Transportation Research Part F 78 (2021) 480–494

Contents lists available at ScienceDirect

Transportation Research Part F

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

Staying on or getting off the sidewalk? Testing the Mehrabian-Russell Model on pedestrian behavior

Hernan Alberto Ortiz-Ramirez [a,*], Jose Agustin Vallejo-Borda [b,c], Alvaro Rodriguez-Valencia [d]

[a] *Sostenibilidad Urbana y Regional (SUR) Research Group, Department of Civil and Environmental Engineering, Universidad de los Andes, Carrera 1E N° 19A-40, 111711 Bogotá, Colombia*
[b] *BRT + Centre of Excellence, Department of Transport Engineering and Logistics, Pontificia Universidad Católica de Chile, Avda. Vicuña Mackenna 4860, Macul, Santiago, Chile*
[c] *AVR Research Group, Department of Civil Engineering, Universidad de Investigación y Desarrollo, Calle 9 N° 23-55, Bucaramanga, Santander, Colombia*
[d] *Department of Civil and Environmental Engineering and Director of Sostenibilidad Urbana y Regional (SUR) Research Group, Universidad de los Andes, Carrera 1E N° 19A-40, 111711 Bogotá, Colombia*

A R T I C L E I N F O

Article history:
Received 23 July 2020
Received in revised form 28 February 2021
Accepted 10 March 2021

Keywords:
Pedestrian behavior
Sidewalk approach
Mehrabian-Russell model
Sensory perception
Pleasure
Dominance
Arousal

A B S T R A C T

Social and environmental psychology provide a variety of models based on which to understand how built environments can elicit people's behavioral responses. The Mehrabian-Russell model (MRM), initially presented in 1974, provides a framework that explains avoid–approach behavior towards a place based on a primary emotional response (PER) and affective states elicited by the perceived stimuli from the environment. However, despite the potential applications of the MRM in travel behavior studies, traditional models (e.g., discrete choice models and integrated choice latent variable) do not incorporate this specific psychological process that converts environmental stimuli into behavioral responses. Hence, this paper aims to test the applicability of MRM to urban sidewalks. To fulfill this objective, we developed a two-level structural equation model using latent variables (LV) identified from a confirmatory factor analysis (CFA) based on 1056 in-person surveys on 30 different sidewalks in Bogotá, Colombia. We then evaluated the effect of the PER on declared avoidance as a proxy of behavioral intention. The CFA uncovered three LV equivalent to the three affective dimensions of the MRM—arousal, pleasure, and dominance—followed by a fourth LV, representing the PER, which explains the three previous LVs. This confirms the applicability of these kinds of psychological and environmental models in pedestrian behavior evaluation. We found that PER can explain the declared intention of avoidance towards the sidewalk in an urban setting. Proving that this kind of model can explain the way in which the built environment can elicit pedestrians' emotional responses and subsequent behaviors, provides information that can be used as input in travel behavior studies focusing on the promotion of active traveling and mode change.

1. Introduction

The modal shift towards active traveling (i.e., walking and bicycling) and public transit transportation is an objective of the sustainable mobility agenda (Asadi-Shekari, Moeinaddini, & Zaly Shah, 2013; Banister, 2008; United Nations, 2020) and can help to mitigate negative transportation externalities. To understand how to accomplish this goal, researchers have

* Corresponding author.
E-mail addresses: ha.ortiz10@uniandes.edu.co (H.A. Ortiz-Ramirez), ja.vallejo907@uniandes.edu.co (J.A. Vallejo-Borda), alvrodri@uniandes.edu.co (A. Rodriguez-Valencia).

https://doi.org/10.1016/j.trf.2021.03.007
1369-8478/

widely studied the association between the built environment and travel behavior or active traveling. Some studies on the transportation field show that different attributes from the built environment can be identified as influencing mode choice and trip rates (Cervero & Kockelman, 1997), route choice (Rodríguez et al., 2015; Shatu & Yigitcanlar, 2018), and active traveling itself (Ameli et al., 2015; Cervero, Sarmiento, Jacoby, Gomez, & Neiman, 2009; Ferrer, Ruiz, & Mars, 2015).

Other authors have developed frameworks proposing theoretical structures that relate the built environment characteristics with traveling behaviors, through individuals' perceptions and attitudes. These frameworks include the study of overall walkability as a walking behavior predictor (Ewing & Handy, 2009), the study of individual and environmental factors explaining walking and walking for recreation (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003), explaining walking and cycling for transport or recreation (Saelens, Sallis, & Frank, 2003), and the study of individual factors impacting sustainable modes choice (Schneider, 2013). These frameworks rely on the inclusion of both objective measured (e.g., geometric characteristics of right-of-way, accessibility, or land use) and subjective attributes (e.g., perceptions of the built environment and attitudes) in theoretical structures developed and validated by experts (Ewing & Handy, 2009; Pikora et al., 2003), literature reviews (Saelens et al., 2003), and in-depth interviews (Schneider, 2013). However, most of these studies and frameworks are based on findings in the literature that associate built environment and travel behavior but, due to their scope, do not explicitly incorporate specific psychological processes that transform the built environment related stimuli on behavioral responses. These kinds of processes are explained by environmental psychology models that are typically referred to as stimuli – organism – response (SOR) models, which study how stimuli are processed in order to generate an output or response (Kim, Lee, & Jung, 2020).

The Mehrabian and Russell (1974) model (MRM) is one of these SOR models, which accounts for how an emotional response (related to the perception of the built environment) can explain approach/avoidance behaviors towards situations (e.g., conversations and social interaction) and places (e.g., restaurants (Jang & Namkung, 2009) or retail stores (Donovan & Rossiter, 1982; Yani-de-Soriano & Foxall, 2006). This model has been considered seminal to developing the SOR structure and to the environmental psychology field (Chen & Yao, 2018; Manthiou et al., 2017; Ngah, Kim, Hanafiah, & Salleh, 2019). Recent studies had implemented the MRM's perspective in fields such as consumer behavior (Chen & Yao, 2018; Ngah et al., 2019), tourism, including events and hotel management (Hung, Peng, & Chen, 2019; Kim et al., 2020; Manthiou et al., 2017; Sun, Chen, Ren, Shih, Ma, Wang, & Ha, 2020), and airline management (Ali, Perumal, & Shaari, 2020). These studies had focused on explaining how behavioral intentions (e.g., revisiting a place, repurchasing goods or services, preferring a place over another, or even the willingness to pay) depend on affective responses (e.g., positive affect (Chen & Yao, 2018) or feeling "good"). These affective responses are usually elicited by contextual stimuli affecting people directly. Hence, these studies often reveal a structure that relates contextual stimuli to an affective response, and such response to behavior or behavioral intention. In the case of active transportation, unlike automobile transportation, individuals are in direct contact with the environment, exposed to contextual stimuli (Vallejo-Borda, Cantillo, & Rodriguez-Valencia, 2020). Thus, we hypothesize that a SOR structure like the MRM can be applied and replicated into the cognitive/affective process that lead to behavioral intentions (i.e. avoid / approach) and, hence, the objective of this study is to test whether the MRM can be used to explain pedestrians' approach or avoidance behavior towards urban sidewalks.

To identify whether the built environment elicits such behavioral responses (i.e., avoid / approach towards sidewalks), in this case for pedestrians, we tested a section of the MRM (see Fig. 1) with data from Bogota, Colombia. In this study, we focus on analyzing the MRM from the SOR perspective, testing the relationships between built environment perceptions, emotional responses, and declared behaviors, by means of a two-level Structural Equation Modelling (SEM) approach. We developed the model based on 1056 in-person surveys collected in 2018 on 30 different sidewalks in Bogotá, Colombia. The data was used to better understand pedestrian perceptions about the built environment and to evaluate pedestrian infrastructure based on such perceptions (Rodriguez-Valencia, Barrero, Ortiz-Ramirez, & Vallejo-Borda, 2020; Vallejo-Borda, Ortiz-Ramirez, Rodriguez-Valencia, Hurtubia, & Ortúzar, 2020) and do not include individuals' characteristics (i.e., their attitudes or personality traits).

2. Literature review

The urban built environment has been widely found to exert an influence on travel behavior in the transport literature (Cervero et al., 2009; Ewing & Cervero, 2010; Handy, Boarnet, Ewing, & Killingsworth, 2002; Saelens & Handy, 2008). The

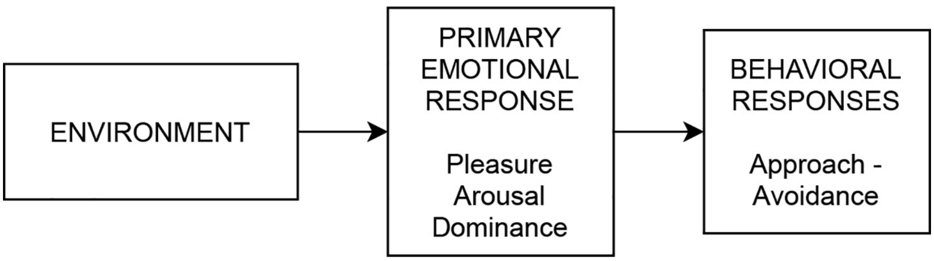

Fig. 1. Mehrabian-Russell framework section, not including personality traits.

studies on this relationship have proposed that the way cities are planned, and their attributes (e.g., density, diversity, design, traffic, walkability) are correlates of mode and route choice (Ameli et al., 2015; Cervero et al., 2009; Cervero & Kockelman, 1997; Ferrer et al., 2015; Rodríguez, Brisson, & Estupiñán, 2009), and thus, the built environment characteristics of the contexts can, at least partly, explain traveling related decisions. Some of the studies on this relationship use discrete choice models in which, for example, the mode or route selection is based on utility maximization related to the alternatives' objective attributes under the random utility theory (Ben-Akiva & Bierlaire, 1999; Walker & Ben-Akiva, 2002).

The potential of including individuals' subjective attributes (e.g., happiness, related to mode change (Abou-Zeid, Witter, Bierlaire, Kaufmann, & Ben-Akiva, 2012)) had been studied in the literature in past decades. Hence, the traditional approach has been complemented with the addition of individuals' beliefs, attitudes, and perceptions through the inclusion of latent variables (LV) in integrated choice and latent variable (ICLV) models (Vij & Walker, 2016). This approach is aimed at understanding decision-making processes by assessing both alternatives' objectively measured attributes and individuals' psychological factors identified from perceptual indicators (Ben-Akiva, Walker, Bernardino, Gopinath, Morikawa, & Polydoropoulou, 2002; Ortúzar & Willumsen, 2011).

Perceptual indicators can be obtained from the assessment of interactions between individuals and contexts. The micro-scale characteristics of the built environment are mostly perceived by people in direct contact with them (e.g., pedestrians and bicyclists) (Barrero & Rodriguez-Valencia, 2021; Ma & Cao, 2019; Samuel et al., 2019), and such perceptions initiate the SOR process (Jang & Namkung, 2009; Ma & Cao, 2019) that explain how environmental stimuli affect individuals' emotions and subsequent behaviors (Bornioli, Parkhurst, & Morgan, 2019).

The seminal case of the SOR process was proposed in the Mehrabian and Russell (1974) model (MRM) (Manthiou et al., 2017). The MRM proposes that behavioral responses (i.e., avoidance – approach) towards an activity or place can be explained by a primary emotional response (PER) that environmental stimuli elicit on an individual. Such emotional response accounts for three affective dimensions (i.e., pleasure, arousal, and dominance) that cover the whole spectrum of individuals' affective states (Mehrabian, 1996; Mehrabian & Russell, 1974). Fig. 1 illustrates a section of the MRM as presented by the authors (Mehrabian & Russell, 1974).

The three affective dimensions, namely pleasure, arousal, and dominance, are dimensions that have been broadly used to understand the spectrum of individuals' emotions in the literature since they interact and coexist. These dimensions have been defined as continuums (Bakker, van der Voordt, Vink, & de Boon, 2014) that can be verbally reported (Mehrabian & Russell, 1974; Samuel et al., 2019), considering semantic differentials (e.g., happy – unhappy for pleasure (Stamps, 2005)).

In the case of pleasure, the literature shows valence as an equivalent concept (Friman, 2010; Paül i Agustí, Rutllant, & Lasala Fortea, 2019; Samuel et al., 2019; Zhang, Ihme, & Drewitz, 2019) that has traditionally been used to describe affective experiences (Russell, Weiss, & Mendelsohn, 1989) and is related to hedonic pursues (Ryan & Deci, 2001). Pleasure refers to the individuals' affective rate of stimuli and experiences as happy/unhappy, enjoyable/unenjoyable, or agreeable/disagreeable (Appolloni, Corazza, & D'Alessandro, 2019; Friman, 2010; Paige Willis, Manaugh, & El-Geneidy, 2013; Wild & Woodward, 2019) and has been measured using semantic differentials such as comfort/discomfort (Samarasekara, Fukahori, & Kubota, 2011), pleasantness/unpleasantness (Stamps, 2005), and satisfaction/dissatisfaction (Bakker et al., 2014; Mehrabian & Russell, 1974). In the transportation field, enjoyment has also been used as a measure for pleasure, as it has been proposed that pedestrians and bicyclists report enjoyment related to travel itself (Gatersleben & Uzzell, 2007; Paige Willis et al., 2013). In addition to this, satisfaction is a standard dependent variable used to evaluate transportation infrastructure and mode performance (Vallejo-Borda, Cantillo, et al., 2020; Vallejo-Borda, Ortiz-Ramirez, et al., 2020; van Lierop, Badami, & El-Geneidy, 2018). Satisfaction is based on the differences between the perceived and expected service provided and has been proven to serve as a driver of behavioral intentions and responses such as approaching specific modes of public transportation (Allen et al., 2019, 2020; Lai & Chen, 2011). Pleasure has been positively associated with approach behaviors and the dominance dimension, and negatively associated with the arousal dimension (Jang & Namkung, 2009; Yani-de-Soriano & Foxall, 2006).

Arousal, also called activation (Friman, 2010; Paül i Agustí et al., 2019), has been defined in the literature as the perceived intensity of stimuli; hence, it is usually described as a state of being, which lies somewhere between relaxed and stimulated (Bakker et al., 2014). The degree of stimuli intensity can be related to both positive and negative affective experience, going from drowsiness to overarousal, which is related to sensory overload and stress (Gatersleben & Uzzell, 2007; Liu & Ma, 2019). Furthermore, Mehrabian and Russell (1974) proposed that arousal correlates with information rates (i.e., increases in stimuli intensity increases arousal), and evidence shows that extreme levels of arousal can be related to avoidance behaviors (Van Oel & Van den Berkhof, 2013). Among the measures used to describe arousal in an environment, noise and pollution appear in different studies (Evans & Stecker, 2004; Gatersleben & Uzzell, 2007; Mehrabian & Russell, 1974) as positively associated with stress and overarousal; therefore, high levels of arousal can be negatively associated with the pleasure dimension.

Dominance or power (Zhang et al., 2019) is related to individuals' perceived control over their activities, situations, or contexts. It can be described as the extent to which an individual feels restricted to act or influence the context (Bakker et al., 2014; Gatersleben & Uzzell, 2007; Mehrabian & Russell, 1974; Stamps, 2005; Yani-de-Soriano & Foxall, 2006). Negative affective experiences, in this dimension, come from a feeling of submissiveness or low control of the situation (Ryan & Deci, 2017; Zhang et al., 2019). In the literature, it has been related to crowding where high densities negatively impact the freedom experienced by individuals (Lombardi & Ciceri, 2019; Mehrabian & Russell, 1974; Van Oel & Van den Berkhof, 2013; Yani-de-Soriano & Foxall, 2006). To evaluate crowding and its effect over negative affective experiences, Liu and Ma (2019) used affirmations as: "*People are very close to me in this place*" and "*There are a high number of people in this place.*".

And, Lombardi and Ciceri (2019) used traffic congestion as a predictor of perceived crowding. It has also been found that the dominance dimension is positively related to approach behavior, meaning that submissiveness is negatively related to such behavior. Furthermore, the dominance dimension showed a positive relationship with the pleasure dimension (Yani-de-Soriano & Foxall, 2006).

These three dimensions can be perceived simultaneously, which implies that they can indicate people's emotional responses. It was found in the literature that these three dimensions correspond to manifestations of a response that can describe a complex state of feeling (Bakker et al., 2014; Jang & Namkung, 2009; Russell, 2003; Russell et al., 1989). In this respect, Lombardi and Ciceri (2019) propose that emotions are combinations of these dimensions, and Stamps (2005) suggests that these three dimensions are descriptors of affective experiences. Furthermore, while modeling an affective response using the SOR approach, Kim et al. (2020) showed that this response accounts for emotional states and perceptions on different individuals' affective dimensions. Based on the information previously presented, a second-order equation structure was proposed.

The MRM framework can potentially be used to understand how the built environment is perceived and how travel-related decisions can be influenced by such perceptions. As shown earlier, previous studies aimed at uncovering the effects of the built environment on traveling employing utility maximization, and more recent studies included psychological factors. However, these models rarely specified underlying psychological processes (i.e., pre-established structures), including affective experiences and emotional responses that mediate between perception and behaviors. The MRM can provide information on such underlying psychological processes and structures, including the specification and understanding of how—in the field of psychology—the broadly studied affective dimensions and emotional responses are influenced by the perception of contextual stimuli. Furthermore, this model can provide insight on how to measure and include these affective dimensions when modeling, explaining, and forecasting traveling related behaviors such as approach towards a mode or infrastructure.

3. Methodology

In-situ data collection and modeling based on LVs were developed to test the MRM. We asked pedestrians about their perceptions of different built environment characteristics and, exclusively, used their answers to the perception questions to test the MRM.

3.1. Data collection

The data used in this study were acquired from interception surveys (n = 1056) applied in 30 locations around Bogota, Colombia, between June 2 and June 19, 2018, with a sample distributed by age, sex, and socio-economic strata similar to Bogotás population (see sample distribution in Table 1). At least 30 surveys were administered at each point.

The locations were selected to attain variety of built environments, e.g., diverse sidewalk typologies, different right-of-way widths, different landscaping, and different traffic volumes (see examples in Fig. 2). Surveys were administered in-person at each sidewalk, reducing biases associated with recalling emotions after the experience (Paül i Agustí et al., 2019; Yani-de-Soriano & Foxall, 2006). The survey enquired into respondents' perceptions of the sidewalk and context on a 0 to 10 Likert-based scale and included trip and sociodemographic characteristics. Each survey lasted about 8 min, and the overall response rate was 33.2%. To attain randomness, surveyors picked respondents on a one in every three passing pedestrians basis.

The questionnaire used in this study was based on the work conducted by Rodriguez-Valencia, Paris, and Vallejo-Borda (2017) and has been used in other pedestrian studies (Bellizzi, Eboli, & Forciniti, 2019; Rodriguez-Valencia et al., 2020;

Table 1
Pedestrian sample distribution.

Indicator	Intercept survey number [%]	2019 HTS (Alcaldía Mayor de Bogotá, 2019) [%]
Sex		
Female	49.32	53.13
Male	50.68	46.87
Age		
≤25 years	35.80	36.84
26–40 years	32.15	22.55
41–59 years	21.79	23.12
≥60 years	10.26	17.48
Socio-economic strata		
1 (lowest)	8.34	11.19
2	37.59	38.41
3	37.49	35.05
4	9.05	10.37
5	5.83	2.88
6 (highest)	1.71	2.09

Rossetti & Hurtubia, 2020; Vallejo-Borda, Cantillo, et al., 2020; Vallejo-Borda, Ortiz-Ramirez, et al., 2020). Based on our literature review, we chose 10 out of 48 perception variables from the dataset to test the MRM. The full set of questions was compared to the questions or statements found in the literature review to indicate each of the affective dimensions. Nine of these variables were used as indicators to identify latent variables and one as the dependent variable. The dependent variable (i.e., avoid, see Table 2) was chosen because its related question was similar to questions referring to approach/avoid intentions proposed by Mehrabian and Russell (1974). For instance, "*how much would you seek out or try to find this situation*" or "*how much would you try to leave*". The nine indicators were used in their original scales. Six out of the nine indicators had an inverse relationship where the higher the value in the Likert-based scale, the worse and negative perception (i.e., bike flow, noise, pollution, pedestrian volume, vehicle distance, and pedestrian distance). On the other hand, three of these indicators (i.e., satisfaction, pleasantness, and comfort) were measured in a positive perception scale, which means that the higher the value, the better the perception of each stimulus.

3.2. Modeling approach

PER is not a response that can be objectively measured, but its affective dimensions (i.e., pleasure, arousal, and dominance) can be verbally reported (Mehrabian & Russell, 1974; Samuel et al., 2019). Verbal reports depend directly on the respondent, making these responses subjective, and commonly expressed through LVs (McDonald & Bollen, 2006; Ortúzar & Willumsen, 2011). Kline (2016) defines LVs as hypothetical constructs that reflect a non-observable continuum that can be identified from observed or measured attributes or indicators. Hence, this kind of variable seems to adequately represent the three dimensions and the PER structure in MRM testing. Also, in developing the model, Mehrabian and Russell (1974) proved that each dimension could be measured using multiple verbally reported measurements. Lombardi and Ciceri (2019) suggest that using more than one measure, within a structural equation modeling approach, could enhance the identification of each dimension. Furthermore, recent literature focused on studying this kind of model on different fields has

Fig. 2. Example of audited sidewalks.

Table 2
Built environment perception related indicators and statements.

Indicator	Question/Statement
Questions on the perceptions of the resultant pedestrian interactions in the sidewalk	
Satisfaction	Where 0 is totally dissatisfied and 10 totally satisfied, rate your satisfaction level while using this sidewalk on a scale of 0 to 10
Bike flow	On a scale of 0 to 10, how annoying would you find the presence of the following when walking on the sidewalk
Noise Pollution	On a scale of 0 to 10, to what extent do the following characteristics at this point of the sidewalk bother you
Where 0 is totally disagree, and 10 totally agree, rate the following statements on a scale of 0 to 10	
I prefer not to walk here (Avoid)*	I would rather not walk on this sidewalk
Pleasantness	Walking on this sidewalk is pleasant
Comfort	Walking on this sidewalk is comfortable
Too many pedestrians (Ped. - volume)	On this sidewalk, the number of pedestrians stops me from walking freely
Vehicular flow too close (Veh. - distance)	On this sidewalk, the motor vehicle flow is too close to me
Pedestrians far away from me (Ped. - distance)	When walking on this sidewalk, I prefer other pedestrians to be far away from me

* This variable was dichotomized to avoid = 1 / approach = 0 based on an acceptability threshold asked the participants.

relied on the estimation of LVs and using SEM to identify and understand the processes behind affective responses and behaviors or behavioral intentions (Ali et al., 2020; Chen & Yao, 2018; Hung et al., 2019; Kim et al., 2020; Manthiou et al., 2017; Ngah et al., 2019; Sun et al., 2020). This methodological approach implies that affective dimensions despite orienting emotional states, cannot be directly measured and as such, should be identified through measurements of individuals' perceptions, points of view, and preferences, among others.

Thus, to identify the dimensions and prove their relationships, in this study, we selected confirmatory factor analysis (CFA) and structural equation modeling (SEM) as our methodological approaches. CFA tests a measurement theory to confirm that LVs can be logically inferred from measured or observed variables (i.e., indicators). At the same time, SEM includes the structural theory that explains the existing relations between LVs (Hair, Black, Babin, & Anderson, 2014). In this case, we evaluated the MRM theory from a perspective in which there are three LVs (i.e., pleasure, arousal, and dominance) that can be assessed from verbal reports, and a fourth one (i.e., PER) identified from the three previous LVs. This kind of structure corresponds to a second-order model (Kline, 2016; Koufteros, Babbar, & Kaighobadi, 2009; Rindskopf & Rose, 1988). In such models, first-order LVs are indicated by observed or measured variables (i.e., pedestrian perceptions). Second-order variables, in turn, are indicated by the first-order LVs. This circumstance means that second-order LVs can account for covariance between the first-order LVs. Fig. 3 shows the generalized structure of a measurement model in which a second-order LV, ξ, is identified.

Equations of a second-order measurement model, according to Rindskopf and Rose (1988) are as follows:

$$\boldsymbol{x} = \Lambda_{\boldsymbol{x}}\eta + \boldsymbol{\delta} \tag{1}$$

$$\boldsymbol{\eta} = \Gamma\xi + \zeta \tag{2}$$

Where:

x: Observed or measured attributes vector
η: First-order LVs
ξ: Second-order LVs
Λ_x: Measured attributes' loadings vector
Γ: First-order LVs' loadings vector
δ: Residual terms for each of the observed or measured attributes vector
ζ: Residual terms for each of the first-order LV vector

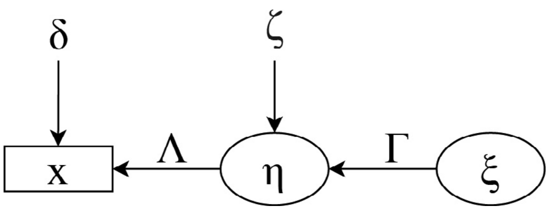

Fig. 3. Second-order measurement model generalization.

The rationale behind this kind of structure's proposal is that the three affective dimensions (i.e., pleasure, arousal, and dominance) can simultaneously be felt by an individual while walking. These dimensions account for a generalized state of feeling (i.e., PER) identified by the correlations between them. The fact that the PER is susceptible to be identified from the three dimensions suggests that a second-order model structure facilitates the identification of a generalized state of feeling or emotional response while using partial identification of pleasure, arousal, and dominance dimensions.

3.3. Model development

Based on the literature on the MRM, and the rationale of the structure selection, we implemented an approach similar to the one developed by Koufteros et al. (2009). We proposed three competing measurement models (i.e., CFA) to prove whether the observed variables could be used to measure or identify three first-order LVs (i.e., affective dimensions) and if they are covariates justifying a second-order LV. We estimated the three CFA models (i) to test whether one first-order LV could be inferred from all the indicators (Fig. 4 a); (ii) to test whether three uncorrelated first-order LVs could be inferred (Fig. 4 b); and (iii) to test whether three correlated first-order LVs could be inferred from the same indicators (Fig. 4 c). Finding if the best fitting model included three correlated first-order LVs justifies the incorporation of a second-order LV to the model. Based on the literature review, we proposed three measured indicators to identify each of the LVs on (ii) and (iii).

For the arousal LV, we proposed noise and pollution perception—since these measures are commonly used in the literature—and the bike flow perception, since the related question enquires into the level of annoyance pedestrians perceive given the specific bicycle flow while being surveyed. Since annoyance is a typical overarousal indicator, we preferred to use this measure on the arousal LV. Besides, this question does not consider the level of coercion perceived due to other users' presence on the right of way, which is why we decided bicycle flow perceived annoyance is not a dominance LV measure. Also, flow is associated with information rate or stimuli intensity which is broadly discussed as an overarousal correlate (Mehrabian & Russell, 1974). For the pleasure LV, the measured indicators (i.e., pleasantness, comfort, and satisfaction) were found as commonly used measures. The measured indicators used to identify the dominance LV (i.e., pedestrian volume, pedestrian proximity, and vehicular proximity) are associated with crowding related perceptions that, according to the literature, impact the individuals' feeling of dominance and control over spaces and situations. As shown in the literature review, traditional questions used to measure overcrowding refers to the perceived proximity of others and are usually asked to demonstrate how restrictive or coercive the context is perceived to be. Hence, the questions used to measure dominance inquire about how other users' presence influences the perception of an overcrowded space. Bicycle flow is not used as a measure in this dimension because it was intentionally left as an arousal measure related to stimuli intensity.

The arousal and dominance LVs represent "negative" constructs given the measures used to identify them. In the case of arousal, the indicators include perceptions of bother and annoyance, which account for an overall negative perception of the physical environment's stimuli. This negative perception corresponds to over-arousal, a negative affective state that is commonly related to avoidance behaviors in the literature. Likewise, the dominance LV is measured with negative perceptions of the effect of other ROW users' distance and volume over pedestrians. These negative perceptions are related to reduced autonomy and decision-making capacity. Accordingly, the dominance LV's name was changed to "*submissiveness*", which is the opposite facet of dominance (Bakker et al., 2014; Mehrabian & Russell, 1974; Stamps, 2005; Yani-de-Soriano & Foxall, 2006).

These three CFA models were individually evaluated and compared to assess whether they show goodness of fit. To do so, absolute, incremental, and parsimony fit indices were evaluated. Absolute fit indices make it possible to evaluate how well the model can replicate the observed data and not directly compare the model's performance with other models (Hair et al., 2014). In this case, absolute fit indices include the normed chi-square (χ^2/df), the standardized root mean residual (SRMR), the root mean square error of approximation (RMSEA), and the goodness-of-fit index (GFI). The incremental fit indices are based on the comparison of the estimated model's performance with a baseline model (e.g., null model) (Hair et al., 2014). For this study, we used the normed fit index (NFI), the Tucker-Lewis index (TLI), the comparative fit index (CFI), and the relative noncentrality index (RNI). Finally, the parsimony fit indices allow us to compare models based on their fit relative to their complexity (Hair et al., 2014), and we used the adjusted goodness of fit index (AGFI). According to Schreiber et al. (2006) and Hair et al. (2014), each index' acceptance threshold was used to test each model and compare them to accept or reject each of the proposed structures.

After comparing the three first-order CFAs goodness of fit indices, and based on the results, we concluded that a second-order structure is justifiable (see Results and analysis section) and, hence, proceeded to propose such a theoretical structure in Fig. 5. After including PER, we estimated an SEM, the objective of this estimation was to evaluate the effect of the PER LV over a declared avoidance behavior (i.e., avoid). The dependent variable was a dichotomous categorical variable (i.e., avoid = 1 and approach = 0) (see Table 2). Consequently, the structural relation between PER and Avoid was evaluated using a probit framework in which we estimated the probability of avoidance/approach (Ortúzar & Willumsen, 2011; Washington, Karlaftis, & Mannering, 2011). Significant relationships between variables (i.e., significance level above 95%, meaning absolute t-statistic values higher than 1.96) and the goodness of fit indices were used to evaluate the SEM.

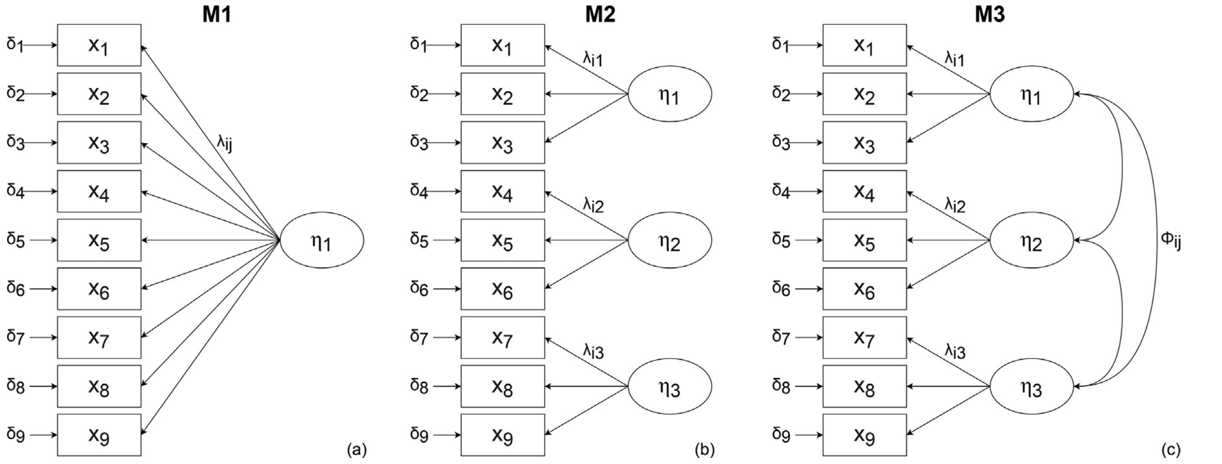

Fig. 4. Structure selection based on Koufteros et al. (2009). Three models are proposed to evaluate data structure and test MRM structure: (a) One first-order LV measurement model (M1), (b) Three uncorrelated LVs measurement model (M2), and (c) Three correlated LVs measurement model (M3).

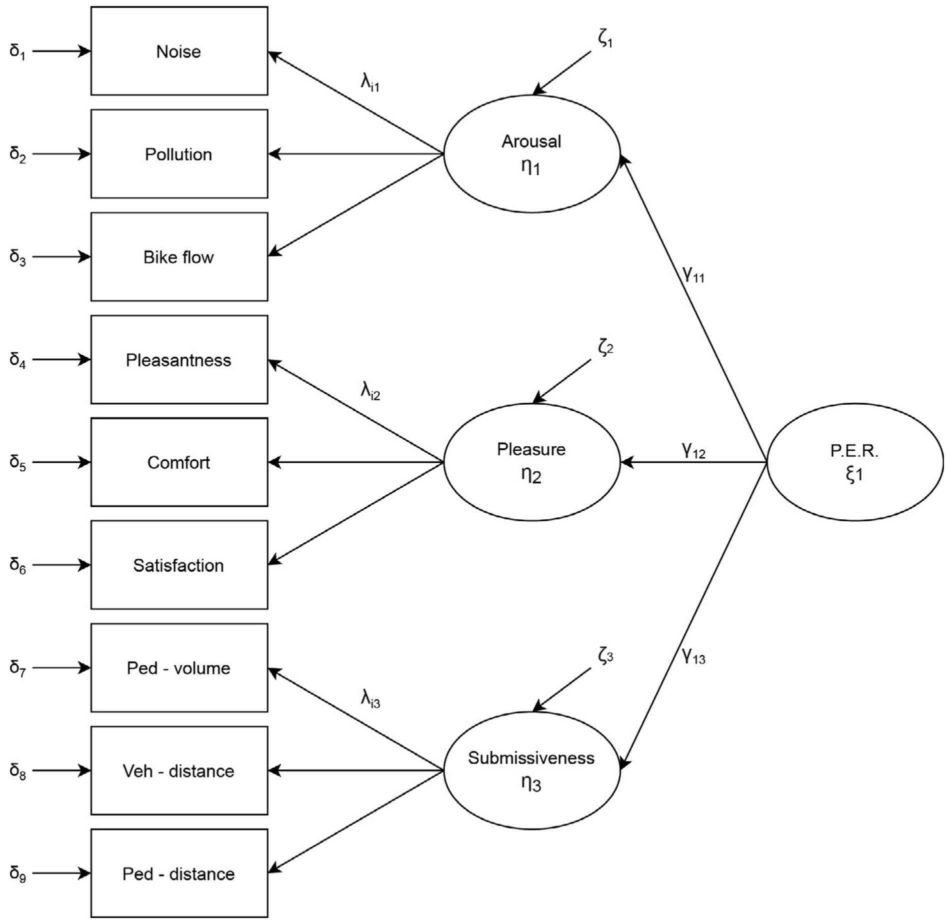

Fig. 5. Theoretical model with three first-order LVs and one second-order LV.

4. Results and analysis

After testing the three different measurement model structures (Fig. 4), we found that M3 complies with the goodness of fit acceptance thresholds; M1 and M2 did not comply with the minimum goodness of fit indicator thresholds (see Table 2).

Despite each indicator having acceptable t-statistic values (i.e., > 1.96), M1 and M2 perform poorly in terms of replicating the observed data (i.e., unacceptable values on absolute fit indices). Also, according to incremental fit indices, the performance of M1 and M2 fails when compared to a baseline model. Furthermore, when assessed in terms of the modeĺs complexity, M1 and M2 show an unacceptable performance. M3 has a better (and acceptable) performance compared to the first two models, which support the inclusion of the PER LV to incorporate correlations between first order LVs. Hence, the two first structures are rejected (for the sake of clarity, first-order latent variables will be written in italics).

The results of the M3 model comprise three latent variables. *Arousal* considers environmental and operational annoyances. Environmental conditions on the sidewalk include the perception of noise and pollution, and operational conditions are associated, to a lesser extent, with the rate of information or stimuli intensity (i.e., bike flow annoyance) in the infrastructure. Contamination and passing bicyclists appear to be correlated with negative affective experiences for pedestrians using the infrastructure. It is suggested by our results that the two sources of arousal (i.e., related to environmental conditions and related to stimuli intensity) have different impacts on the perception of this LV. The previous suggestion was made considering the low loading value of the bicycle flow indicator, which represents the stimuli intensity, compared with the other two indicators, which represent the impact of contamination. A better practice concerning this finding would be to assess the arousal only from one perspective, which means that the arousal identification should rely only on measures of environmental contamination or traffic stimuli intensity (i.e., how annoying traffic flows are perceived to be).

Pleasure is associated with positive emotions derived from stimuli in a given location. In this case, from the perceived comfort and pleasantness of the walking experience on the sidewalks and satisfaction with the infrastructure. The three indicators show a positive loading, which makes pleasure a positive affective dimension. In other words, good feelings can be elicited from the experience of walking in an infrastructure perceived to provide good quality. As shown in M1 (see Table 3), the three pleasure indicators present a contrary sign towards the other six indicators as expected, based on the questions asked.

Submissiveness is associated with indicators from perceptions of the proximity of both pedestrians and vehicles in the infrastructure. Like the outcomes found in the literature review, crowding indicates the degree of dominance (i.e., opposite of submissiveness) felt by a pedestrian on a sidewalk. The proximity of other users (i.e., other pedestrians and motorized vehicles) seems to generate a negative affective experience associated with a reduced feeling of freedom to move and autonomy on the sidewalk.

In M3, the correlation between the three LVs could be expected to justify the creation of a second-order LV that can be inferred from the first-order LVs and is consistent with the theoretical framework shown in Fig. 5 and with findings from other authors (Kim et al., 2020). Based on the superiority of fit indices of the model with correlations between the three dimensions (i.e., M3), it is justifiable to propose that they are covariates given a higher-order LV (i.e., PER). This finding implies that the three affective dimensions depend on each other and are experienced simultaneously to different degrees by pedestrians while walking. Based on the proposed measurement structure (Fig. 5), the second-order LV (i.e., PER) is negative, as the first indicator (i.e., *arousal*) is fixed and shows a negative scale. In other words, the emotional response is

Table 3
Coefficients and fit indices for measurement models M1, M2, and M3.

Indicator	M1		M2		M3	
	Std. coef LV 1	t-statistic	Std. coef LV1	t-statistic	Std. coef LV1	t-statistic
Noise	0.653	28.231	0.927	11.576	0.967	13.691
Pollution	0.641	27.993	0.788	11.398	0.756	13.356
Bike flow	0.113	3.517	0.215	5.661	0.212	5.570
			LV2		LV2	
Pleasantness	−0.762	−47.995	0.836	38.303	0.839	45.614
Comfort	−0.731	−40.108	0.837	37.490	0.817	40.413
Satisfaction	−0.476	−19.566	0.518	19.938	0.559	21.941
			LV3		LV3	
Ped - volume	0.578	25.793	0.940	19.864	0.848	30.937
Veh - distance	0.520	21.428	0.598	17.356	0.676	25.550
Ped - distance	0.330	12.004	0.449	14.118	0.448	15.260

Goodness of fit indices

Index	Acceptance threshold	M1	M2	M3
χ^2/df	<3.000	54.900	35.424	1.769
SRMR	<0.080	0.168	0.137	0.030
RMSEA	<0.060	0.242	0.193	0.029
GFI	≥0.950	0.948	0.966	0.998
NFI	≥0.950	0.777	0.856	0.994
TLI	≥0.950	0.706	0.812	0.996
CFI	≥0.950	0.779	0.859	0.997
RNI	≥0.950	0.779	0.859	0.997
AGFI	≥0.950	0.755	0.842	0.992

characterized by negative affect. The emotional response towards the stimuli perceived on a given sidewalk is a three-dimensional construct that depends on feelings elicited by the attributes of the built environment. The higher first-order LV loading on PER corresponds to *submissiveness*, then *pleasure*, while the lower loading corresponds to *arousal*. This means that the sense of autonomy (i.e., a typical feeling associated with submissiveness) felt on the sidewalk can provide more information to identify and describe the emotional response of pedestrians, compared to feelings from the *pleasure* or *arousal* dimensions. Furthermore, the *arousal* indicators seem to provide much less information (i.e., less than half, compared to pleasure, and less than a third, compared to submissiveness) about the PER. Given these results, we proceeded to estimate a final SEM model to test the effect of PER over declared avoidance behaviors (The final model is shown in Table 4 and Fig. 6).

The second-order standardized final SEM (Table 4 and Fig. 6) representing the pedestrian application of the MRM shows that avoidance can be expected due to a negative emotional response towards the stimuli on the infrastructure. Feeling controlled or overstimulated increases this negative feeling, whereas being satisfied or feeling comfortable reduces the negative emotional response. As mentioned before, PER is a negative response directly related to declared avoidance behaviors, which means that increases in this negative response (or "feeling bad") are associated with infrastructure avoidance. Furthermore, concerning the first order LVs or affective dimensions, we can see that *arousal* and *submissiveness* both increase along with increases in PER. In this case, feeling overstimulated or overexcited (i.e., perceptions related to *arousal*) and feeling controlled and coerced to behave (i.e., perceptions related to *submissiveness*) indicate a negative emotional response. On the other hand, in the case of *pleasure*, there is a negative relation. This negative relation means that increases in pleasant feelings are associated with decreases in the negative emotional response. This result is coherent with intuition since feeling pleasure is related to increases in positive affect and decreases in negative affect (i.e., pleasure increases "feeling good" states and decreases "feeling bad" states). In this case, PER evinces negative affect; hence, our results show a logical association between pleasure and PER.

As shown in the literature, the stimuli from the environment are perceived by individuals and, subsequently, an affective and behavioral response is elicited, including approach/avoidance. We found that perceptions towards contextual stimuli are evidence of *arousal, pleasure, and submissiveness*, which describe an emotional response, PER, that influences declared avoidance behaviors. This finding illustrates the relevance of the MRM in explaining certain behaviors towards urban infrastructure and validates the SOR structure as a way to understand the effects of the built environment on pedestrian behavior.

5. Discussion

Proving that the MRM can be applied to urban sidewalks contributes to the body of research focusing on studying the effects of the built environment on sustainable transportation. This environmental psychology model was validated by

Table 4
Final SEM model including second order LV and its direct effect on declared avoidance behavior.

Indicator	Latent Variable	Std. coef	Std. error	t-statistic
Noise	Arousal	0.965	0.069	13.979
Pollution		0.757	0.055	13.683
Bike flow		0.211	0.038	5.485
Pleasantness	Pleasure	0.833	0.019	44.063
Comfort		0.819	0.021	39.876
Satisfaction		0.569	0.025	22.437
Ped - volume	Submissiveness	0.820	0.024	33.685
Veh - distance		0.694	0.025	28.270
Ped - distance		0.459	0.029	15.679
First order Latent Variable				
Arousal		0.230	0.042	5.456
Pleasure		−0.610	0.037	−16.303
Submissiveness	PER	0.887	0.039	22.503
Direct effects*				
Avoid	PER	0.738	0.038	19.169

Goodness of fit indices

Index	Acceptance threshold	Value
χ^2/df	<3.000	1.726
SRMR	<0.080	0.032
RMSEA	<0.060	0.028
GFI	≥0.950	0.998
NFI	≥0.950	0.992
TLI	≥0.950	0.996
CFI	≥0.950	0.997
RNI	≥0.950	0.997
AGFI	≥0.950	0.992

* Indirect effects are taken into account as part of the estimation of the PER LV.

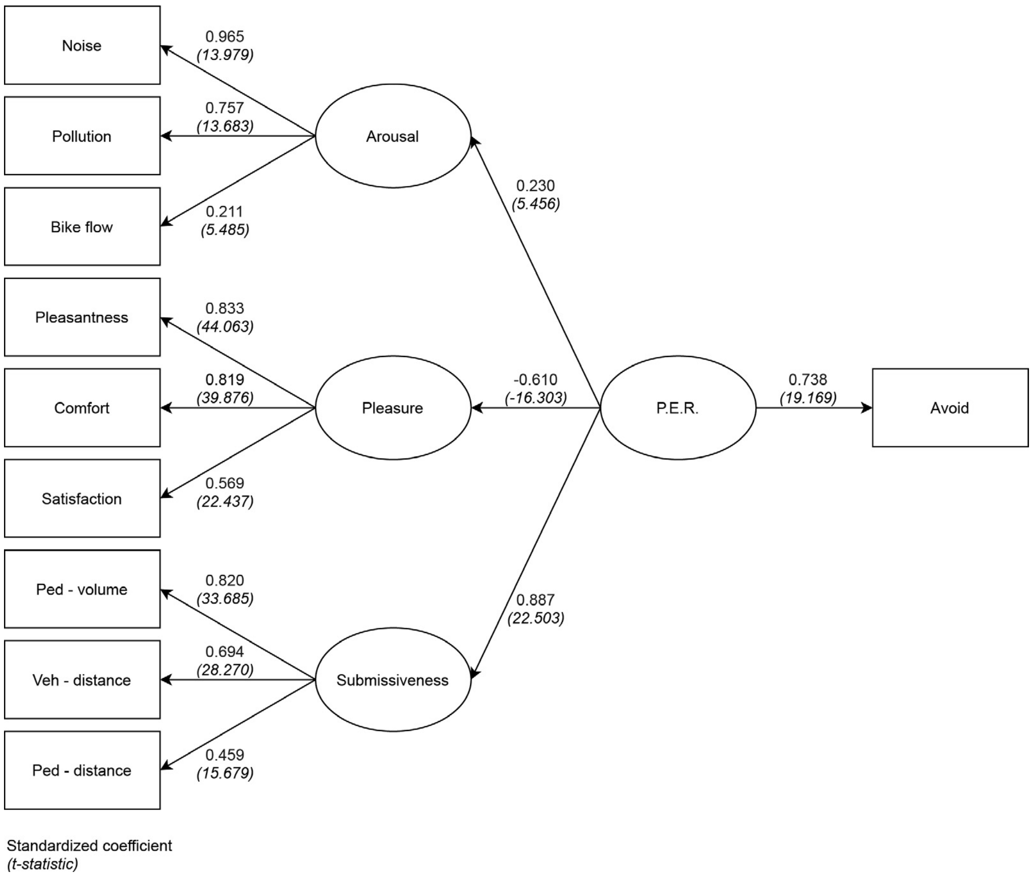

Fig. 6. Final SEM: Second-order standardized SEM representing the pedestrian application of the MRM.

our results, with data from the transportation field, and provides evidence to justify the incorporation of this kind of structure within the field. Over the last two decades, sustainable transportation studies have included subjective attributes as perceptions in modeling and frameworks (Ewing & Handy, 2009; Ma & Cao, 2019; Pikora et al., 2003; Saelens et al., 2003; Schneider, 2013). Our results show that a specific psychological process can demonstrate how perceptions of the built environment influence avoidance towards an infrastructure via affective dimensions and emotional responses. Also, our findings provide insight into how to incorporate perceptions of the built environment in different transportation models. Hence, this kind of structure contributes to sustainable transportation literature, providing an opportunity to increase our understanding of behaviors such as active traveling.

According to our study, in line with the theoretical SOR structure (Kim et al., 2020; Ma & Cao, 2019), perceptions of the built environment influence approach / avoid behavior with respect to pedestrian infrastructure. Specifically, our findings showed that, for pedestrians, the three affective dimensions proposed by the MRM (1974) (i.e., arousal, dominance, and pleasure) could be indicated from different kinds of stimuli on the sidewalk and the levels they are perceived at. As shown in the literature, we found that when people are over-aroused, they are more likely to avoid situations or places because of the high intensity of stimuli and sensory overload and stress (Gatersleben & Uzzell, 2007; Liu & Ma, 2019). In this respect, we can expect increased pollution, noise, and bicycle flow on sidewalks to indicate over-arousal for pedestrians (see Table 4) and consequent avoidance behavior, mediated by a negative emotional response (see Fig. 6). This information suggests that nearby vehicular infrastructure and vehicular contamination act as a source of arousing stimuli for pedestrians and proposes how such stimuli impact their emotional states and consequent decision to stay on or leave the infrastructure. This perspective highlights the relevance of understanding the complexity of traffic externalities and their effects. Our study shows that traffic externalities are indeed related to preferring to avoid a specific infrastructure or place from a pedestrian's point of view.

Feeling that one is externally controlled engenders submissiveness and a negative emotional response that influences avoidance behavior. With respect to the dominance dimension, and in line with the theory, our findings show a correlation between feelings of being controlled and negative affect (Ryan & Deci, 2017). Remarkably, others' presence and proximity (i.e., pedestrians and bicyclists (see Table 4)) can be expected to decrease autonomy and self-regulated behavior while walking, indicating negative emotional responses and further avoidance behaviors. In this respect, the availability of space in which to walk in terms of one's ability to move being restricted by other sidewalk users is a is critical variable. That is, less space and a higher volume of users would probably be associated with negative affect and an attempt, if possible, to leave the situation.

In contrast, and following the literature review, our results showed that pleasure indicators (i.e., pleasantness, comfort, and satisfaction (see Table 4)) are related to a positive emotional response and negatively associated with avoidance behaviors (see Fig. 6). In other words, feeling good while walking is related to choosing to stay on a sidewalk. In this case, as expected, hedonic pursues and experiences are related to positive emotional responses (Ryan & Deci, 2001), and such responses influence a person's decision to stay on the sidewalk. Furthermore, the pleasure dimension's indicators are related to a common approach to evaluating transportation infrastructure and services. Two of the three indicators (i.e., satisfaction and comfort) have been used to measure transportation infrastructure or services (Arellana, Saltarín, Larrañaga, Alvarez, & Henao, 2019; Ojo, 2019; Sarkar, 2003; van Lierop et al., 2018). This information implies that transportation supply assessment techniques include considerations on the pleasure dimension. However, as we showed with our results, evaluating only the pleasure dimension does not fully account for the spectrum of emotional responses that can explain approach / avoid behaviors. In other words, incorporating the other two dimensions (i.e., arousal and dominance) could be a way to enhance the performance evaluation frameworks. This finding is relevant since the sustainable transportation paradigm (Banister, 2008) proposes that people should be attracted to sustainable modes such as public transportation and walking.

A street that invites people to approach it and walk on it can be a valuable instrument in addressing transportation issues and promoting sustainable transportation. Based on our results, we can suggest that urban streets that are inviting can include strategies that decrease noise and pollution perception (e.g., through trees allocation (Coutts & Hahn, 2015; Pulighe, Fava, & Lupia, 2016; Säumel, Weber, & Kowarik, 2015)), and by separating bicyclists from pedestrians to reduce overarousal. Other strategies in this respect include the provision of greater comfort and pleasantness related to the walking trip itself (e.g., by providing amenities such as chairs), to increase the pleasure; and the provision of more pedestrian space and more separation between people and between people and motorized vehicles (e.g., right of way redistribution) to increase dominance (i.e., decrease submissiveness).

Broader transportation research could also benefit from validating the MRM in pedestrians. Within the transportation field, other examples of applications of this structure could include the calibration of ICLV models to estimate mode or route choice, including affective dimensions such as utilities related to the individuals' perception. In these models, researchers could identify the effects of arousal, pleasure, dominance, and the emotional response over modal selection. Furthermore, transit satisfaction studies could be enhanced by including the MRM. For example, these studies can identify how pleasant experiences influence positive emotional responses and approach behaviors towards public transportation. This information offers a new framework of plausible interventions that enrich strategies intended to promote and design sustainable transportation.

6. Conclusions and further investigation

We tested the MRM for pedestrians' approach/avoidance behavior on sidewalks in Bogota, Colombia and found that an emotional response, identified from three affective dimensions, namely arousal, dominance, and pleasure can explain pedestrian approach/avoidance behavioral intention. This paper provides evidence of the latter, which has been suggested in many frameworks and theories, but that has never been empirically tested. We showed that the three dimensions indicate an emotional state and that such response influence behavior, demonstrating how the SOR structure operates.

In terms of practical implementation and policy, this research contributes to unveiling that certain characteristics of the built environment can affect the actual use of public space for walking (transportation) and as a place. Given the recent increase in understanding the relevance of all the functions of a street, practitioners should consider that attractive sidewalks on which to move and spend time are vital to promoting behavioral changes towards a more active lifestyle and to revitalize public space in cities. Cities worldwide are investing a lot in creating livable attractive places to enhance quality of life and well-being. Thus, providing information on how to elicit positive emotional responses towards the built environment is critical in this pursuit. Furthermore, these positive emotional responses are evidence of well-being which is a correlate of life quality, illustrating the relevance of emotions and affective dimensions in terms of livable cities. In sum, to make walking attractive is key to attaining more sustainable transportation, for example, in the case of the 15-minute cities initiative.

The immediate research should be focused on identifying what built environment elements increase people's pleasure and reduce submissiveness and over-arousal. This implies the assessment of how to generate an impact on PER to promote walking by understanding the most highly valuated elements of the built environment from each of the affective dimensions. Commonalities and differences enrich the design routines and practices of the public realm. Similar to curriers, airlines, or transit, asking users and considering the role of people's perceptions of their contexts is key to improving the delivery of infrastructure, services, or experiences. Finally, future studies on the subject could be conducted in different cities to validate our findings and the pertinence of MRM. To do so, we suggest revisiting our literature review to build a questionnaire that makes it possible to gather perceptions regarding the three affective dimensions. With these specific indicators, the constructs should be easier to identify, and the model could be enhanced to validate whether our results are generalizable. Also, with this consideration in mind, future studies could test the MRM for users of other modes of transportation such as bicycles, given that bicyclists are indeed in direct contact with the built environment, or test the model for other infrastructure (e.g., plazas and parks).

This paper is the initial step into a vast field that requires much more research. As cyclists also have direct contact with the built environment, it would be reasonable to hypothesize that the SOR process also holds for them, as well as for those who travel on scooters and skateboards. It is also relevant to quantify the impacts of PER changes in the desire to walk (i.e., sensibility analysis of emotional responses on walking). Finally, we also suggest the application of more sophisticated and recent modeling approaches, including both objective and subjective variables (e.g., SEM-MIMIC forecasting models). An SEM-MIMIC approach can be used to differentiate the effects on PER by considering heterogeneity between users (e.g., age groups, sex, trip purpose) which can also be applied in conjunction with different group analysis able to capture differences by separating them into groups. Besides, this would benefit public policy and planning processes because the estimations made using SEM-MIMIC models provide statistical information on how measurable right-of-way attributes (e.g., sidewalk width, buffer presence, or the number of ramps) can influence affective dimensions, emotional responses, and approach behaviors.

A limitation of this study is that we did not test the impact of personality-related characteristics, including attitudes. As such, and considering that we found that stimuli perceptions are key to understanding behaviors through emotional responses, this finding could be enriched by understanding how individual attitudes mediate the process between stimuli perception and behavior or behavioral intention. Related studies propose that attitudes and personality characteristics can directly impact affective/emotional responses and behavioral intentions, both directly and indirectly. Hence, we propose that further research into this perspective should include personal attitudes as LVs that impact both an emotional response and behavioral intention.

Our data collection methodology allowed us to observe that in-situ surveys provide an opportunity to capture perceptions almost while they are perceived. This means that pedestrians are reporting their perceptions as they experience the stimuli. This is not the case for other methodologies in which respondents are asked about their perceptions after the experience. In these cases, it is common to expect that recalling the experience modifies the answer. Further studies could be developed to compare how in situ perceptions are different from "remembered" perceptions. In our study, we did not incorporate the availability of alternative infrastructure. Thus, we did not analyze declared avoidance behavior in conditions where the audited infrastructure was the only possible alternative for an individual. To correct this, other questions such as "*to what extent would you seek out or try to encounter this situation*" or "*to what extent would you try to leave*" could be added to the survey as proposed in the MRM.

CRediT authorship contribution statement

Hernan Alberto Ortiz-Ramirez: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing - original draft. **Jose Agustin Vallejo-Borda:** Formal analysis, Funding acquisition, Investigation, Writing - original draft. **Alvaro Rodriguez-Valencia:** Funding acquisition, Project administration, Resources, Writing - review & editing.

Acknowledgments

The authors are grateful for the support received by MINCIENCIAS under forgivable financing 6172, by the School of Engineering, and the Vice-presidency of Research and Creation at Universidad de los Andes for financing the doctoral research of two of the authors of this paper. We are also grateful to the Sostenibilidad Urbana y Regional (SUR) research group at the School of Engineering and the Department of Civil and Environmental Engineering at Universidad de los Andes.

References

Abou-Zeid, M., Witter, R., Bierlaire, M., Kaufmann, V., & Ben-Akiva, M. (2012). Happiness and travel mode switching: Findings from a Swiss public transportation experiment. *Transport Policy, 19*(1), 93–104. https://doi.org/10.1016/j.tranpol.2011.09.009.

Alcaldía Mayor de Bogotá. (2019). Resultados de la Encuesta de Movilidad de Bogotá y municipios vecinos 2019.

Ali, J., Perumal, S., & Shaari, H. (2020). Application of the stimulus-organism-response model in the airline industry: Examining mediating role of airline image in repurchase intention. *International Journal of Supply Chain Management, 9*(2), 981–989.

Allen, J., Eboli, L., Mazzulla, G., & Ortúzar, J. de D. (2020). Effect of critical incidents on public transport satisfaction and loyalty: An Ordinal Probit SEM-MIMIC approach. *Transportation, 47*(2), 827–863. https://doi.org/10.1007/s11116-018-9921-4.

Allen, J., Muñoz, J. C., & Rosell, J. (2019). Effect of a major network reform on bus transit satisfaction. *Transportation Research Part A: Policy and Practice, 124*, 310–333. https://doi.org/10.1016/j.tra.2019.04.002.

Ameli, S. H., Hamidi, S., Garfinkel-castro, A., Ewing, R., Garfinkel-castro, A., & Ewing, R. (2015). Do Better Urban Design Qualities Lead to More Walking in Salt Lake City, Utah? In Journal of Urban Design (Vol. 20, Issue 3, p. 3). Taylor & Francis. https://doi.org/10.1080/13574809.2015.1041894.

Appolloni, L., Corazza, M. V., & D'Alessandro, D. (2019). The pleasure of walking: An innovative methodology to assess appropriate walkable performance in urban areas to support transport planning. *Sustainability (Switzerland), 11*(12). https://doi.org/10.3390/su11123467.

Arellana, J., Saltarín, M., Larrañaga, A. M., Alvarez, V., & Henao, C. A. (2019). Urban walkability considering pedestrians' perceptions of the built environment: A 10-year review and a case study in a medium-sized city in Latin America. *Transport Reviews ISSN:*. https://doi.org/10.1080/01441647.2019.1703842.

Asadi-Shekari, Z., Moeinaddini, M., & Zaly Shah, M. (2013). Non-motorised Level of Service: Addressing Challenges in Pedestrian and Bicycle Level of Service. *Transport Reviews, 33*(2), 166–194. https://doi.org/10.1080/01441647.2013.775613.

Bakker, I., van der Voordt, T., Vink, P., & de Boon, J. (2014). Pleasure, Arousal, Dominance: Mehrabian and Russell revisited. *Current Psychology, 33*(3), 405–421. https://doi.org/10.1007/s12144-014-9219-4.

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy, 15*(2), 73–80. https://doi.org/10.1016/j.tranpol.2007.10.005.

Barrero, G. A., & Rodriguez-Valencia, A. (2021). Asking the user: A perceptional approach for bicycle infrastructure design. *International Journal of Sustainable Transportation*. https://doi.org/10.1080/15568318.2020.1871127. In press.

Bellizzi, M. G., Eboli, L., & Forciniti, C. (2019). Segregation vs interaction in the walkways: An analysis of pedestrians' perceptions. *Research in Transportation Business and Management*. https://doi.org/10.1016/j.rtbm.2019.100410.

Ben-Akiva, M., & Bierlaire, M. (1999). Discrete Choice Methods and their Applications to Short Term Travel Decisions. In *Handbook of Transportation Science* (pp. 5–33). Springer Science + Business Media. https://doi.org/10.1007/978-1-4615-5203-1_2.

Ben-Akiva, M., Walker, J., Bernardino, A. T., Gopinath, D. A., Morikawa, T., & Polydoropoulou, A. (2002). Integration of Choice and Latent Variable Models. In In Perpetual Motion (pp. 431–470). Elsevier. https://doi.org/10.1016/B978-008044044-6/50022-X.

Bornioli, A., Parkhurst, G., & Morgan, P. L. (2019). Affective experiences of built environments and the promotion of urban walking. *Transportation Research Part A: Policy and Practice.*. https://doi.org/10.1016/j.tra.2018.12.006.

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research Part D: Transport and Environment, 2* (3), 199–219. https://doi.org/10.1016/S1361-9209(97)00009-6.

Cervero, R., Sarmiento, O. L., Jacoby, E., Gomez, L. F., & Neiman, A. (2009). Influences of Built Environments on Walking and Cycling: Lessons from Bogotá. *International Journal of Sustainable Transportation, 3*(4), 203–226. https://doi.org/10.1080/15568310802178314.

Chen, C. C., & Yao, J. Y. (2018). What drives impulse buying behaviors in a mobile auction? The perspective of the Stimulus-Organism-Response model. *Telematics and Informatics, 35*(5), 1249–1262. https://doi.org/10.1016/j.tele.2018.02.007.

Coutts, C., & Hahn, M. (2015). Green infrastructure, ecosystem services, and human health. *International Journal of Environmental Research and Public Health, 12*(8), 9768–9798. https://doi.org/10.3390/ijerph120809768.

Donovan, R. J., & Rossiter, J. R. (1982). Store Atmosphere: An Environmental Psychology Approach. *Journal of Retailing, 58*(1), 34. https://doi.org/Article.

Evans, G. W., & Stecker, R. (2004). Motivational consequences of environmental stress. *Journal of Environmental Psychology, 24*(2), 143–165. https://doi.org/10.1016/S0272-4944(03)00076-8.

Ewing, R., & Cervero, R. (2010). Travel and the Built Environment. *Journal of the American Planning Association, 76*(3), 265–294. https://doi.org/10.1080/01944361003766766.

Ewing, R., & Handy, S. (2009). Measuring the Unmeasurable: Urban Design Qualities Related to Walkability. *Journal of Urban Design, 14*(1), 65–84. https://doi.org/10.1080/13574800802451155.

Ferrer, S., Ruiz, T., & Mars, L. (2015). A qualitative study on the role of the built environment for short walking trips. *Transportation Research Part F: Traffic Psychology and Behaviour, 33*, 141–160. https://doi.org/10.1016/j.trf.2015.07.014.

Friman, M. (2010). Affective dimensions of the waiting experience. *Transportation Research Part F: Traffic Psychology and Behaviour, 13*(3), 197–205. https://doi.org/10.1016/j.trf.2010.04.006.

Gatersleben, B., & Uzzell, D. (2007). Affective appraisals of the daily commute: Comparing perceptions of drivers, cyclists, walkers, and users of public transport. *Environment and Behavior, 39*(3), 416–431. https://doi.org/10.1177/0013916506294032.

Hair, J. F. J., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Multivariate data analysis* (7th ed.). Pearson Education Limited.

Handy, S. L., Boarnet, M. G., Ewing, R., & Killingsworth, R. E. (2002). How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine, 23*(2 SUPPL. 1), 64–73. https://doi.org/10.1016/S0749-3797(02)00475-0.

Hung, K., Peng, N., & Chen, A. (2019). Incorporating on-site activity involvement and sense of belonging into the Mehrabian-Russell model – The experiential value of cultural tourism destinations. Tourism Management Perspectives, 30(June 2018), 43–52. https://doi.org/10.1016/j.tmp.2019.02.003.

Jang, S. C., & Namkung, Y. (2009). Perceived quality, emotions, and behavioral intentions: Application of an extended Mehrabian-Russell model to restaurants. *Journal of Business Research, 62*(4), 451–460. https://doi.org/10.1016/j.jbusres.2008.01.038.

Kim, M. J., Lee, C. K., & Jung, T. (2020). Exploring Consumer Behavior in Virtual Reality Tourism Using an Extended Stimulus-Organism-Response Model. *Journal of Travel Research, 59*(1), 69–89. https://doi.org/10.1177/0047287518818915.

Kline, R. (2016). Principles and practice of structural equation modeling (M. in the social Sciences (ed.); 4th ed.). Guilford Press.

Koufteros, X., Babbar, S., & Kaighobadi, M. (2009). A paradigm for examining second-order factor models employing structural equation modeling. *International Journal of Production Economics, 120*(2), 633–652. https://doi.org/10.1016/j.ijpe.2009.04.010.

Lai, W. T., & Chen, C. F. (2011). Behavioral intentions of public transit passengers-The roles of service quality, perceived value, satisfaction and involvement. *Transport Policy, 18*(2), 318–325. https://doi.org/10.1016/j.tranpol.2010.09.003.

Liu, A., & Ma, E. (2019). Travel during holidays in China: Crowding's impacts on tourists' positive and negative affect and satisfactions. *Journal of Hospitality and Tourism Management, 41*, 60–68. https://doi.org/10.1016/j.jhtm.2019.09.008.

Lombardi, D. B., & Ciceri, M. R. (2019). Dealing With Feeling Crowded on Public Transport: The Potential Role of Design. *Environment and Behavior*. https://doi.org/10.1177/0013916519879773.

Ma, L., & Cao, J. (2019). How perceptions mediate the effects of the built environment on travel behavior? *Transportation, 46*(1), 175–197. https://doi.org/10.1007/s11116-017-9800-4.

Manthiou, A., Ayadi, K., Lee, S. (Ally), Chiang, L., & Tang, L. (Rebecca) (2017). Exploring the roles of self-concept and future memory at consumer events: The application of an extended Mehrabian-Russell model. *Journal of Travel and Tourism Marketing, 34*(4), 531–543. https://doi.org/10.1080/10548408.2016.1208786.

McDonald, R. P., & Bollen, K. A. (2006). Structural Equations with Latent Variables. *Journal of the American Statistical Association*. https://doi.org/10.2307/2289630.

Mehrabian, A. (1996). Pleasure-Arousal-Dominance: A General Framework for Describing and Measuring Individual Differences in Temperament. *Current Psychology: Developmental, Learning, Personality, Social Winter, 14*(4).

Mehrabian, A., & Russell, J. A. (1974). *An approach to environmental psychology*. The Mit Press.

Ngah, A. H., Kim, H. D., Hanafiah, R. M., Salleh, N. H. M., Jeevan, J, & Asri, N. M. (2019). Willingness to pay for Halal transportation cost: The Stimulus-organism-response model. International Journal of E-Navigation and Maritime Economy, 12(January 2020), 11–021. http://www.e-navigation.kr/.

Ojo, T. K. (2019). Quality of public transport service: an integrative review and research agenda. In Transportation Letters (Vol. 11, Issue 2, pp. 104–116). Taylor and Francis Ltd. https://doi.org/10.1080/19427867.2017.1283835.

Ortúzar, J. de D., & Willumsen, L. G. (2011). Modelling Transport. In John Wiley & Sons (Ed.), Modelling Transport (3.). https://doi.org/10.1002/9781119993308.

Paige Willis, D., Manaugh, K., & El-Geneidy, A. (2013). Uniquely satisfied: Exploring cyclist satisfaction. *Transportation Research Part F: Traffic Psychology and Behaviour, 18*, 136–147. https://doi.org/10.1016/j.trf.2012.12.004.

Paül i Agustí, D., Rutllant, J., & Lasala Fortea, J. (2019). Differences in the perception of urban space via mental maps and Heart Rate Variation (HRV). *Applied Geography, 112*. https://doi.org/10.1016/j.apgeog.2019.102084.

Pikora, T., Giles-Corti, B., Bull, F., Jamrozik, K., & Donovan, R. (2003). Developing a framework for assessment of the environmental determinants of walking and cycling. *Social Science & Medicine, 56*(8), 1693–1703. https://doi.org/10.1016/S0277-9536(02)00163-6.

Pulighe, G., Fava, F., & Lupia, F. (2016). Insights and opportunities from mapping ecosystem services of urban green spaces and potentials in planning. *Ecosystem Services, 22*, 1–10. https://doi.org/10.1016/j.ecoser.2016.09.004.

Rindskopf, D., & Rose, T. (1988). Some Theory and Applications of Confirmatory Second-Order Factor Analysis. *Multivariate Behavioral Research, 23*(1), 51–67. https://doi.org/10.1207/s15327906mbr2301_3.

Rodriguez-Valencia, A., Barrero, G. A., Ortiz-Ramirez, H. A., & Vallejo-Borda, J. A. (2020). Power of User Perception on Pedestrian Quality of Service. *Transportation Research Record: Journal of the Transportation Research Board, 2674*(5), 250–258. https://doi.org/10.1177/0361198120914611.

Rodriguez-Valencia, A., Paris, D., & Vallejo-Borda, J. A. (2017). *Uso de percepciones para determinar el nivel de servicio peatonal* (p. 1). Bogotá, Colombia: Caso carrera séptima.
Rodríguez, D. A., Brisson, E. M., & Estupiñán, N. (2009). The relationship between segment-level built environment attributes and pedestrian activity around Bogota's BRT stations. *Transportation Research Part D: Transport and Environment, 14*(7), 470–478. https://doi.org/10.1016/j.trd.2009.06.001.
Rodríguez, D. A., Merlin, L., Prato, C. G., Conway, T. L., Cohen, D., Elder, J. P., . . . Veblen-Mortenson, S. (2015). Influence of the Built Environment on Pedestrian Route Choices of Adolescent Girls. In Environment and Behavior (Vol. 47, Issue 4). https://doi.org/10.1177/0013916513520004.
Rossetti, T., & Hurtubia, R. (2020). An assessment of the ecological validity of immersive videos in stated preference surveys. *Journal of Choice Modelling, 34*. https://doi.org/10.1016/j.jocm.2019.100198.
Russell, J. A. (2003). Core Affect and the Psychological Construction of Emotion. *Psychological Review, 110*(1), 145–172. https://doi.org/10.1037/0033-295X.110.1.145.
Russell, J. A., Weiss, A., & Mendelsohn, G. A. (1989). Affect Grid: A Single-Item Scale of Pleasure and Arousal. *Journal of Personality and Social Psychology, 57*(3), 493–502. https://doi.org/10.1037/0022-3514.57.3.493.
Ryan, R. M., & Deci, E. L. (2001). On Happiness and Human Potentials: A Review of Research on Hedonic and Eudaimonic Well-Being. *Annual Review of Psychology, 52*, 141–166.
Ryan, R. M., & Deci, E. L. (2017). *Self-Determination Theory. Basic Psychological Needs in Motivation, Development and Wellness*. The Guilford Press.
Saelens, B. E., & Handy, S. (2008). Built Environment Correlates of Walking. *Medicine & Science in Sports & Exercise, 40*(Supplement), S550–S566. https://doi.org/10.1249/MSS.0b013e31817c67a4.
Saelens, B., Sallis, J. F., & Frank, L. D. (2003). Environmental Correlates of Walking and Cycling: Findings From the Transportation, Urban Design, and Planning Literatures. *Annals of Behavioral Medicine, 25*(2), 80–91. https://doi.org/10.1207/S15324796ABM2502_03.
Samarasekara, G. N., Fukahori, K., & Kubota, Y. (2011). Environmental correlates that provide walkability cues for tourists: An analysis based on walking decision narrations. *Environment and Behavior, 43*(4), 501–524. https://doi.org/10.1177/0013916510379350.
Samuel, O., Walker, G., Salmon, P., Filtness, A., Stevens, N., Mulvihill, C., ... Stanton, N. (2019). Riding the emotional roller-coaster: Using the circumplex model of affect to model motorcycle riders' emotional state-changes at intersections. *Transportation Research Part F: Traffic Psychology and Behaviour, 66*, 139–150. https://doi.org/10.1016/j.trf.2019.08.018.
Sarkar, S. (2003). Qualitative Evaluation of Comfort Needs in Urban Walkways in Major Activity Centers. *Transportation Quarterly, 57*(4), 39–59. https://doi.org/10.1007/s11116-006-9109-1.
Säumel, I., Weber, F., & Kowarik, I. (2015). Toward livable and healthy urban streets: Roadside vegetation provides ecosystem services where people live and move. *Environmental Science and Policy, 62*, 24–33. https://doi.org/10.1016/j.envsci.2015.11.012.
Schneider, R. J. (2013). Theory of routine mode choice decisions: An operational framework to increase sustainable transportation. *Transport Policy, 25*, 128–137. https://doi.org/10.1016/j.tranpol.2012.10.007.
Schreiber, James B, Stage, Frances K, King, Jamie, Nora, Amaury, & Barlow, Elizabeth A (2006). Reporting Structural Equation Modeling and Confirmatory Factor Analysis Results: A Review. *The Journal of Educational Research, 99*(6), 323–337.
Shatu, F., & Yigitcanlar, T. (2018). Development and validity of a virtual street walkability audit tool for pedestrian route choice analysis—SWATCH. *Journal of Transport Geography, 70*(June), 148–160. https://doi.org/10.1016/j.jtrangeo.2018.06.004.
Stamps, A. E. (2005). In search of dominance: The case of the missing dimension. *Perceptual and Motor Skills, 100*, 559–566 http://ammonsscientific.com.
Sun, J., Chen, P.-J., Ren, L., Shih, E. H.-W., Ma, C., Wang, H., & Ha, N.-H. (2020). Place attachment to pseudo establishments: An application of the stimulus-organism-response paradigm to themed hotels. Journal of Business Research, April 2019. https://doi.org/10.1016/j.jbusres.2020.10.005.
United Nations. (2020). The Sustainable Development Goals Report.
Vallejo-Borda, J. A., Cantillo, V., & Rodriguez-Valencia, A. (2020). A perception-based cognitive map of the pedestrian perceived quality of service on urban sidewalks. *Transportation Research Part F: Psychology and Behaviour, 73*, 107–118. https://doi.org/10.1016/j.trf.2020.06.013.
Vallejo-Borda, J. A., Ortiz-Ramirez, H. A., Rodriguez-Valencia, A., Hurtubia, R., & Ortúzar, J. de D. (2020). Forecasting the Quality of Service of Bogota's Sidewalks from Pedestrian Perceptions: An Ordered Probit MIMIC Approach. *Transportation Research Record: Journal of the Transportation Research Board, 2674*(1), 205–216. https://doi.org/10.1177/0361198119896782.
van Lierop, D., Badami, M. G., & El-Geneidy, A. M. (2018). What influences satisfaction and loyalty in public transport? A review of the literature. *Transport Reviews, 38*(1), 52–72. https://doi.org/10.1080/01441647.2017.1298683.
Van Oel, C. J., & Van den Berkhof, F. W. D. (2013). Consumer preferences in the design of airport passenger areas. *Journal of Environmental Psychology, 36*, 280–290. https://doi.org/10.1016/j.jenvp.2013.08.005.
Vij, A., & Walker, J. L. (2016). How, when and why integrated choice and latent variable models are latently useful. *Transportation Research Part B: Methodological, 90*, 192–217. https://doi.org/10.1016/j.trb.2016.04.021.
Walker, J., & Ben-Akiva, M. (2002). Generalized random utility model. *Mathematical Social Sciences, 43*(3), 303–343. https://doi.org/10.1016/S0165-4896(02)00023-9.
Washington, S. P., Karlaftis, M. G., & Mannering, F. L. (2011). Statistical and Econometric Methods for Transportation Data Analysis (Taylor & Francis Group (ed.); 2nd ed.). CRC Press.
Wild, K., & Woodward, A. (2019). Why are cyclists the happiest commuters? Health, pleasure and the e-bike. *Journal of Transport and Health, 14*. https://doi.org/10.1016/j.jth.2019.05.008.
Yani-de-Soriano, M. M., & Foxall, G. R. (2006). The emotional power of place: The fall and rise of dominance in retail research. *Journal of Retailing and Consumer Services, 13*(6), 403–416. https://doi.org/10.1016/j.jretconser.2006.02.007.
Zhang, M., Ihme, K., & Drewitz, U. (2019). Discriminating drivers' emotions through the dimension of power: Evidence from facial infrared thermography and peripheral physiological measurements. *Transportation Research Part F: Traffic Psychology and Behaviour, 63*, 135–143. https://doi.org/10.1016/j.trf.2019.04.003.