMA scale (Kaiser & Wilson, 2000; Tennant et al., 2019). Descriptive statistics, MIC and Cronbach's α values, as well as distribution percentiles, and scale inter-correlations for the TOS, PAV, and SMA scale scores are summarized in Table 4. As it can be observed, MIC items suggested adequate internal consistency for all scales (Clark & Watson, 1995), although the SMA scale showed a Cronbach's alpha coefficient value slightly lower than .70 (Nunnally & Bernstein, 1994).

When the TOS, PAV, and SMA scale mean scores were formally compared using repeated measure ANOVA, the Mauchly's sphericity test was highly significant, W = .68, χ^2 (2) = 279.85, p<.001, e = .76. The hypothesis of scale mean equality was rejected, Huyn-Feldt $F_{(1.519,\ 1107.081)} = 158.46$, p<.001, η^2 = .18. As it can be observed in Table 4, Bonferroni paired-sample post hoc contrasts showed that SMA mean score was significantly lower than both TOS and PAV mean scores, whereas TOS mean score was significantly higher than PAV mean score. In other terms, in our sample sustainable mobility attitudes were significantly less considered than technological optimism and positive disposition towards automated vehicles, at least as they were operationalized in the SMA, TOS, and PAV scales, respectively. Confirming and extending previous findings (e.g., Tennant et al., 2019), in our study TOS and PAV were positively, significantly, and moderately correlated; rather, SMA scores were independent from measures of technological optimism and positive disposition towards automated vehicles. Participant's years of driving experience were not significantly associated with TOS, r = −.05, p>.10, and PAV, r = −.07, p>.05, total scores, while showing a significant and negative, albeit weak relationship with SMA total score, r = −.14, p<.001.

In our sample, gender comparison could not be carried out on non-binary gender participants because of their small number; a significant multivariate effect of participant's binary gender on TOS, PAV, and SMA scale scores was observed, Hotelling's T^2 = 496.80, $F_{(6,\ 1440)} = 8.33$, p<.001. Descriptive statistics in male and female participants and Bonferroni *t*-test comparisons of TOS, PAV, and SMA scale mean scores are reported in Table 5. As it can be observed, female participants showed a significantly higher attitude to sustainable mobility than male participants, although the effect size (i.e., Cohen's *d* value) was modest. In line with previous reports, (e.g., Tennant et al., 2019), male participants scored significantly higher than female participants on self-report measures of technological optimism and positive disposition towards automated vehicle drive; however, effect size (i.e., Cohen's *d* values) for these mean differences were in the small-to-moderate range.

No significant multivariate effect of participants' job on TOS, PAV, and SMA scale scores was observed in one-way MANOVA, Pillai's V = .01, $F_{(6,\ 1440)} = 1.69$, p>.10. Although previous studies (e.g., Hudson et al., 2019) found

Figure 4 – Network structure estimated using Exploratory Graph Analysis)

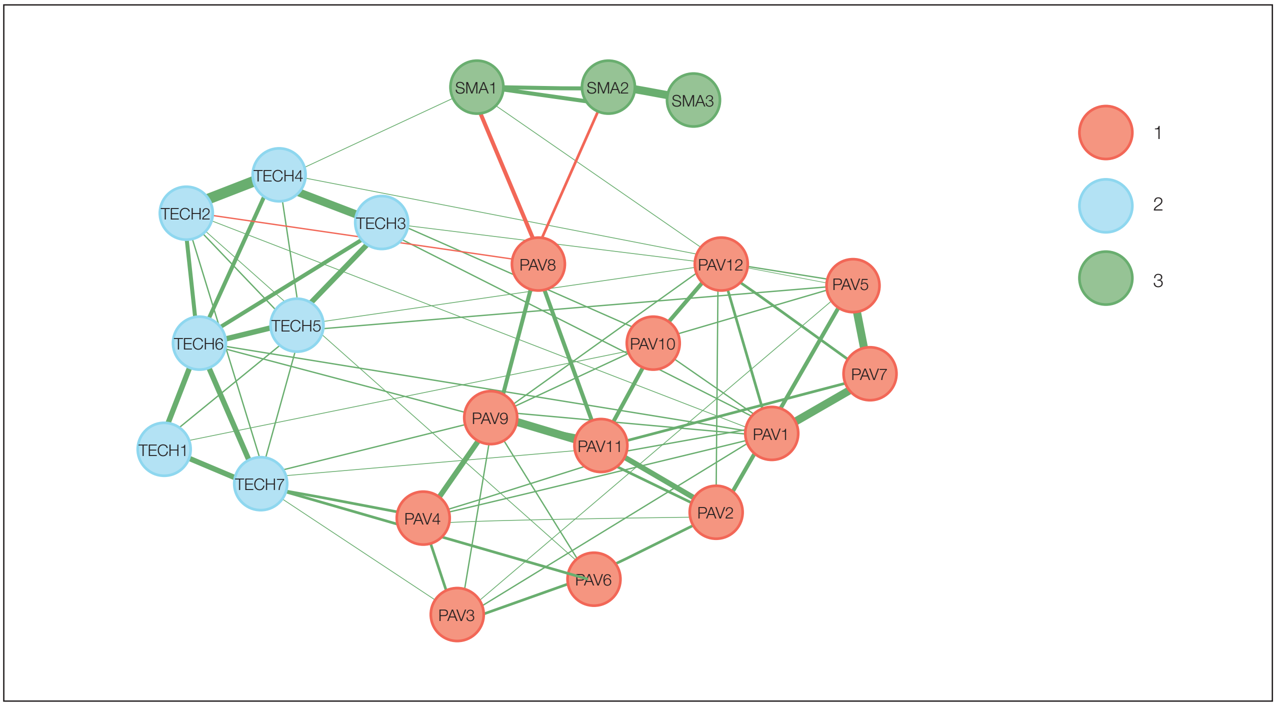


Figure 5 – Bootstrap EGA_{GLASSO} variable stability results

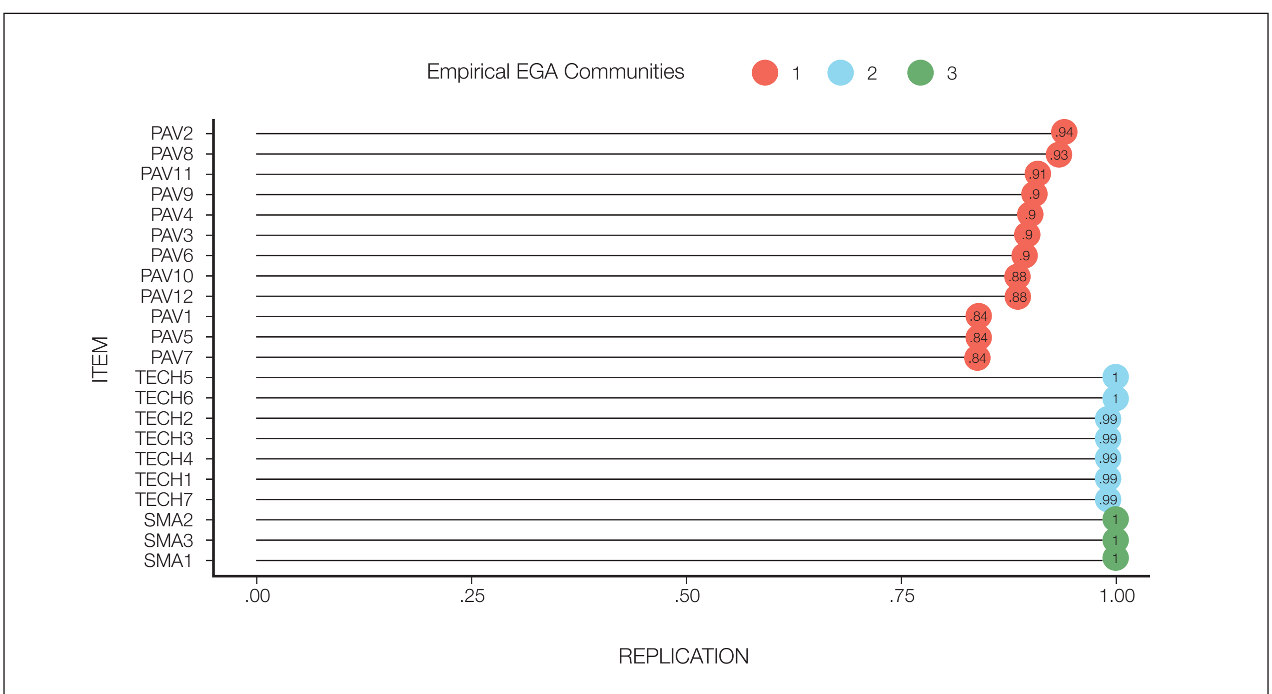


Figure 6 – *Z*-scored centrality metrics (betweenness, closeness, strength) for the Exploratory Graph Analysis model

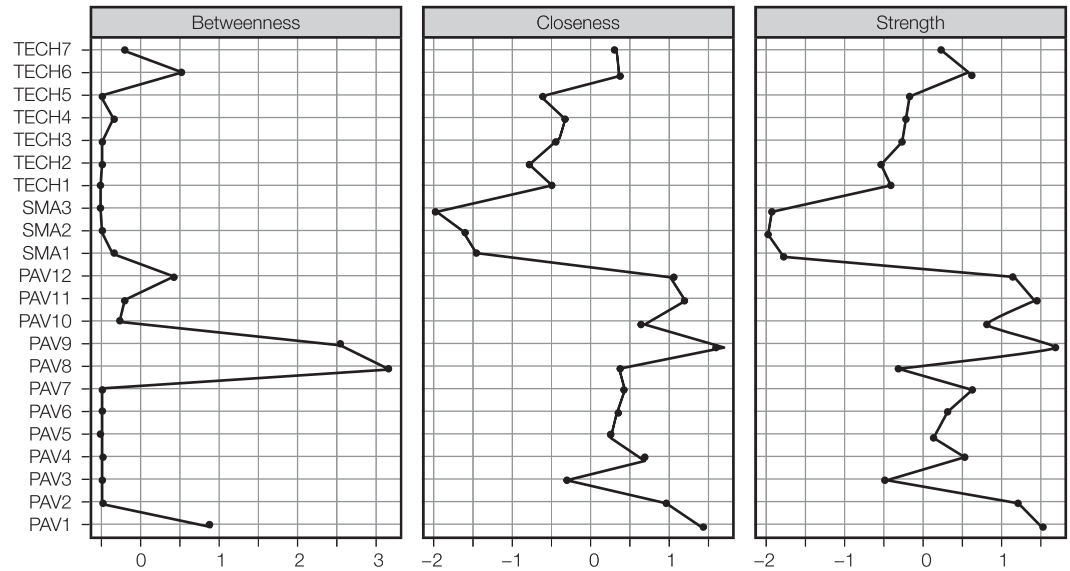


Table 4 – Technological Optimism, Perception of Automated Vehicles, and Sustainable Mobility Attitudes scale scores: descriptive statistics, mean inter-item correlation, Cronbach's alpha value, distribution percentiles, and scale inter-correlations (i.e., Pearson *r* coefficient values) in Italian community-dwelling adult participants (N = 730)

					Distribution percentiles							**Pearson *r* values**		
Scales	*M*	*SD*	MIC	*α*	*5*	*10*	*25*	*50*	*75*	*90*	*95*	*1*	*2*	*3*
1. TOS	3.23	.66	.32	.77	2.14	2.43	2.86	3.29	3.71	4.13	4.35	–		
2. PAV	2.70	.62	.33	.85	1.67	1.84	2.25	2.75	3.08	3.50	3.67	.37***	–	
3. SMA	2.57	1.03	.42	.68	1.00	1.00	1.67	2.67	3.33	4.00	4.33	.06	−.07	–

Legenda. TOS = Technological Optimism Scale; PAV = Perception of Automated Vehicles Scale; SMA = Sustainable Mobility Attitudes; MIC = Mean inter-item correlation; α = Cronbach's alpha coefficient.
Note. Means with different superscripts were significantly different in Bonferroni paired-sample post-hoc constructs.
*** *p*<.001

Table 5 – Technological Optimism, Perception of Automated Vehicles, and Sustainable Mobility Attitudes scale scores in community-dwelling adult male (n = 276) and female (n = 446) participants: descriptive statistics and Bonferroni mean comparisons

	Male participants (*n* = 276)		**Female participants (*n* = 446)**		**Mean comparisons**	
	M	*SD*	*M*	*SD*	*t* (720)	*d*
TOS	3.40	.65	3.13	.65	5.53 *	.42
PAV	2.84	.65	2.61	.58	4.89 *	.38
SMA	2.43	.96	2.66	1.07	−2.89 *	.23

Legenda. TOS = Technological Optimism Scale; PAV = Perception of Automated Vehicles Scale; SMA = Sustainable Mobility Attitudes.
Note. The nominal significance level (i.e., $p<.05$) for independent-sample *t*-tests was corrected according to the Bonferroni procedure and set at $p<.0167$.
* $p<.0167$

a negative association between being unemployed or retired and propensity to use AVs, it should be observed that this finding was not unexpected given that our sample was mainly composed by active community members (i.e., 94%). Future studies may address this issue including a larger number of unemployed and retired participants. One-way MANOVA results seemed to indicate a significant multivariate effect of participant's civil status on TOS, PAV, and SMA scale scores, Pillai's $V = .04$, $F_{(9,\ 2169)} = 3.01$, $p<.01$. However, when the effect of participant's binary gender was controlled for in two-way MANOVA, Pillai's $V = .02$, $F_{(6,\ 1426)} = 2.59$, $p<.05$, the effect of participant's civil status on TOS, PAV, and SMA scale scores became non-significant, Pillai's $V = .01$, $F_{(9,\ 2142)} = 1.19$, $p>.20$; no significant gender-by-civil status interaction effect was observed, Pillai's $V = .02$, $F_{(12,\ 2142)} = 1.12$, $p>.30$. Rather, one-way MANOVA results evidenced a significant multivariate effect of participant's educational level on TOS, PAV, and SMA scale scores, Pillai's $V = .07$, $F_{(9,\ 2175)} = 5.42$, $p<.001$. Descriptive statistics, univariate *F*-tests, and Bonferroni post hoc contrasts are summarized in Table 6; the nominal significance level (i.e., $p<.05$) of univariate *F*-tests was corrected according to the Bonferroni procedure and set at $p<.0167$. Bonferroni post hoc contrasts were computed only for Bonferroni-significant univariate *F*-tests. In line with previous findings showing that highly educated people tend to show more willingness to use AVs as they perceive them to be safer (e.g., Pettigrew, Talati & Norman, 2018), we found that participants who obtained a graduate and post-graduate degree showed higher PAV scores.

Finally, the Pearson *r* coefficient values for the associations between the TOS, PAV, and SMA scale scores and the BFI scale scores are summarized in Table 7; the nominal significance level (i.e., $p<.05$) was corrected according to the Bonferroni procedure and set at $p<.0033$. As a whole, the relationships between self-reports of Big Five personality dimensions and TOS, PAV, and SMA scale scores were small and non-significant. Technological optimism, at least as it was operationalized in the TOS scale, was positively and significantly, albeit weakly associated with self-reported openness to experience, while showing a modest, negative, and significant association with participant's disposition towards negative affectivity, at least as it was operationalized in the BFI Neuroticism scale. Rather, participant's disposition towards negative affectivity was significantly, positively, and weakly associated with sustainable mobility attitude, at least in our sample of Italian community-dwelling adult participants.

Table 6 – Technological Optimism, Perception of Automated Vehicles, and Sustainable Mobility Attitudes scale scores broken down by educational level: descriptive statistics and Bonferroni mean comparisons

	Junior High School (n = 26)		High School (n = 301)		Graduate (n = 354)		Post-Graduate (n = 48)			
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	$F_{(3, 725)}$	η^2
TOS	2.76	.93	3.13	.65	3.33	.63	3.40	.56	10.96 *	.04
PAV	2.36	.76	2.61 [a]	.60	2.76	.61	2.95	.60	8.80 *	.04
SMA	2.41	1.00	2.48	.96	2.63	1.09	2.73	1.08	1.77	.01

Legenda. TOS = Technological Optimism Scale; PAV = Perception of Automated Vehicles Scale; SMA = Sustainable Mobility Attitudes.
Note. The nominal significance level (i.e., p<.05) for univariate F-tests was corrected according to the Bonferroni procedure and set at p<.0167.
Bonferroni post-hoc contrasts were computed only for Bonferroni-significant univariate F-tests; within each row, means with different superscripts were significantly different in Bonferroni post-hoc contrast.
* p<.0167

Table 7 – The Big Five Inventory Personality scales: descriptive statistics, Cronbach' alpha values, and correlations (i.e., Pearson's r coefficient values) with Technological Optimism, Perception of Automated Vehicles, and Sustainable Mobility Attitudes scale scores in Italian community-dwelling adult participants (N = 730)

	Big Five Inventory Personality scales				
	Openness	*Conscientiousness*	*Extraversion*	*Agreeableness*	*Neuroticism*
TOS	.12*	.04	.02	.06	–.21 *
PAV	.09	–.11	–.04	–.02	–.11
SMA	.07	–.06	–.09	–.02	.14 *
M	36.99	35.32	25.88	33.05	24.36
SD	6.12	5.44	5.86	5.31	5.92
Cronbach's α	.82	.83	.84	.74	.83

Legenda. TOS = Technological Optimism Scale; PAV = Perception of Automated Vehicles Scale; SMA = Sustainable Mobility Attitudes.
Note. The nominal significance level (i.e., p<.05) for Pearson r coefficients was corrected according to the Bonferroni procedure and set at p<.0033.
* p<.0033

CONCLUSIONS AND LIMITATIONS

As a whole, our findings seemed to suggest that the short measure assessing positive dispositions towards technology (i.e., TOS), and automated vehicles (i.e., PAV), and sustainable mobility attitudes (i.e., SMA), developed in the present study was provided with adequate psychometric properties, at least in a sample of Italian volunteers who agreed to participate in the present investigation. Moreover, the results of our study may prove useful in integrating Tennant and colleagues' (2019) data on attitudes to driving alongside AVs, focusing on different aspects (e.g., sustainable mobility attitudes), while proving an extensive focus on the Italian context. Finally, the development of a short measure thought to assess dispositions towards AVs may represent the starting point for collecting demographically representative data on the acceptance of AVs, which is considered as a key factor for the success of them (e.g., Othman, 2021). Indeed, the availability of standardized brief measures of positive dispositions towards technology, positive dispositions towards automated vehicles, and sustainable mobility attitudes may enable researchers to embed them in a larger number of studies, which would serve to expedite the process of identifying the key aspects related to the willingness to use AVs. Notably, these short instruments could be used to reliably assess the dispositions towards AVs in large data collection where administration time is valuable and limited.

Of course, the results of the present study should be considered in the light of several, important limitations. Although we relied on a moderately large community-dwelling adult sample, it was composed of adults who volunteered to participate in the study. Thus, it represents a convenient study group rather than a sample representative of the Italian population. Future studies based on representative samples are needed. In the present investigation, participants were adult volunteers who received no incentive for taking part in the research; although no economic interests were at issue, we relied exclusively on self-report questionnaire, with no possibility to rely on observations or interviews. Of course, further studies based on different methods of assessment are badly need before accepting our findings. Moreover, it should be observed that our findings should be considered in the light of the fact that AVs are not widespread adopted; thus, the results largely relied on people's ideas about AVs rather than AVs driving experience (see also, Kyriakidis et al., 2015). Finally, although we relied on sound psychometric methods, we think that independent replications of our findings are needed, possibly considering also vulnerable road users (e.g., pedestrians and bicyclists; Penmetsa et al., 2019) as a relevant research target.

Even keeping these limitations in mind, we think that our findings may represent a useful contribution to the available literature on AVs providing researchers a short measure to assess different aspects contributing to the perception of AVs among community-dwelling participants, at least in Italy. Because public perceptions play a crucial role in wider adoption of AVs (Othman, 2021; Penmetsa et al., 2019), the availability of a standardized measure of dispositions towards technology and automated vehicles, and sustainable mobility attitudes may provide useful data to both researchers and automotive industries.

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SUPPLEMENTARY MATERIAL

Technological Optimism Scale (TOS)

English version

- Science and technology make our way of life change too fast (R)
- I'm not interested in new technologies (R)
- Science and technology are making our lives healthier, easier and more comfortable
- I enjoy making use of the latest technological products and services when I have the opportunity
- New technologies are all about making profits rather than making people's lives better (R)
- I am worried about where all this technology is leading (R)
- Machines are taking over some of the roles that humans should have (R)

Italian version

- La scienza e la tecnologia cambiano il nostro modo di vivere troppo velocemente (R)
- Non sono interessato/a alle nuove tecnologie (R)
- La scienza e la tecnologia stanno rendendo le nostre vite più sane, più facili e più confortevoli
- Mi piace utilizzare gli ultimi prodotti e servizi tecnologici quando ne ho l'opportunità
- Le nuove tecnologie mirano a realizzare profitti piuttosto che a migliorare le vite delle persone (R)
- Sono preoccupato/a per dove sta portando tutta questa tecnologia (R)
- Le macchine stanno prendendo il posto di alcuni ruoli che dovrebbero essere degli esseri umani (R)

Perception of Automated Vehicles Scale (PAV)

English version

- Most accidents are caused by human error so autonomous vehicles would be safer
- I wouldn't mind whether I was driving alongside human drivers or autonomous vehicles (R)
- Autonomous cars could malfunction (R)
- As a point of principle, humans should be in control of their vehicles at all times (R)
- Autonomous cars would behave more predictably than human drivers
- Machines don't have the common sense needed to interact with human drivers (R)
- Machines don't have emotions so they might be better drivers than humans
- I would miss the enjoyment of driving (R)
- I would feel uncomfortable if I wasn't in control of my car (R)
- I would take the opportunity to do other things while the autonomous car takes care of the driving
- It would make no difference to me whether I was in control of the car or not
- Riding in an autonomous car would be easier than driving myself

Italian version

- La maggior parte degli incidenti è causata da errore umano; quindi, i veicoli a guida autonoma sarebbero più sicuri
- Per me non farebbe alcuna differenza se fossi in macchina con conducenti umani o se guidassi veicoli a guida autonoma (R)
- Le auto autonome potrebbero non funzionare correttamente (R)
- In linea di principio, gli esseri umani dovrebbero avere il controllo dei loro veicoli in ogni momento (R)
- Le automobili a guida autonoma si comporterebbero in modo più prevedibile dei conducenti umani
- Le macchine non hanno il buon senso necessario per interagire con i conducenti umani (R)
- Le macchine non hanno emozioni, quindi potrebbero essere dei conducenti migliori degli umani
- Mi mancherebbe il piacere di guidare (R)
- Mi sentirei a disagio se non avessi il controllo della mia automobile (R)
- Coglierei l'occasione per fare altre cose mentre l'automobile a guida autonoma si occupa della guida
- Non farebbe differenza per me se avessi il controllo dell'automobile o no
- Guidare un'automobile a guida autonoma sarebbe più facile che guidare io stesso

Sustainable Mobility Attitudes (SMA)

English version

- I do not know whether I can use leaded gas in my automobile
- I usually drive on freeways at speeds under 60 mph
- When possible in nearby areas (around 20 miles), I use public transportation or ride a bike

Italian version

- Non so se posso utilizzare benzina al piombo per la mia automobile (R)
- Generalmente, in autostrada guido a meno di 130 km/h
- Quando possibile per raggiungere mete vicine (circa 30 km), uso i trasporti pubblici o la bicicletta