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It's so hot: predicting climate change effects on urban tourists' time-space experience

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ABSTRACT

Progressive changes in mean annual temperatures are arguably the strongest evidence of ongoing climate change. In destinations with a Mediterranean climate, in contrast to the colder months, during summer, rising air temperatures are believed to inhibit tourist movements and activities, and consequently affect tourists' evaluation of and satisfaction with their experiences. To the best of our knowledge, no previous study has investigated the potential impact of climate change on tourists' time-space activity using actual behavioural tracking-based information. Data collected via GPS technology and a post-visit survey of tourists ($n = 404$) visiting Lisbon during the summer were analysed via structural equation modelling (PLS-SEM). The results report empirical evidence of the present impact of (summer) weather on urban tourists' time-space activity and on their intra-destination experience evaluation. Specifically, maximum air temperature is found to have a significant negative effect on overall satisfaction, while the meteorological conditions of the entire day reveal a significant impact on tourists' activities and movements. The results are particularly useful for the sustainable adaptive management of urban attractions and destinations that are especially vulnerable to climate change, as well as in managing its adverse impact on tourists' experiences.

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Introduction

With regard to tourism, climate influences destinations, supports resource-specific activities, and acts as an attraction in itself (Gómez Martín, 2005). In turn, day-to-day weather has an undeniable influence on the tourist experience. Once at the destination, it is believed that tourists are influenced by meteorological conditions in relation to their activities, itineraries and subsequent satisfaction with travel experience (Fitchett, Robinson, & Hoogendoorn, 2017; Giddy, Fitchett, & Hoogendoorn, 2017). Due to the impact of the day-to-day weather on tourism resources and on tourists themselves (e.g. their comfort, safety, destination perception), the impact of climate change on local/regional weather patterns is considered a key priority for destinations and tourism stakeholders to address (Fang, Yin, & Wu, 2018), especially given its large-scale and long-lasting nature (Buckley, 2008).

In recent decades, the political and academic debate on climate change has expanded significantly (Becken, 2013; Dubois & Ceron, 2006; Fang et al., 2018), prompted by the publication of scientific results, including the assessment reports released by the IPCC since 1990. According to the fifth of these reports, climate warming is indisputable, and by the end of the twenty-first century (2081–2100), the global mean surface temperature, compared to 1986–2005, is likely to increase by between 0.3 °C and 1.7 °C under the best scenario, and between 2.6 °C and 4.8 °C under the worst-case scenario (IPCC, 2014). The 2015 Paris Agreement established a long-term goal of keeping the increase in global average temperature to within +2 °C of the pre-industrial baseline. Even though projections are undeniably uncertain (Paeth et al., 2017), scientists are developing new kinds of scenarios and models (Riahi et al., 2017) in preparation for the next IPCC assessment report due early next decade, with some suggesting that +1.5 °C is achievable if a rapid shift towards large-scale low-carbon energy supplies is implemented (Wigley, 2018), as well as reduced energy use and development of new carbon-dioxide removal technologies (Rogelj et al., 2018).

Climate change is expected to have an impact on destination choice and tourist flows, with a gradual shift towards higher latitudes and a probable increase in domestic trips within colder countries (Rosselló & Santana-Gallego, 2014). Moreover, this impact may alter the combination of activities and attractions chosen by visitors, affect tourist safety and the quality of attractions and infrastructure and redefine destination competitiveness (Buckley, 2008).

Research on climate change and its interaction with tourism relates mainly to impact and adaptation, mitigation strategies, policy (Becken, 2013), vulnerability of the tourism industry, tourist behaviour and demand in response to climate change, and emission reductions in the tourism sector (Fang et al., 2018). Studies on this matter have been carried out at different scales: global or international (Nicholls & Amelung, 2008; Scott, McBoyle, & Schwartzentruber, 2004; Tranos & Davoudi, 2014), national (Harrison, Winterbottom, & Sheppard, 1999; Kovács, Németh, Unger, & Kántor, 2017; Moyle et al., 2018) and regional (Gómez Martín, 2006; Kent, Newnham, & Essex, 2002; Soboll, Klier, & Heumann, 2012) levels. Empirical research on climate change has also been applied to different kinds of environments: mountains (Pröbstl et al., 2008; Yan et al., 2015), coast/beaches (Filies & Schumacher, 2013; Perch-Nielsen, 2010), forests (Endler & Matzarakis, 2011) and cities (Bosman, 2008; Dolnicar, Laesser, & Matus, 2010). As for the climate suitability of destinations, studies can be clustered into three types of approaches: expert-based, revealed preferences and stated preferences (Scott, Gössling, & de Freitas, 2008). In cities, which are particularly vulnerable to the risks linked to the impacts of climate change (Tapia et al., 2017), the most common climatic problems are associated with the thermal component (e.g. through the effect of the urban heat island; Alcoforado, Lopes, Andrade, & Vasconcelos, 2005). On the other hand, regions with a Mediterranean climate are considered “hot spots” due to the expected warming, especially in summer, and the drying of the region (Lionello & Scarascia, 2018; Paeth et al., 2017). Combining revealed and stated preferences approaches, this study focuses on urban environments, summer time and weather parameters that are particularly relevant to climate change projections (e.g. maximum air temperature) regarding Mediterranean-type climate regions.

Tourists’ time–space activity in the urban context

Tourists move according to what they want to do and visit. In the urban intra-destination context, tourists’ time–space activity consists of the sequence of movements from one attraction to another (Xia et al., 2010), considering attractions in a broad sense: “landscapes to observe, activities to participate in, and experiences to remember” (Lew, 1994, p. 291). Given their multifunctionality and attractive diversity, urban destinations address diverse tourist motivations and interests (Ashworth & Page, 2011; Edwards, Griffin, & Hayllar, 2008). Indeed, visitors often include

multiple destinations in their trip itineraries; in the urban intra-destination setting, “multi-attraction travel” – a concept coined by Hunt and Crompton (2008) – is possibly even more common. Urban tourists usually move from one attraction to another over the course of the day, taking advantage of the density and compactness of the recreation opportunities available that make cities the perfect stage for the multi-attraction visit experience (Caldeira & Kastenholz, 2015). In the urban context, tourist movement has been operationalised as “the movement from one attraction district to another during a single day” (Tussyadiah & Fesenmaier, 2007, p. 2261). Consequently, two basic dimensions emerge from the analysis of tourists’ intra-destination time–space activity: movement and multi-attraction (Caldeira & Kastenholz, 2017; Xia, Zeephongsekul, & Packer, 2011).

Although the multi-attraction visit is the most common pattern of urban time–space experience, in this as in other contexts, tourism has usually been studied as a static phenomenon (De Cantis, Ferrante, Kahani, & Shoal, 2016; Zillinger, 2007) and until recently there were few studies examining urban tourists’ intra-destination movements. With the advent of new digital information technologies that have brought about advanced tracking methods, however, empirical research on this matter is growing (Grinberger, Shoal, & McKercher, 2014; Shoal & Isaacson, 2006). Tourist time–space behaviour is a complex phenomenon and as such is difficult to track. Replacing data collection methods such as trip diaries, observation or paper surveys, the recent integration of GPS tracking data and traditional questionnaire-based surveys is the methodology most often used in recent empirical research in this context (Edwards & Griffin, 2013; Xia et al., 2010), since it yields higher accuracy and better in-depth comprehension of the intra-destination tourist experience (De Cantis et al., 2016; McKercher, Shoal, Ng, & Birenboim, 2012; Zakrisson & Zillinger, 2012).

According to Downs and Stea (2009, p. 7), there are four groups of variables that influence human spatial behaviour: “the spatial environment itself, the information or stimulus set, the intervening cognitive processes, and the group and individual differences in the operation of these processes”. In tourism, movements do not happen at random (Luberichs & Wachowiak, 2010; Zillinger, 2007), but are influenced by internal as well as external factors. The former refer to the tourist and the travel context (Tideswell & Faulkner, 1999); the latter to the geographic characteristics of the destination (Tussyadiah & Zach, 2012). In turn, Lau and McKercher (2006) place tourist time–space behaviour determinants into three categories: human push factors (e.g. tourist role, travel group, personal motivations, previous visits), physical pull factors (geomorphology, destination configuration) and temporal factors (duration of stay at destination, duration of travel).

Weather conditions as an influencing factor of tourists’ activities and movements

“It seems almost self-evident that tourism is dependent on weather and climate” (Smith, 1993, p. 398). The difference between weather and climate “is a measure of time”: weather refers to the state of the atmosphere during a short interval, while climate is the prevailing condition of the atmosphere over long periods of time (NASA, 2005). As first put by Herbertson (1901), climate is what we expect, weather is what we actually get, the latter being more influential with regard to tourist decision-making and visitor experiences (Perry, 1972).

Weather can be a tourism motivator – a “pull factor”, as Turnbul and Uysal (1995) advocate – or an inhibitor (Day, Chin, Sydnor, & Cherkauer, 2013). Although the impact of meteorological conditions has already been the subject of research on tourist flows (Falk, 2015), tourist demand (Becken, 2012; Perkins & Debbage, 2016), economic performance (Chen & Lin, 2014), choice of destinations (Järv, Aasa, Ahas, & Saluveer, 2007), activities (Becken, 2012; Chen & Lin, 2017; Chen, Lin, & Chang, 2017) and tourist experience (Giddy et al., 2017), its effect on the attractiveness of

tourist destinations and on tourist behaviour needs further investigation (Becken, 2012; Day et al., 2013; McKercher, Shoval, Park, & Kahani, 2015).

Nevertheless, several studies have already corroborated the link between weather and tourist behaviour (Beaudin & Huang, 2014; Becken, 2012; Chen & Lin, 2017; Falk, 2015; Gómez Martín, 2005; Ibarra, 2011; Järv et al., 2007; Perkins & Debbage, 2016; Perry, 1972; Smith, 1993). Recent research by Giddy et al. (2017), on American tourists' experience with day-to-day weather in South Africa using stated preferences, supports the view that unfavourable weather conditions significantly impact tourists' participation in outdoor activities in particular, and often give rise to a change in travel plans. Weather variables correspond to different perceptible dimensions: physical (e.g. rain), physiological (e.g. air temperature), psychological (e.g. "clear blue skies") or "combinations of all three" (de Freitas, 2003, p. 48). Temperature, number of sun hours, precipitation, wind, humidity and fog are the weather variables with the strongest influence on tourism (Gómez Martín, 2005). Human response to weather derives from the individual's perception, excluding the thermal component, and addresses the "combined effects of weather elements (thermal, physical, aesthetic, etc.)" (de Freitas, 2003, p. 48). Several weather-related indices, including tourism-specific ones, have been created to measure individual physiological comfort (Fang et al., 2018), which does not depend only on air temperature. In the present warming scenario, empirical evidence is not clear about the interaction between tourism and temperature, with some studies exhibiting a non-linear relationship (Rosselló & Santana-Gallego, 2014). There are three main categories of factors affecting human thermal comfort: atmospheric (air temperature, humidity, wind, radiation), individual (metabolic rate, posture, activity, clothing) and environmental (physical setting; Höppe, 1999). Tourists tend to prefer destinations with sunny weather (Gómez Martín, 2005) and mild temperatures (Day et al., 2013). Although establishing an ideal temperature range is debatable, since it depends on the individual, the setting, and the activities practiced, research by Machete, Lopes, Gómez-Martín, and Fraga (2014) in Lisbon, for instance, found the temperature range of 22–28 °C to be most commonly preferred by visitors to the city. In turn, unpleasant meteorological conditions may lead tourists to substitute their outdoor activities for other less weather-dependent activities (McKercher et al., 2015), such as indoor cultural visits or socializing. In fact, though relatively few studies have investigated the impact of weather on tourist arrivals and participation in activities (Day et al., 2013), tourist activities are moulded by climate and weather: tourists tend to visit places that provide the highest level of comfort and well-being (Olya & Alipour, 2015) and are influenced with regard to "what and when (especially outdoor) activities can be carried out", making weather information particularly useful (Gómez Martín, 2005, p. 582).

In the study by Chen et al. (2017), temperature was not confirmed to have an impact on demand, in contrast to other studies (Perkins & Debbage, 2016). McKercher et al. (2015) investigated the impact of weather on the behaviour of urban tourists in Hong Kong, identifying a minimal effect on areas visited by tourists and concluding that urban tourists, especially those arriving by plane, are more resilient to weather conditions and less prone to cancelling activities or staying in the hotel, although the study found evidence of a certain level of activity substitution and changes in movement intensity. Particularly in urban destinations, in light of the future increase of extreme weather events (heat waves, storms, floods and droughts), artificial climates created by means of heating and air-conditioning may reduce the effect of climate change on tourists' comfort. Furthermore, artificial attractions may be used (e.g. shopping centres, theme parks, swimming pools) to replace natural attractions (e.g. urban parks, waterfronts, beaches; Buckley, 2008).

Urban tourists' evaluation of intra-destination experience

Tourist experiences, as complex phenomena, can be seen as "an orchestrated model of interacting elements" (Pearce & Wu, 2014, p. 220). Identifying and understanding visitors' time-space

activity patterns is central to efficient and successful destination management (Bauder & Freytag, 2015). Urban tourism, like any other kind, implies the consumption of the experiential characteristics (e.g. physical, social and cultural) of places and sights (Tussyadiah & Zach, 2012). Several studies have been developed based on new tracking technologies which allow a better understanding of tourists' spatial and temporal consumption of cities (Caldeira & Kastenholtz, 2015; McKercher & Lau, 2008).

The concepts of place and mobility have been considered the key defining elements of tourist experiences (Hayllar & Griffin, 2005; Li, 2000). Every tourist experience occurs in a given place, which may be defined as a space with meaning (Madanipour, 1996), and involves mobility, in this case, the ability to move around at the destination. Their manifest spatiotemporal dimension (Volo, 2009) means they are undoubtedly influenced by contextual variables, including weather conditions.

Tourists' evaluation of their travel experiences has a proven impact on their future intention to revisit the destination and to spread positive word of mouth to relatives and friends (Hui, Wan, & Ho, 2007; Lee, Yoon, & Lee, 2007). Consequently, it is of utmost importance to relate the study of time-space activity to tourists' evaluation of their place experiences (Hall & Page, 2002).

The spatial behaviour of tourists has clear "implications for management of visitor experiences and satisfaction" (Andereck, 1997, p. 706). One of the most significant and studied outcomes of tourist experience evaluation is satisfaction, which has been approached from a variety conceptual and analytical perspectives. According to del Bosque and Martín (2008, p. 553), satisfaction is defined as an "as an individual's cognitive-affective state derived from a tourist experience". Most researchers study satisfaction as a result – *a posteriori* satisfaction – since it is difficult to study satisfaction as an ongoing process (Cutler & Carmichael, 2010). This perspective is centred on the psychological outcomes of tourist experience, namely on its evaluation (Hayllar & Griffin, 2005; Tung & Ritchie, 2011). In terms of theoretical perspectives, interactive theories on this topic explain tourist satisfaction as the interaction between situational aspects, such as weather and personal characteristics (Sirgy, 2010). Fornell (1992) provided a multidimensional operationalisation to measure satisfaction, combining two main theories, "expectation-performance" (Oliver, 1980) and "performance-only" (Cronin & Taylor, 1992), which has been abundantly applied. The evaluation of tourist experience has been empirically assessed through the study of overall satisfaction, as well as satisfaction with destination or experience attributes.

Thermal discomfort, unpleasant wind or precipitation may decisively affect a travel experience, which could be enjoyable in all other aspects. In one of the few empirical studies that explicitly study the relationship between weather and tourist experience, Gössling, Abegg, and Steiger (2016), based on an *ex post* approach, found no evidence that weather aspects have a long-term impact on memories of tourist experiences, yet they constitute a decisive factor for the formation of destination image. The study took place in northern European countries, with precipitation being the most negative weather perception. In this domain, weather has been identified as a specific determinant of tourists' experience that influences their length of stay (Adongo, Badu-Baiden, & Boakye, 2017). Jeuring and Peters (2013), drawing from travel blog narratives, identified different tourists' evaluations of the weather impacts, permitting specific weather types to be related to tourist decision-making in terms of itineraries and activities.

Given the relevance of weather to tourism activity and the significant impact of climate change on it, the scarcity of empirical work on these topics constitutes a gap in the academic literature that our work aims to address. Moreover, since the impact of weather variables depends on setting (e.g. urban, beach, mountain; Scott et al., 2008) and corresponding tourist expectations (Perkins & Debbage, 2016), the current study allows specific insights regarding the urban tourist experience. In the next sections, a conceptual model to investigate the influence of weather on time-space tourist activity in cities and experience evaluation will be suggested, and the subsequent empirical study will be discussed. The results contribute to the debate on the potential impact of climate change, namely rising air temperatures, on tourist behaviour.

Research model

The focus of our research is the influence of the potential effects of climate change, especially rising air temperatures, on urban tourists' time-space activity and on their experience evaluation, with special emphasis on warming effects since it addresses the particular context of the Mediterranean summer, which is the high season in most temperate zones. The model proposed (Figure 1) is based on three main components: (1) weather indicators, selected according to their pertinence to the geographic context of the research; (2) tourists' time-space activity, assessed in terms of activities and movements; and (3) a twofold tourist evaluation of experience, including destination attributes and overall experience satisfaction (Appendix 1).

Tourism activity is particularly dependent on weather (Gómez Martín, 2005). The model is based on the assumption that urban tourists respond to different weather states in their behaviour in time and space. In this context, air temperature is one of the most relevant indicators of weather perceptions and climate change effects. Moreover, daily average temperatures have exhibited a significant increase in recent decades and climate change scenarios forecast more frequent heat waves (Rosselló & Santana-Gallego, 2014). This becomes even more significant in areas with Mediterranean-type climate, where the greatest menace of climate change, by all indications, is higher summer temperatures, with the relatively attractive hot summer being progressively perceived as unpleasant, or on the hottest days even intolerable, reducing the appeal of destinations. Therefore, among weather indicators, special consideration is given to air temperature, using the following indicators:

1. *Maximum air temperature.* It is the peak temperature, usually recorded after midday during the hottest period of the day that may affect the tourists most negatively with regard to thermal comfort in the case of the particular study context. As de Freitas (2003, p. 48) points out, the weather experienced is not accurately described by average measures: people

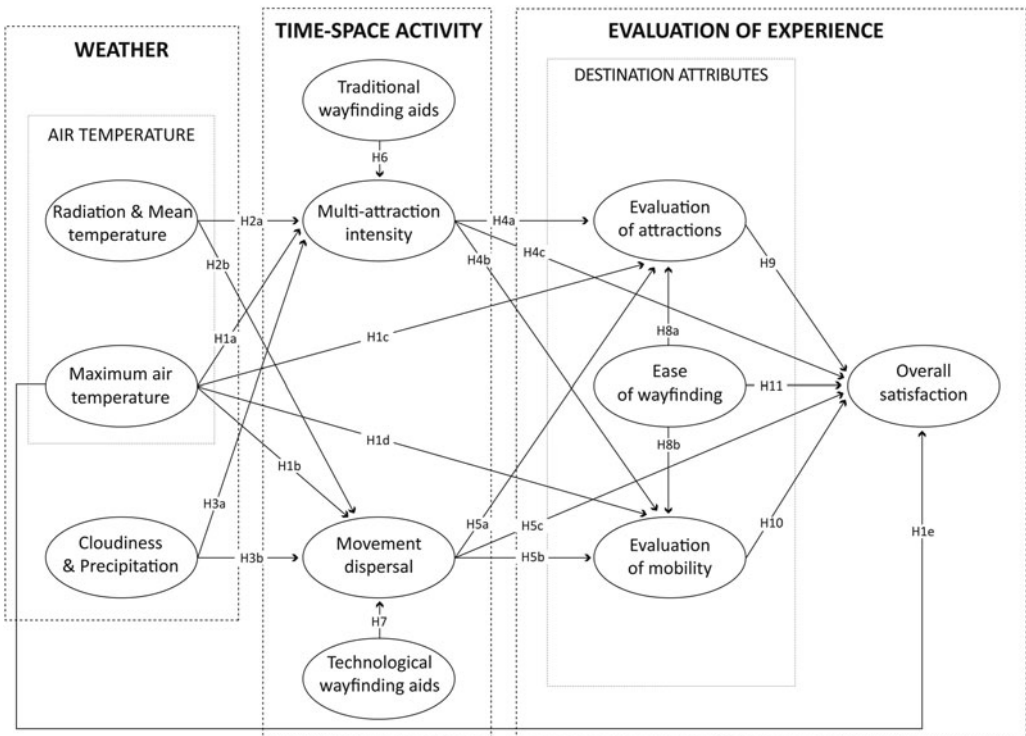


Figure 1. Research model.

respond to real meteorological conditions “rather than averages”, with weak “physiological or psychological meaning”.

2. *Solar radiation and mean air temperature.* Although mean air temperature is an average measure, it is used to represent the overall thermal context of the day, since maximum air temperature, though very influential, is restricted to only one period. Tourists tend to decide their itineraries and activities at the beginning of the day of the visit, which probably does not coincide with the period of maximum air temperature. Particularly linked to air temperature (Bristow & Campbell, 1984), total solar radiation – in conjunction with mean air temperature – accounts for the thermal component of the whole day of the visit.

Despite its pertinence to the current study and the fact that many researchers on tourism climatology “single out the thermal component of climate as the most important element”, other factors “assume greater importance in determining the pleasantness rating of a given weather or climate condition” (de Freitas, 2003, p. 48). Thus a further construct related to weather was included in the model:

3. *Cloudiness* (i.e. the fraction of the sky covered by clouds when observed from a particular location, in this case presented in percentage) and *precipitation*. Although their frequency and magnitude are not great during summer in the study area, when occurring, the adverse impact is expected to negatively influence time–space tourist activity and experience evaluation (Gössling et al., 2016).

The proposed research model results from the incorporation of weather factors into an integrative conceptual framework for the analysis of the relationships between tourist time–space behaviour and tourists’ evaluation of experience developed by Caldeira (2014). Based on theories discussed and the results of previous studies, time–space activity is assessed in terms of its two basic dimensions: movement and multi-attraction (Caldeira & Kastenholz, 2017; Xia et al., 2011). Specifically:

4. *Movement dispersal*, which refers to the territoriality (Lew & McKercher, 2006) of tourist movements (i.e. the spatial dispersal or amplitude of the tourists’ itineraries, which is related to the impact and perception of distance). Movements may be restricted to the hotel surroundings, or conversely exhibit a broad spatial consumption (Shoval, 2008). Adverse meteorological conditions are believed to have a negative impact on movement amplitude, whether by walking more slowly and doing less than initially planned (McKercher et al., 2015) or changing itineraries to avoid discomfort or risk (Giddy et al., 2017).
5. *Multi-attraction intensity.* Intensity was operationalised by McKercher and Lau (2008) as the number of stoppages or attraction locations visited by the tourists. In the scope of multi-attraction intensity, among other factors, the duration of the day visit has also been studied (Caldeira & Kastenholz, 2015, 2017). Multi-attraction intensity expresses the level of tourist involvement with the destination in spatial and temporal terms.

In the sphere of time–space tourist activity, traditional and technological wayfinding aids were considered. The purpose was to integrate the pertinent dimension of navigation in the context of tourists’ mobility, as well as to expand the predictive power of the model (Tussyadiah & Zach, 2012; Xia, 2007).

Both expressive and instrumental attributes are central to the evaluation of tourist experiences (Pearce & Wu, 2014). According to the authors, instrumental components refer to the physical or tangible elements that facilitate the tourist experience (such as, in the context of this study, transports, signposting or attraction opening hours), whereas expressive components encompass the more intangible and holistic features of the setting (such as the cultural offer,

monuments or history). In order to assess the quality of tourist experiences, it is crucial for destinations to know how tourists evaluate the different destination attributes, which are the components of a complex visitor experience (Medlik & Middleton, 1973). Subsequently, for the tourists' evaluation of the experience, we adopted a twofold assessment:

- evaluation of destination attributes with regard to attractions, mobility aspects and ease of wayfinding;
- overall experience satisfaction, following the multidimensional operationalisation suggested by Fornell (1992).

"Experience evaluation" refers to the "the individual's unique cognitive and affective impressions", encompassing the entire "process, the outcome (enjoyment or otherwise), and their positive or negative memories" (Dong & Siu, 2013, p. 542). It is common, especially in quantitative research on experience evaluation, to ask respondents to rate several attributes (Pearce & Wu, 2014; Pizam & Mansfeld, 2000) – in this case according to the two main dimensions of urban tourists' time–space activity (multi-attraction and tourist movements). Apart from overall satisfaction, therefore, the evaluation of the experience encompassed the destination attributes, with regard to mobility conditions, ease of wayfinding and the attractions on offer (i.e. evaluation of those elements of experience directly linked to attractions). Less is known about the impacts of weather on tourist participation in activities (Day et al., 2013). To date, empirical research has not yet clearly established "how daily weather events influence attendance decisions, particularly relating to the physiological thermal comfort levels of each visitor" (Perkins & Debbage, 2016, p. 1). Nonetheless, adverse meteorological conditions are expected to inhibit consumption of attractions and amplitude of movements (Buckley, 2008; Day et al., 2013). Weather conditions at the destination can also influence the degree of satisfaction (Hübner & Gössling, 2012). Consequently, and taking into account the geographic area of research, the following hypotheses are suggested:

H1: Maximum air temperature has a negative impact on:

- a. multi-attraction intensity;
- b. movement dispersal;
- c. evaluation of attractions on offer;
- d. evaluation of mobility conditions;
- e. overall satisfaction.

H2: Radiation and mean air temperature have a negative impact on:

- a. multi-attraction intensity;
- b. movement dispersal.

H3: Cloudiness and precipitation have a negative impact on:

- a. multi-attraction intensity;
- b. movement dispersal.

With regard to the influence of time–space tourist activity on visitors' evaluation of their experience, satisfaction involves an idea of fulfilment (Oliver, 2010). Urban tourists tend to make the most of the agglomeration of recreational opportunities, exploring the city and possibly extending, to a lesser or greater degree, the geographical scope and range of different attractions in search of novelty and variety to reduce the risk of dissatisfaction (Hunt & Crompton, 2008; Tideswell & Faulkner, 1999) until they reach an optimal point of fulfilment.

Besides, more adventurous tourists, possibly with a wider spatiotemporal behaviour, tend to achieve higher levels of satisfaction (Plog, 2002), as empirically confirmed by Hasegawa (2010) who found evidence that tourists with larger itineraries evaluated their travel experience more positively. As range of movements and attractions visited are expected to have an impact on tourists' evaluation of their experience (whether regarding destination attributes or overall satisfaction), we postulate that:

H4: Multi-attraction intensity will have a positive influence on:

- a. evaluation of attractions on offer;
- b. evaluation of mobility conditions;
- c. overall satisfaction.

H5: Movement dispersal will have a positive influence on:

- a. evaluation of attractions on offer;
- b. evaluation of mobility conditions;
- c. overall satisfaction.

Technological as well as traditional navigation aids are believed to play an important role for tourists when exploring the urban destination, reducing the risk of getting lost (Xia, 2007). Getting lost affects the tourist experience, creating an unpleasant loss of one's sense of direction, reinforced by the fact of being out of one's usual environment (Findlay & Southwell, 2004). Regarding the technological means of guidance used, Tussyadiah and Zach (2012) investigated the role of geotechnology (navigation applications, car navigation systems, portable GPS equipment) in the acquisition of geographic knowledge. Helped by city landmarks, signage, technological devices or other sources of spatial information, human beings tend to economise effort and follow principles of distance minimisation (Downs & Stea, 2009). Therefore, we postulate that technological devices are related to amplitude of movements (Tussyadiah & Zach, 2012) and, in turn, traditional wayfinding references are particularly helpful in terms of multi-attraction intensity of visitation. Accordingly, the intensity of traditional and technological wayfinding aids will have a positive influence, respectively on:

H6: multi-attraction intensity;

H7: movement dispersal.

As far as tourist experience evaluation is concerned, considering that finding the way is instrumental when moving from one attraction to another, the following hypotheses are proposed:

H8: The tourists' perceived ease of wayfinding will have a positive relationship with:

- a. evaluation of attractions on offer;
- b. evaluation of mobility conditions.

Finally, overall satisfaction is considered a global judgment of a cumulative and multifaceted experience process. Hence, the following hypothesis suggests that the three sets of destination attributes have a positive impact on overall satisfaction:

H9: The tourists' evaluation of attractions on offer will have a positive relationship with overall satisfaction;

H10: The tourists' evaluation of destination mobility conditions will have a positive relationship with overall satisfaction;

H11: The tourists' perceived ease of wayfinding will have a positive relationship with overall satisfaction.

Methodology

Study area

Lisbon is the capital of Portugal and one of the top European urban tourist destinations, with more than three million international arrivals in 2016, and it occupies sixty-first place in the world ranking of city destinations (Euromonitor, 2017).

Once the capital of an empire, Lisbon condenses a wide variety of attractions in a small geographical area (WTTTC, 2007): “monuments, the architecture with a large diversity of styles that conflux harmoniously, the geographic position, the pleasant year-round climate, the authenticity of traditions, the diversity of landscapes, the rich gastronomy” (Sarra, Di Zio, & Cappucci, 2015, p. 3). Alongside the city are the beaches of Cascais and Caparica, the village of Sintra – with its attractive palaces and natural scenery – and other natural areas and historical places. For this reason, tourists engage in multiple activities, especially visiting attractions, dining out, walking around, visiting diverse locations, participating in organised tours; and, less frequently, going to the beach, shopping and engaging in nature activities (Turismo de Lisboa, 2012b). The number of guests and overnight stays in Lisbon has been increasing significantly in recent years. According to Statistics Portugal (2013), during the peak season (i.e. July and August) most hotel guests in Lisbon come from Europe (70.1%), followed by America (mainly from the United States and Brazil). Turismo de Lisboa (2012a) presents the following profile of Lisbon’s tourists: about 46% were below 35 years and 42% between 35 and 54 years; 50% had at least a bachelor’s degree as an academic qualification; 31% had previously visited Lisbon; and 53% travelled as a couple, 33% with friends, and 24% with children or other relatives.

The Lisbon region has a Mediterranean-type climate (Pereira & Morais, 2007) characterised by a long, hot, dry summer, with most precipitation occurring in the period between October and April (Machete et al., 2014). Specifically, and according to the Köppen Climate Classification System, Lisbon’s climate is classified as temperate with dry or hot summer, the type of climate which covers most of the Iberian Peninsula and the Mediterranean coastal regions (Institute of Meteorology of Portugal, 2011). In accordance with the climatological normal (1971–2000), the average temperature in August, the hottest month, is 23 °C, followed by July (22.7 °C) and September (21.8 °C); in terms of total average precipitation, July records 6.1 mm and August 6.8 mm, increasing in September (28.5 mm). Lisbon’s climatic characteristics derive from geographical factors such as latitude, topography, its proximity to the Atlantic Ocean, and its position facing the Tagus river (Alcoforado et al., 2005).

As climate strongly influences the choice of destination as well as the time of trip (Scott & Lemieux, 2010), the attractiveness of the Portuguese capital for tourists derives largely from its climatic conditions. The brightness that characterises the Mediterranean skies, the greater exposure to sunshine on the north bank of the river, and the proximity of the sea currently make Lisbon one of the mildest European capitals. According to the annual survey conducted by the local tourism authority in 2011, the weather was the aspect of the city most valued by visitors (Turismo de Lisboa, 2012b).

However, the disorderly expansion of its metropolitan area has given rise to negative impacts, manifested in the changing winds and the “urban heat island” phenomenon (Alcoforado et al., 2005). Additionally, climate change effects, especially with rising air temperatures, are already clearly noticeable in Lisbon. Confirming the long-term tendency, the especially hot months of September and October of 2017 were the driest of the previous 87 years (IPMA, 2017a, 2017b), with nearly the whole Iberian Peninsula facing extreme drought. The main climate changes forecasted for Lisbon by the end of the twenty-first century include: an increase in annual average temperature, especially maximums; a significant increase in maximum summer temperatures (e.g. an increase in the number of days with temperatures exceeding 35 °C; and of tropical nights, with minimum temperatures of exceeding 20 °C); more frequent and intense heat waves; a

decrease in average annual precipitation and number of days with precipitation; and, to a lesser extent, an increase in extreme phenomena (e.g. excessive precipitation, increase in precipitation intensity; Câmara Municipal de Lisboa, 2016).

The territorial delimitation of Lisbon as the research area is based on the concept of local destination (Lew & McKercher, 2006). For the purposes of this study, the destination was operationalised as the territory within the physical boundaries of a day trip (World Tourism Organization & Terzibasoglu, 2007).

Sampling and data collection

The data were collected amongst tourists staying in 10 hotels located in the three major tourist areas in Lisbon (eight in downtown, one in Belém, and one in Parque das Nações, in line with the spatial distribution of accommodation units in the city, belonging to three-, four-, and five-star categories) in the summer of 2012, from mid-July to the first week of September. The target population was leisure tourists in Lisbon and a two-stage cluster sampling method, defined in time and place, was applied (Kastenholz, 2004). The destination management organisation (DMO, Tourism of Lisbon Association) contacted all the city hotels, inviting them to cooperate with the research, with each hotel that agreed to collaborate being associated to a cluster of tourists belonging to the population of interest (Davis, 1996). Then, each day, the first author of this article would randomly choose one of the 10 hotels and, once there, at a given time, usually in the early morning, would approach potential respondents – all those passing by the lobby after breakfast or already on their way out to their day visit – until no further GPS devices were available. About 70% of the tourists approached agreed to participate in the study. Tourists were fully informed of the objectives and conditions of the study, namely that they would be asked to carry a GPS tracking device. Then the researcher would move to the street with those who agreed to participate, to get the satellite signal more easily, and activate the device in front of them: a sport watch (Garmin Forerunner 110) equipped with GPS technology, following the procedures suggested by Edwards, Dickson, Griffin, and Hayllar (2010). Subsequently, upon their return to the hotel, the participants were approached again by the researcher and asked to respond to the post-visit questionnaire about the 1-day visitation period. This second research instrument furnished increased accuracy and additional in-depth knowledge of participants' behaviour and experience evaluation.

Instruments and measures

Taking a quantitative research approach, the tourists' movements were monitored using mixed methods: a questionnaire survey and GPS tracking of tourist routes. Since tourists' movements and activities are difficult to trace accurately, the combination of GPS tracking with surveys is recommended (Edwards et al., 2010; Xia et al., 2010).

The weather factors considered for analysis were: maximum air temperature – measured by the indicator daily maximum air temperature (°C); radiation and mean air temperature – assessed by the daily total global solar radiation indicator (kJ/m²), in conjunction with daily mean air temperature (°C); cloudiness and precipitation – accounted for through daily maximum diurnal cloudiness (%) and daily total precipitation (mm). The meteorological data were provided by the Portuguese national meteorological authority (Instituto Português do Mar e da Atmosfera), collected in the central Lisbon meteorological station (Gago Coutinho).

The GPS unit recorded the time, speed, distance, position and direction of movement, allowing data to be collected which were used to assess multi-attraction intensity (two items) and movement dispersal (two items; Caldeira & Kastenholz, 2015, 2017; McKercher & Lau, 2008). The remaining data were collected via questionnaire, whose items were used as follows: firstly, to

measure the intensity of use of technological wayfinding aids (two items) and of traditional wayfinding aids (two items; Tussyadiah & Zach, 2012; Xia, 2007); secondly, to make an evaluation of attractions (seven items), evaluation of mobility conditions (three items) and ease of wayfinding (two items; with the items of these three constructs adapted from Bramwell, 1998; Cegielski, Espinoza, May, Mules, & Ritchie, 2004; Chen, Chen, & Lee, 2011; Fuchs & Weiermair, 2004; Joppe, Martin, & Waalen, 2001; Xia, 2007); and lastly, to gauge overall satisfaction (three items; Fornell, 1992). Items with significant missing values (e.g. evaluation of nightlife, tour guides or ease of parking) were not considered for analysis.

The questionnaire used in the study encompassed three sections: (1) respondent profile; (2) time–space activity; (3) evaluation of experience (sections “Tourists’ time–space activity in the urban context” and “Weather conditions as an influencing factor of tourists’ activities and movements” were answered on 10-point Likert scales). It was formulated in the three dominant languages used by tourists in Lisbon: Portuguese, English and Spanish. The translation and back translation were carried out to ensure clarity of language and minimal differences amongst versions. A pre-test conducted in Lisbon with 90 complete responses contributed to clear comprehension of the final questionnaire and the validity of the chosen items.

Data analysis

Spatiotemporal data were extracted using the online software Garmin Connect. For subsequent statistical modelling, it was then analysed by means of the same software (to register data such as distance travelled and confirm information collected by the survey such as the attractions visited), as well as the Google Earth programme (which allowed measurement of the maximum point of dispersal, in a straight line, from the hotel; Caldeira & Kastenholz, 2015, 2017). The tourists’ trajectories were also mapped via ArcGis software for further analysis (De Cantis et al., 2016; McKercher et al., 2015). Weather data were introduced in the database, corresponding to each respondent’s date of participation, and then used for statistical analysis.

The suggested research model (Figure 1) was tested using Partial Least Squares Structural Equation Modeling (PLS-SEM), specifically with the statistical software SmartPLS 3 (Ringle, Wende, & Becker, 2014). As a prediction-oriented variance-based SEM technique, PLS accommodates non-normal data distribution and single-item constructs (Chin, 1998). It is especially indicated for theory development, as is the case of this study, testing path models hypotheses in an exploratory manner (Nitzl, Roldan, & Cepeda, 2016). Thus, PLS was considered to be the most suitable tool. Owing to its flexibility (Ayeh, Au, & Law, 2013), the PLS algorithm has been increasingly applied to tourism studies (Han, McCabe, Wang, & Chong, 2018; Loureiro & Kastenholz, 2011; Martínez García de Leaniz, Herrero Crespo, & Gómez López, 2017; Rasoolimanesh, Jaafar, Kock, & Ahmad, 2017).

Ensuring the validity and reliability of PLS modelling is a two-step process (Hair, Hult, Ringle, & Sarstedt, 2014): firstly, the measurement (outer) model is assessed, evaluating the relationships between the constructs and their associated indicators; then the structural (inner) model is evaluated, with the analysis of the hypothesised relations between the constructs in the research model. Each of the various hypothesised relationships is related to the corresponding causal path that links each pair of constructs in the structural model (Henseler, Ringle, & Sinkovics, 2009). The standardised path coefficients and significance levels provide evidence of the inner model’s quality, with *t*-values being obtained with the bootstrapping procedure (5000 samples).

Results

Sample profile

Within a final sample of 413 respondents, 404 GPS itineraries were validated, constituting the sample considered for analysis. With the “10 times” rule of thumb (Barclay, Higgins, & Thompson,

1995) providing a basic guideline for the minimum sample size required for PLS use (Hair et al., 2014), the study employed the G*Power 3.1.9.2 software, a statistical power analysis programme commonly applied in social and behavioural research (Faul, Erdfelder, Lang, & Buchner, 2007). With parameters of 95% statistical power, an effect size median of 0.15, and 5% probability of error, the minimum sample size required would be 138, clearly exceeded in this study.

Table 1 sums up the characterisation of the study sample in terms of sociodemographic characteristics and travel behaviour. Respondents were 56.2% female, with 50.5% the aged between 25 and 44, and 79% holding a college degree. Only 2.5% were resident in Portugal, while 74.9% came from Europe. With regard to travel behaviour, about 73.6% were first-time visitors, and 58.5% were accompanied by just one companion. The majority (76.7%) of the study participants stayed in Lisbon from one to five nights. The similarity of the results (e.g. age, country of residence, travel party, prior destination experience) with the aforementioned data (Turismo de Lisboa, 2012a, 2012b) indicates that the research sample is reasonably representative.

On the days of data collection, the lowest daily maximum air temperature was 25 °C and the highest was 34 °C, with a mean of 29.5 °C. During the period of data collection, there were 9 days without clear sky (> 10%), with rain on two of those days.

Model assessment

The measurement model adopted in this study includes 11 constructs, of which four were measured as formative (cloudiness and precipitation; multi-attraction intensity; traditional wayfinding aids; and technological wayfinding aids). “The decision of whether to measure the construct reflectively or affirmatively is not clear-cut” (Hair et al., 2014, p. 46), but basically in formative measurement indicators cause the construct, while in reflective measurement causality comes

Table 1. Profile of the respondents.

Characteristics	Frequency	Percentage
<i>Gender</i>		
Men	177	43.8
Women	227	56.2
<i>Age</i>		
15–24	34	8.5
25–34	124	30.8
35–44	79	19.7
45–54	75	18.7
55 or over	90	22.4
<i>Education</i>		
Elementary	6	1.5
Secondary	76	19.3
Higher	312	79.2
<i>Country of residence</i>		
Portugal	10	2.5
Other European country	302	74.9
America	85	21.1
Other continent	6	1.5
<i>Prior destination experience</i>		
First-timers	293	73.6
Repeaters	105	26.4
<i>Travel group size</i>		
1 companion	231	58.5
2 or more companions	164	41.5
<i>Length of stay</i>		
1–3 nights	158	39.6
4–5 nights	148	37.1
6 or more nights	93	23.3
<i>Participation in city tour</i>		
Yes	62	15.4
No	340	84.6

from the construct to its measures. Formative and reflective measurements require different assessment procedures.

With regard to reflective constructs, as described by Henseler et al. (2009), indicator reliability (with all loadings above the cut-off of 0.6), internal consistency reliability (with composite reliability, also termed Dillon-Golstein's rho, exceeding 0.7 for all constructs), and convergent validity (with values of the average variance extracted well above 0.5) were checked (Table 2). Furthermore, discriminant validity of the constructs was confirmed using the criteria of Fornell and Larcker (1981): in all cases, the AVE values are higher than the squared inter-correlations with other constructs (Table 3).

As for the assessment of formative constructs, the indicators' weight and respective significance (Table 1), as well as their multicollinearity were examined. Based on the Variation Inflation Factor (VIF), collinearity problems were discarded since values range from 2.672 to 1.009, clearly below 5, as suggested by Hair et al. (2014). As for single-item constructs, as the construct equals its measure (indicator is 1.00), conventional reliability and convergent validity assessments are inadequate (Hair et al., 2014).

Table 2. Measurement statistics of construct scales.

Construct/indicators	Mean	SD	Indicator loading/weight ^a	t-value ^b	CR	AVE
Maximum air temperature					1	1
Daily maximum air temperature (°C)	30.0	3.14	1	n.a.		
Radiation & mean temperature					n.a.	n.a.
Daily total global solar radiation (kJ/m ²)	24,027	3431	0.870	7.568		
Daily mean air temperature (°C)	22.8	2.18	0.351	2.001		
Cloudiness and precipitation					0.708	0.558
Daily maximum diurnal cloudiness (%)	20.5	22.7	0.580	2.824		
Daily total precipitation (mm)	1.33	1.21	0.883	7.123		
Multi-attraction intensity					n.a.	n.a.
Number of attractions and activities	6.94	2.03	0.710	4.039		
Day visit duration (hours)	08:04:41	2.65	0.460	2.326		
Movement dispersal					0.988	0.975
Distance travelled (km)	38.2	40.1	0.989	468.108		
Dispersal from accommodation (km)	10.5	14.4	0.986	258.741		
Traditional wayfinding aids					n.a.	n.a.
Signposting	5.03	4.48	0.709	3.410		
Traditional maps	8.42	3.43	0.648	3.110		
Technological wayfinding aids					n.a.	n.a.
Car navigation system	1.45	1.96	0.940	5.682		
Other technological devices	1.66	2.61	0.363	2.001		
Evaluation of attractions					0.906	0.582
Range of tourist attractions	7.95	1.49	0.794	31.126		
Monuments/heritage/history	8.27	1.43	0.801	38.479		
Cultural offer: museums, galleries and exhibitions	7.96	1.51	0.864	47.383		
Parks/outdoor recreation	7.90	1.41	0.700	17.070		
Attractions/activities opening hours	7.74	1.49	0.733	23.012		
Attractions/activities employees	7.85	1.51	0.800	28.879		
Price of attractions/activities	7.01	1.93	0.622	13.803		
Evaluation of mobility conditions					0.847	0.649
Walking around	8.13	1.51	0.795	33.868		
Traffic	7.22	1.74	0.813	36.465		
Transports	8.03	1.59	0.810	31.969		
Ease of wayfinding					0.908	0.831
Ease/difficulty in wayfinding	7.63	1.65	0.927	125.459		
Signposting	7.03	1.71	0.896	42.400		
Overall satisfaction					0.911	0.774
Degree of overall satisfaction	8.45	1.26	0.890	64.828		
Comparison to expectations	7.93	1.49	0.868	42.477		
Comparison to ideal	7.72	1.48	0.880	62.669		

Note. CR: composite reliability; AVE: average variance extracted; ^aloadings are indicated for indicators reflective constructs and weights are indicated for indicators of formative constructs; ^bt-values were obtained with the bootstrapping procedure (5000 samples) and are significant at the 0.05 level; n.a.: not applicable (for single-item or formative constructs).

Table 3. Discriminant validity of the constructs.

Constructs	1	2	3	4	5	6	7	8	9	10	11
1. Maximum air temperature	a)										
2. Radiation and mean temperature	0.656	b)									
3. Cloudiness and precipitation	-0.459	-0.694	0.747								
4. Multi-attraction intensity	-0.206	-0.281	0.107	b)							
5. Movement dispersal	-0.082	-0.120	0.247	0.099	0.988						
6. Traditional wayfinding aids	-0.107	-0.062	0.009	0.244	-0.014	b)					
7. Technological wayfinding aids	0.007	-0.080	0.132	0.019	0.251	-0.171	b)				
8. Attractions	0.015	-0.061	0.106	-0.027	0.094	-0.007	-0.002	0.763			
9. Mobility	0.074	0.012	-0.002	0.020	-0.036	0.053	-0.071	0.524	0.806		
10. Wayfinding	0.061	0.057	0.062	-0.084	-0.011	-0.014	-0.095	0.409	0.616	0.912	
12. Overall satisfaction	-0.077	-0.071	0.076	0.112	0.083	0.027	0.013	0.585	0.510	0.348	0.880

Note. The square root of AVEs is shown diagonally in bold; (a) single-item constructs; (b) formative construct.

Once the validity and reliability of the outer model were established, the estimates of the inner model were examined to assess the hypothesised relationships amongst the constructs of the research model, as well as the value of the R^2 coefficients of the endogenous constructs (Henseler et al., 2009). Results of testing the research model are exhibited in Figure 2.

The explained variance (R^2) reveals the predictive power of the research model. Since the R^2 values vary between 0.12 and 0.42 (Figure 2), the model presents predictive relevance of endogenous constructs. On the other hand, the R^2 coefficients for movement dispersal, multi-attraction intensity and evaluation of attractions were 0.12, 0.14, and 0.18, respectively. The assessment of the value of the R^2 is highly dependent upon the research area. In behavioural studies, a value of 0.2 may be considered suitable (Hair et al., 2014). The constructs with the highest variance explained by the model are overall satisfaction ($R^2 = 0.42$) and evaluation of mobility ($R^2 = 0.39$). Consequently, the R^2 coefficients indicate that overall satisfaction and evaluation of mobility conditions are appropriately explained but, in the case of movement dispersal, multi-attraction intensity and evaluation of attractions, it is likely that “omitted variables account for a fairly large percentage of the variance of these constructs” (Rasoolimanesh et al., 2017, p. 210). In fact, apart from weather, there are many other factors that impact on time-space activity (e.g. individual characteristics, travel party dynamics, and other destination features such as topography, range and location of attractions, and the city’s suitability for tourism). Thirteen of the 22 hypotheses under analysis were supported (Table 4).

Amongst the first hypotheses – H1a to H3b, predicting that weather factors had a negative impact over time-space activity in terms of movements and activities as well as on evaluation of experience – significant relationships were found. Maximum air temperature exhibits one significant negative effect on overall satisfaction ($\beta = -0.08, p < 0.05$) and radiation and mean temperature reveal a negative effect over multi-attraction intensity ($\beta = -0.37, p < 0.001$). As for cloudiness and precipitation, two significant relationships are identified over multi-attraction intensity and movement dispersal, though the last relationship was found to be in the opposite direction from our hypothesis. Additionally, radiation and mean temperature manifest a positive impact, again with a different sign from what was hypothesised and only significant at the 0.1 level.

As for hypotheses H4a to H4c, multi-attraction intensity reveals a significant positive influence on evaluation of mobility ($\beta = 0.09, p < 0.05$) and on overall satisfaction ($\beta = 0.10, p < 0.05$). In turn, amongst hypotheses H5a to H5c, only one significant impact was found: movement dispersal positively influences evaluation of attractions ($\beta = 0.10, p < 0.05$). As expected, traditional wayfinding aids show a strong positive impact on multi-attraction intensity ($\beta = 0.22, p < 0.05$) and technological wayfinding aids also have a positive effect on movement dispersal ($\beta = -0.09, p < 0.05$).

With regard to hypotheses H8a and H8b, ease of wayfinding presents a strong impact on both evaluation of attractions ($\beta = 0.41, p < 0.001$) and evaluation of mobility ($\beta = 0.62, p <$

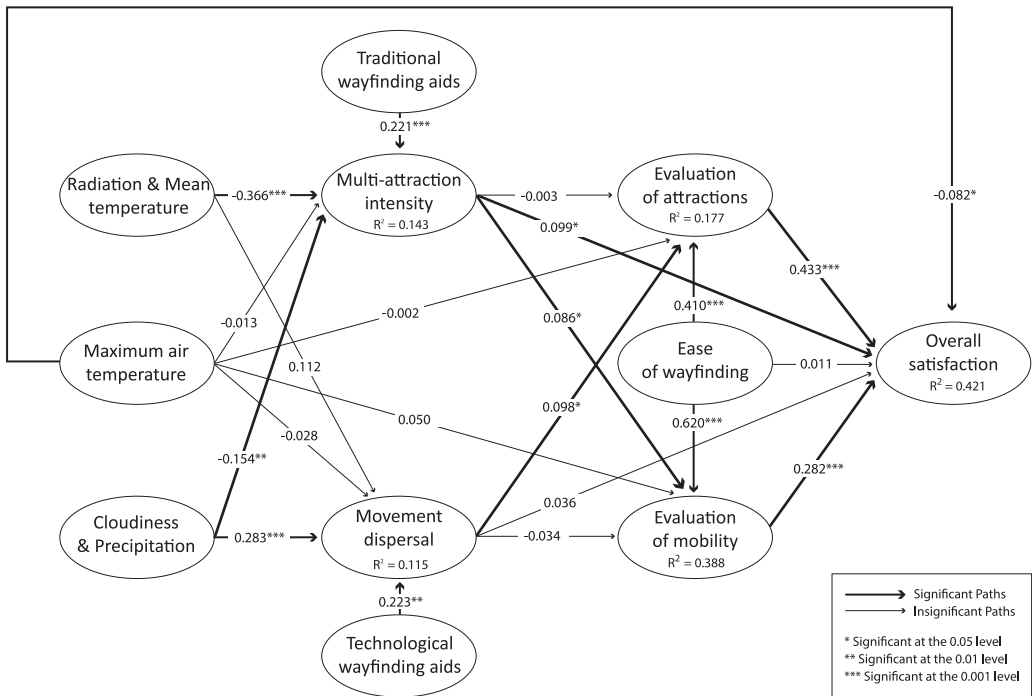


Figure 2. Results of hypothesis testing.

Table 4. Hypotheses testing.

Hypothesis	Path coefficient	t-value ^a	p-value	Supported
H1a: Maximum air temperature -> Multi-attraction intensity	-0.013	0.224	0.823	No
H1b: Maximum air temperature -> Movement dispersal	-0.028	0.362	0.717	No
H1c: Maximum air temperature -> Evaluation of attractions	-0.002	0.049	0.961	No
H1d: Maximum air temperature -> Evaluation of mobility	0.050	1.234	0.217	No
H1e: Maximum air temperature -> Overall satisfaction	-0.082	2.108	0.035	Yes
H2a: Radiation & Mean temperature -> Multi-attraction intensity	-0.366	4.965	0.000	Yes
H2b: Radiation & Mean temperature -> Movement dispersal	0.112	1.946	0.052	No
H3a: Cloudiness & Precipitation -> Multi-attraction intensity	-0.154	2.612	0.009	Yes
H3b: Cloudiness & Precipitation -> Movement dispersal	0.283	4.176	0.000	No (different sign)
H4a: Multi-attraction intensity -> Evaluation of attractions	-0.003	0.051	0.959	No
H4b: Multi-attraction intensity -> Evaluation of mobility	0.086	2.198	0.028	Yes
H4c: Multi-attraction intensity -> Overall satisfaction	0.099	2.438	0.015	Yes
H5a: Movement dispersal -> Evaluation of attractions	0.098	2.149	0.032	Yes
H5b: Movement dispersal -> Evaluation of mobility	-0.034	0.812	0.417	No
H5c: Movement dispersal -> Overall satisfaction	0.036	1.101	0.271	No
H6: Traditional wayfinding aids -> Multi-attraction intensity	0.221	4.377	0.000	Yes
H7: Technological wayfinding aids -> Movement dispersal	0.223	3.147	0.002	Yes
H8a: Ease of wayfinding -> Evaluation of attractions	0.410	9.013	0.000	Yes
H8b: Ease of wayfinding -> Evaluation of mobility	0.620	17.219	0.000	Yes
H9: Evaluation of attractions -> Overall satisfaction	0.433	8.005	0.000	Yes
H10: Evaluation of mobility -> Overall satisfaction	0.282	4.408	0.000	Yes
H11: Ease of wayfinding -> Overall satisfaction	0.011	0.189	0.850	No

Note. ^at-values were obtained with the bootstrapping procedure (5000 samples).

0.001), the latter having the highest impact of the model estimation. Taken together, hypotheses H9 to H11, predicting a positive impact of the evaluation of destination attributes on overall satisfaction, are supported at the 0.001 level, except for the relationship between ease of wayfinding with overall satisfaction, which is non-significant. Nonetheless, when examining the indirect and total effects of the independent constructs on the dependent ones (Appendix 2), which provides useful information regarding cause-effect relationships, wayfinding exhibits a strong

indirect effect on overall satisfaction ($\beta = 0.35, p < 0.000$). Whether to identify a potential mediator effect of evaluation of attractions or of evaluation of mobility regarding overall satisfaction, the procedure suggested by Hair et al. (2014) was implemented. Firstly, the significance of the direct effect between the independent variable and the dependent variable (excluding the interaction of the mediator) must be checked. After establishing the significance of the direct effect of evaluation of mobility on overall satisfaction, variance accounted for (VAF) was calculated to assess the size and strength of the mediation. The corresponding VAF score (ease of wayfinding \rightarrow evaluation of mobility \rightarrow overall satisfaction = 54.2%) represents a partial mediation ($>20\%$ and $<80\%$).

Discussion of results

With the focus on summer thermal conditions, the results reveal objective effects of rising temperatures on tourists' spatial and temporal patterns (Rosselló & Santana-Gallego, 2014) at the intra-destination level. Even though maximum air temperature, which is associated to a limited period of the day visit, does not have a significant effect on activities and movements that take place over the entire day, it significantly reduces overall satisfaction. This finding is in line with Giddy et al. (2017, p. 57): "day-to-day weather did often impact the enjoyment of their visit". Given the importance of overall satisfaction for attractions, tourist services and destination competitiveness, this is arguably the most relevant result of the study, confirming the negative impact of observed and projected climate change impacts investigated in real context. Our study had limited variability (from 25 °C to 34 °C) and a maximum value which is not extraordinarily high in the context of the Mediterranean climate. This finding is all the more valuable when research linking weather factors to satisfaction is limited and the interaction between tourism and temperature is not clearly established (Rosselló & Santana-Gallego, 2014).

The tourists' reaction to the rise in maximum air temperature is in line with research by Fitchett et al. (2017), who studied climate suitability in various locations in South Africa using tourism climate indices. The authors concluded that Cape Town, for example, with a Mediterranean climate as well, is categorised as having ideal conditions for tourism in the summer, forecasting nonetheless that projected warming may exceed the upper limits for thermal comfort. Specifically in Lisbon, research based on weather types forecasts that by "2050 some days are expected to be unacceptably hot" (Machete et al., 2014, p. 170). Although the authors conclude that high temperatures would not be reflected in the room occupation rates of the city of Lisbon, what the present study reveals is that, once at the destination, tourists' overall satisfaction and, to a certain extent, behavior are indeed affected. In turn, the thermal conditions registered during the whole day have a significant influence on activities and, at the 0.1 level, on movements. In fact, the rise in total solar radiation and mean air temperature considerably reduces multi-attraction intensity, since effects may be felt increasingly from the time in the morning when tourists probably plan their itineraries and activities, even if adapted over the course of the day. Thus, tourists end up having a lower engagement with the destination by visiting fewer attractions, performing fewer activities or reducing the duration of their daytime visit to the city. These results confirm the effect of aversion to heat, in line with the findings of Perkins and Debbage (2016), and are particularly relevant in the context of increasing independent travel, with tourists being able to adapt their intra-destination itineraries (Xiang, 2013). On the other hand, contrary to what was hypothesised, even with increased thermal discomfort felt during the day, tourists exhibit, to some extent, greater dispersal of their movements. This may be because they choose to go to the beach or to cooler locations nearby (such as the city of Sintra, with its fresher micro-climate), with a corresponding effect on their itineraries, or because they tend to avoid walking around visiting the central attractions that are more concentrated in space. In fact, there are some important attractions located at some distance. Tourists prefer

visiting places that provide the highest level of comfort and well-being, with the results confirming that tourist activities, especially those that take place outdoors, are significantly influenced by weather (Gómez Martín, 2005; Olya & Alipour, 2015). On the other hand, as Bujosa, Riera, and Pons (2015) point out, time and space are substitute resources: less time spent visiting several attractions or engaged in several activities corresponds to broader movements, which points to a dichotomy between concentration/intensity and amplitude/dispersal. In a certain way, this effect on dispersal of movements may contribute to reducing congestion in city centres and may take tourists to less explored areas or secondary attractions. In this line, it is pertinent to notice that movement dispersal accounts for a significantly higher evaluation of attractions, allowing tourists to visit less congested locations that lie off the beaten track.

As for the worsening weather conditions arising from cloudiness and precipitation, similar to the adverse effects of high solar radiation and temperature, the results confirm again that time and space are substitute resources: in the presence of clouds or rain, tourists significantly reduce their intensity of consumption of attractions and activities, but at the same time widen their movements, possibly preferring the shelter of transport instead of outdoor walking. Although future climate change scenarios forecast lower levels of precipitation in the specific geographical context, more frequent downpours are predicted, even if their impact is much more temporary than the increase in air temperatures. On the other hand, the increase in drought forecasted will produce arguably similar discomfort, with possibly analogous effects.

As a complement to the investigation of the effects of weather factors, the test of the remaining hypotheses sheds light on the relationship between time–space tourist activity and evaluation of experience. Multi-attraction intensity, negatively impacted by adverse meteorological conditions, contributes positively and significantly to overall satisfaction, which stresses the pertinence of destinations providing conditions that facilitate comfortable exploration of attractions and activities. Moreover, multi-attraction intensity reveals a significant positive effect on evaluation of mobility, possibly because more concentrated spatial patterns liberate tourists from potential traffic or transport inconveniences and induce a feeling of autonomy when walking. In turn, the only significant impact of movement dispersal is on the evaluation of attractions, as already discussed.

Wayfinding, in terms of intensity of use of navigation aids as well as the related tourists' evaluation, exhibits some of the most significant impacts of the model, confirming the tourists as effort economisers (Downs & Stea, 2009) and the inconvenience of getting lost (Findlay & Southwell, 2004). Ease of wayfinding does not register a direct significant effect on overall satisfaction, since this is mediated by tourists' evaluation of mobility. Hence, tourists' evaluation of the wayfinding aspects only impacts significantly on overall satisfaction when evaluation of mobility is at stake.

Finally, tourists' evaluation of attractions in particular, but also of mobility conditions, positively influences overall satisfaction as predicted, underlining the relationship between evaluation of destination attributes and overall satisfaction. The results call attention to the importance of the movement dimension of the tourist experience, emphasizing factors such as mobility conditions, ease of wayfinding, and urban legibility, reflecting the city's overall suitability for tourism.

Conclusions

The key conclusion of this study is that weather impacts tourists' time–space experience, which is confirmed by objective meteorological data and accurately tracked behaviour and, as such, implications may be derived from the results to forecast how the expected effects of climate change will influence urban tourists' time–space activity. Specifically, our findings indicate that adverse meteorological conditions that impact the entire period of visitation exert a significant inhibitory effect on tourist activities and, in contrast, act as a facilitator of movement dispersal,

while maximum air temperature negatively impacts tourists' overall satisfaction (Gómez Martín, 2005). To some extent, this corroborates the fact that researchers generally consider "air temperature to be the climate variable of primary importance to tourism" (Scott et al., 2008, p. 67).

Combining revealed and stated preferences approaches, this study extends knowledge in the research area of climate change effects and their relationship with the tourist experience and tourists' spatiotemporal behaviour in urban destinations. Resulting from the successful incorporation of weather factors in a model which is innovative in itself, it systematises the relationship between dimensions of spatiotemporal tourist behaviour and tourists' evaluation of experience. Examining "on-site experience" increases the reliability of research, "since individuals are experiencing conditions first hand" (de Freitas, 2003, p. 48). To the best of our knowledge, this is the first study to test a research model interrelating weather conditions and tourist time-space activity and evaluation of tourist experience using a triangulation of methods. Specifically, our study differs from previous research in that: (1) the effects of weather conditions are studied based on actual behavioural information collected by GPS tracking; (2) the research model presents an integrated approach to tourists' time-space activity in cities, since it tests its antecedents (weather factors) and consequences (evaluation of destination attributes and overall satisfaction); (3) it uses PLS-SEM to analyse simultaneously the relationships between physical meteorological data, registered/observed behaviour and stated perceptions.

Tourism is particularly vulnerable to weather, and the impacts of climate change underline the vulnerabilities of city destinations (Buckley, 2008). A better understanding of the influence of weather on the behaviour of tourists also contributes to the evaluation of the potential impacts of climate change on tourism activities in general (Nicholls, Holecek, & Noh, 2008; Pickering, 2011) and in the Lisbon destination in particular. To know in practice how weather conditions tourists' behaviour is important for the planning and management of a destination, in order to minimise sources of discomfort by adapting the offer of activities and open spaces (Nikolopoulou, 2001), designing accommodation and infrastructure, and managing the mobility of tourists and systems of transport and communications (Gómez Martín, 2005). Due to the increasing effect of climate change on the attractiveness of destinations and the safety and comfort of tourists, the findings are valuable with regard to the potential typology and spatial reconfiguration of the supply of attractions and activities, a city's suitability for tourism, the development of artificial climates, and other adaptation and negative effects reduction strategies (Buckley, 2008). Good management in this area will improve the attractiveness and functionality of destinations, boosting the comfort and health of tourists and their level of satisfaction and propensity to revisit (Gómez Martín, 2005). The social and economic sustainability of these urban destinations may also thus be enhanced through these measures, since tourists, residents and destination suppliers should benefit from such adaptations, especially if tourist flows are redirected to reduce congestion and spread visitors in a manner that places value on less-visited sites and urban resources.

As cities are usually hotter than their surroundings (Pereira & Morais, 2007), promoting visits to attractions located nearby, particularly those with fresher climate conditions due to vegetation or proximity to the ocean and its winds, would be an interesting adaptive strategy. On the other hand, extending the operating period of central attractions in summer – for example by keeping them open in the evening and even at night – could be a possible adaptation in order to preserve attractiveness and ensure a more comfortable visiting experience. Additionally, cities and tourist providers should identify critical areas and activities, employing strategies to increase thermal comfort: developing more green spaces, providing greater shade cover, and preventing physical exertion during peak temperature of the day (Fitchett et al., 2017).

In face of tourists' discomfort avoidance and in order to facilitate a pleasant tourist experience, data collection, for instance via electronic city card data management (Ellwood, 2017), can relate tourists' real-time itineraries to weather parameters, and the data used for pertinent tourist information in visitor centres and social media recommendations. Moreover, tourists can only benefit from real-time weather information accessible via smart-city applications (Quarati et al.,

2017). City DMOs should also take into consideration how tourists tend to react to excessive warming, weather forecasts and the mapping of the main climatic problems (e.g. urban heat island, wind and air quality), when choosing the location and conditions of outdoor diurnal and nocturnal events.

A limitation of this study is that it tracked the movements of individuals during only 1 day of their stay in Lisbon, due to the battery time restrictions and the need to recover the GPS device. However, the aggregation of individual days of visit to collective research on tourist movements is deemed appropriate (McKercher & Lau, 2008). On the other hand, the sample did not include guests who chose other means of accommodation (e.g. hostels, campsite) or visiting friends and relatives (VFR).

Many destinations, including cities, rely on a noteworthy proportion of outdoor attractions (Fitchett et al., 2017). Since adverse weather conditions are expected to make urban tourists switch to indoor activities, investigating which of these would be most adequate and appealing to urban tourists constitutes an interesting line of research. Further research should also intensify the conceptual effort to understand and model the role of weather factors in the tourist experience, as well as expanding it to other climate zones, seasons of the year and destination types. Finally, the literature suggests other variables of influence (e.g. length of stay, group dynamics, cultural differences) on the movements of tourists, which would eventually add to the understanding of the relationships analysed here.

Given that rising air temperatures are expected to also induce different tourist behaviour in colder destinations, it must be acknowledged that results can only be extrapolated to places with a similar climate. Nevertheless, this study sheds light on how tourists respond in reality in space and time at the intra-destination level, and thus provides valuable theoretical developments and useful practical recommendations for urban tourist systems in general, in the context of the climate change that we now live with.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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Appendix 1. Constructs and respective indicators.

Data source/Constructs	Indicators
Weather data	
Maximum air temperature	Daily maximum air temperature (°C)
Radiation and mean temperature	Daily total global solar radiation (kJ/m ²)
	Daily mean air temperature (°C)
Cloudiness and precipitation	Daily maximum diurnal cloudiness (%)
	Daily total precipitation (mm)
Tracking study data	
Multi-attraction intensity	Number of attractions and activities
	Day visit duration (hour)
Movement dispersal	Distance travelled (km)
	Dispersal from accommodation (km)
Questionnaire survey data	
Traditional wayfinding aids	Signposting
	Traditional maps
Technological wayfinding aids	Car navigation system
	Other technological devices
Evaluation of attractions	Range of tourist attractions
	Monuments/heritage/history
	Cultural offer: museums, galleries and exhibitions
	Parks/outdoor recreation
	Attractions/activities opening hours
	Attractions/activities employees
	Price of attractions/activities
Evaluation of mobility conditions	Walking around
	Traffic
	Transports
Ease of wayfinding	Ease/difficulty in wayfinding
	Signposting
Overall satisfaction	Degree of overall satisfaction
	Comparison to expectations
	Comparison to ideal

Appendix 2. Indirect and total effects.

Path coefficient	Indirect effect	Total effects		
		Path coefficient	t-value	p-value
Maximum air temperature -> Evaluation of attractions	-0.003	-0.005	0.104	0.917
Maximum air temperature -> Evaluation of mobility	0.000	0.050	1.219	0.223
Maximum air temperature -> Overall satisfaction	0.010	-0.073	1.467	0.142
Radiation & Mean temperature -> Evaluation of attractions	0.012	0.012	0.592	0.554
Radiation & Mean temperature -> Evaluation of mobility	-0.035	-0.035	1.987	0.047
Radiation & Mean temperature -> Overall satisfaction	-0.037	-0.037	1.686	0.092
Cloudiness & Precipitation -> Evaluation of attractions	0.028	0.028	1.650	0.099
Cloudiness & Precipitation -> Evaluation of mobility	-0.023	-0.023	1.560	0.119
Cloudiness & Precipitation -> Overall satisfaction	0.001	0.001	0.039	0.969
Multi-attraction intensity -> Evaluation of attractions	0.012	0.012	0.592	0.554
Multi-attraction intensity -> Evaluation of mobility	-0.035	-0.035	1.987	0.047
Multi-attraction intensity -> Overall satisfaction	-0.037	-0.037	1.686	0.092
Movement dispersal -> Overall satisfaction	0.033	0.069	1.369	0.171
Traditional wayfinding aids -> Evaluation of attractions	-0.001	-0.001	0.048	0.962
Traditional wayfinding aids -> Evaluation of mobility	0.019	0.019	1.775	0.076
Traditional wayfinding aids -> Overall satisfaction	0.027	0.027	2.058	0.040
Technological wayfinding aids -> Evaluation of attractions	0.022	0.022	2.047	0.041
Technological wayfinding aids -> Evaluation of mobility	-0.008	-0.008	0.647	0.518
Technological wayfinding aids -> Overall satisfaction	0.015	0.015	1.315	0.188
Ease of wayfinding -> Evaluation of attractions	0.022	0.022	2.047	0.041
Ease of wayfinding -> Evaluation of mobility	-0.008	-0.008	0.647	0.518
Ease of wayfinding -> Overall satisfaction	0.352	0.363	8.024	0.000