# Emotional And Cognitive Responses To Cultural Heritage: A Neuromarketing Experiment Using Virtual Reality In The Tourist Destination Image Model Context

Alexis-Raúl Garzón-Paredes[1], and Marcelo Royo-Vela [2, *]

1 Alexis-Raúl Garzón-Paredes1[0000-0001-5683-933X] and
[2]Marcelo Royo-Vela2[0000-0002-9310-5201*]
1 Universidad UTE, Quito 170508, Ecuador. alexisr.garzon@ute.edu.ec
Universitat de València, Valencia 46003, Spain.
araulgar@alumni.uv.es
Instituto Superior Universitario de Artes Visuales, Quito
170102, Ecuador, alexis.gazon@iavq.edu.ec
2 Universitat de València, Valencia 46003, Spain. Marcelo.Royo@uv.es
* Correspondence: Marcelo Royo Vela; Marcelo.Royo@uv.es

Abstract:

The research is driven to identify and measure, through electroencephalography the impact of cultural and architectural heritage emulated by virtual reality on the mind of a tourist, in the form of cognitive and emotional responses measured as brain waves, identifies, through electroencephalogram, the cognitive and the emotional responses by subjects immersed in cultural tourist destination virtual reality, takes as conceptual framework the tourist destination image model and focus on tourist destinations characterised by historical, cultural, and architectural heritage. A neuromarketing experiment is caried out in which the cognitive and affective responses can be observed and measured using alpha α and beta β brain bioelectric waves, the data obtained directly from the human brain is used to carry out an analysis using the partial least squares regression algorithm PLS. The results show that the cognitive and emotional response caused by the tourist destination cultural heritage through virtual reality in individuals, is positive.

Keywords: Neuromarketing; virtual reality; cultural tourism, heritage; tourist destination image model; cognitive response, emotional response.

## 1. Introduction

Indeed, the tourism industry worldwide has experienced a major hiatus as a result of the COVID-19 pandemic (Buckley & Cooper, 2021). However, the vision of tourists play an important role in tourism development (Jangra et al., 2021; Serrano-Arcos et al., 2021) and tourists can have unique tourist experiences with a destination's multimedia through content such as images, text, videos and audios (Lupu et al., 2021) With the recent explosion of virtual tours (Njerekai, 2019), virtual platforms are becoming increasingly important as entertainment tools. Together to this, consumption of multimedia content is increasing globally and systematically generates new research questions in the tourism marketing and destination management fields (Palazzo et al., 2021)

The tourist destination image - hereinafter TDI - means a strategic effort for all tourism actors and has been researched intensively during the last decades. However, regarding its measurement, it is problematic when travellers subjectively assess it by means of surveys (Wullur & Sutapa, 2019). For this reason, this research that uses electroencephalography to obtain metric data directly from the subject's brain has to be understood as a methodological proposal, to reduce this subjective bias.

The TDI is a multidimensional construct consisting of cognitive and affective dimensions (Beerli-Palacio & Martín-Santana, 2017; Elliot & Papadopoulos, 2016; Hernández et al., 2016; Huete Alcocer & López Ruiz, 2019; Kani et al., 2017; M. Y. Lai et al., 2020; Marine-Roig & Anton Clavé, 2016) that has been developed under the prism of different definitions and formation models, and therefore allowing more than one interpretation (Garzón-Paredes & Royo-Vela, 2021). The findings suggest that greater conceptual work is required (Duignan, 2021) and the same can be said regarding TDI measurement methodologies and scales which shows to the researcher, perhaps because of the destination diversity, a wide set of methods and tools (Garzón-Paredes & Royo-Vela, 2021). In this sense, research on the TDI framework that use simultaneously virtual reality, multivariate analysis and neuroscience to investigate urban or rural cultural destinations, in which heritage is present, is scarce. According to (Kim et al., 2017), to understand relationship and effects between culture and tourism is an interesting and necessary research topic, however it has been little studied so far.

Since an important part of the tourist product can be culture, cultural tourism plays a fundamental role both in the attractiveness of destinations and its image (Huete-Alcocer et al., 2019). Thus, the contribution of cognitive and affective images to the image of a destination can be related to its local heritage. Intangible culture as well as the tangible culture such as historical and architectural heritage can increase the cognitive and emotional response to a destination and consequently, its image, its attractiveness and its competitiveness (Folgado-Fernández et al., 2017; George, 2017), it can be said that the cognitive and emotional components of the TDI can be studied through the historical, architectural, and cultural heritage of cities (Royo-Vela, 2009).

Therefore, the research is driven to identify and measure, through electroencephalography (Yulita et al., 2020), the impact of cultural and architectural heritage emulated by virtual reality on the mind of a tourist in the form of cognitive and emotional responses (Barrile et al., 2020) measured as brain waves (Rawnaque et al., 2020). Data obtained from a neuromarketing experiment and directly from the human brain is used to carry out an analysis using the partial least squares regression algorithm PLS, applying structural equation models; thus evaluating, the effects of the cultural and architectural heritage on the TDI. It is the general hypothesis of this research that the emotional and cognitive impact that architectural and cultural heritage has on the minds of tourists is intense and generates a positive image of the destination.

### 1.1. Literature review and hypotheses setting

**Use of virtual reality to investigate heritage**

The starting point of the presented research is the theory of destination marketing, in which the concept of destination branding is the key element that elements of nature and historical heritage are strongly present (Adamus-matuszyńska et al., 2021) a traveller has a mental image of a destination that could have unique characteristics, but there is also a common and public mental image of a destination (Obenour et al., 2005).- For this reason, the application of neuroscience and virtual reality constitutes a significant leap forward in the investigation of the destination image and the impact of heritage. According to Park and D. Njite (Park & Njite, 2010), also (Gholitabar et al., 2018), by linking tourism with virtual reality (Y. Li et al., 2021), heritage has a crucial socio-psychological dimension connected with national identity through experience attributes. There is a psychological mechanism influencing behaviour; its effects are significant due to the modality and navigability in the emotional and cognitive dimensions of virtual travel experience.

It is possible to group target image data, using hybrid techniques of artificial intelligence and evolutionary arithmetic algorithms. However, only with a broader understanding of relationships between virtual reality and the image of the destination, tourism opportunities will be better utilized. Virtual reality offers a variety of promising applications (Dogan & Kan, 2020; W. J. Lee & Kim, 2021; Lo & Cheng, 2020; Schott & Marshall, 2021; van Nuenen & Scarles, 2021) in areas ranging from administration to entertainment. It allows people to have virtual experiences similar to reality and perform various tasks by achieving predetermined objectives using simulated scenes (Hyun & O'Keefe, 2012; Streimikiene & Korneeva, 2020). The findings on the use of virtual reality allow improving the motor, functional, and cognitive performance of a person (Aminov et al., 2018; Gui, 2021). Using virtual reality can be exciting, fun, and increases motivation (de Rooij et al., 2016)

When the product is a destination, the creation of images is critical since the tourist cannot test the product before acquiring it. Virtual reality allows eliminating this restriction. Furthermore, virtual reality offers the ability to create alternative experiences that can be useful for heritage preservation (Mongelli et al., 2021) its use will continue to increase potentially, both in applications and importance; Researchers and professionals have an excellent opportunity to exploit virtual reality in this field (Guttentag, 2010).

It's interesting to investigate the behaviour of the tourist through stimuli that emulate a possible visit to a destination endowed with cultural heritage and thus evaluate the conceptions in the human mind. (Sirgy & Su, 2000) For this, it is possible to use the navigability advantages in a virtual travel experience. It is known from previous studies that virtual reality significantly influences the emotional and cognitive dimensions of the experience (Briciu et al., 2020; Choi et al., 2018) which facilitates the investigation of the concept. Due to technological advances, distance has lost its traditional role as a cognitive filter between the subject and the site, resulting in tourist cultural spaces becoming filled with images and icons. Tourist destinations are becoming compelled to overcome new challenges offered by virtual reality media.

The tourist Destination Image

Positive images of the destination after visits can satisfy important factors. (Andersson et al., 2021). Tourism is a multifaceted field and in order to understand its complexity (Chia et al., 2021) the tourist expectation has a positive and significant effect on destination attractiveness (Trimurti & Utama, 2021) the TDI construct, definition and formation has been widely (Sun et al., 2021) researched for more than 50 years (Gómez et al., 2018) regarding the formation model, also there is a large amount of scientific literature that has identified and measured antecedents, factors, constructs and consequences from various approaches, places, scales, constructs, structures and statistical techniques, mainly with the modelling of structural equations. See (Baloglu & Mccleary, 1999; Baloglu & McCleary, 1999; Asunción Beerli & Martín, 2004; Asunciòn Beerli & Martín, 2004; Bigné Alcañiz et al., 2009; Echtner & Ritchie, 1993; Esper & Rateike, 2010; Gallarza et al., 2001; Gartner, 1994; Govers et al., 2007; C.-K. Lee et al., 2005; Royo-Vela, 2005, 2009; Royo & Serarols, 2005; Tasci et al., 2007)

The literature is extensive, and it is still going; however, the TDI is consensually defined as mental impressions and perceptions that tourists have of a place (K. Lai & Li, 2016) as well as is an emotional response. According to Royo-Vela (2005), the TDI are cognitive and emotional responses towards a destination based on a cognitive-affective structure formed along the time by the individual. (Royo-Vela, 2005)

The image represents a simplification of many associations and pieces of information and emotion connected to the site (Domínguez-Azcue et al., 2021; Shi et al., 2021; Zaman & Aktan, 2021) they are the product of the mind trying to integrate cognition and emotion about a place, places which, by the way, are far from being similar. For this reason, the conceptualization and measurement of the destination image needs to fit the touristic destination (Royo-Vela, 2009).

According to (Garzón-Paredes & Royo-Vela, 2021; Royo-Vela, 2009) the destination image is of paramount importance for tourist destination management since it motivates the interest of tourists, their satisfaction, loyalty, or intention to behave. There are obvious differences in tourists' emotional response, knowledge and perception in terms of overall perception, tourist resources, environment perception, recreational status and tourism attraction management (Lin & Zhao, 2021). It is an ever-changing construct that can be classified according to the conscious control that a person has over a place, is a mental representation of knowledge, thoughts, emotions and general impression about a destination that consists of three components: cognitive image, affective image, and general image of the destination. (Fu & Timothy, 2021; Lindblom et al., 2018; Rosa et al., 2018; Skavronskaya et al., 2017; Stylidis et al., 2017; Sultan et al., 2021; Yap et al., 2018)

The image become part of the economy of self-representations online (Baumann, 2021) previous studies indicate that there is a hierarchical influence of the cognitive component on the image straight on and through the affective component as well as an effect of the affective component on the image. (Chiu et al., 2016) (Echtner & Ritchie, 1993) (Gartner, 1994) (Baloglu & McCleary, 1999) (Royo-Vela, 2005). That is, cognition is hierarchical above affect; therefore, from these results found in previous investigations, we can establish the first hypothesis:

H1: The virtual cognitive image (cognitive response) influences the virtual affective image (emotional response)

Before an image can influence behaviour, it is essential to understand how an image affects the viewer since a person's beliefs influence the attitude (Stylidis et al., 2021) towards the site. In this regard, previous causal links indicate that cognitive and emotional skills serve to attribute values and feelings to images (Ryan & Cave, 2005). Therefore, a key factor to consider is the emotional content as an expression of affective states. The emotional content of an image is linked to experience (T. T. Li et al., 2021) in situ and previous expectations, whereas cognitive assessment is related to visual effects. The perception of landscape elements is crucial to understand the role of visual elements. The cognitive image is a combination of information resources as well as capabilities and previous experiences, and the affective image is based on expectations, evaluations and experience in situ (Zhou, 2014) Accordingly, cognition and emotion are positively related to the image of a destination (Lindblom et al., 2018). In other words, environments and places produce cognitive and emotional responses on the traveller (Baloglu & Mccleary, 1999) Thus, the TDI is generated by tourists based on their cognitive and affective responses (Shafiee et al., 2016). Based on these research, hypotheses two and three are presented below:

H2: The virtual cognitive image (cognitive response) positively influences the image of the destination.

H3: The virtual emotional image (emotional response) positively influences the image of the destination.

## 2. Materials and Methods

### Participants

Neuromarketing is the execution of techniques that belong to neurosciences applied in the field of marketing (Aguiló-Lemoine et al., 2020; Garczarek-Bąk et al., 2021; Juárez-Varón et al., 2020; Mañas-Viniegra et al., 2021; Mansor & Isa, 2020; Nilashi et al., 2020), identifying responses to stimuli designed with specific objectives. These techniques are used to obtain accurate data on consumer reactions, optimising the management of market resources, and improving products and services. The primary function of the collection of responses to these stimuli is to investigate the behaviour and decision-making process of tourists.

The current investigation uses electroencephalography experimentation to collect brain wave data as responses to the stimulation of virtual reality in a sample of 25 people residing in Ecuador randomly selected between the ages of 21 and 60 years. Before the experiment, each participant has given written consent to sign, and they are informed that participation is optional and that they reserve the right to withdraw at any time (Gholami Doborjeh et al., 2018) tourists' perceived destination image positively enhances their behavioural, (Tavitiyaman et al., 2021) it´s important to mention that tourists did not previously know any of the evaluated destinations heritage.

**Materials and procedure**

The data collection procedure is performed in a physiology laboratory equipped with an electroencephalogram EEG (Aldayel et al., 2020); virtual reality (VR) goggles; a projector; headphones, and an iPhone 6 smartphone (see figures 1, 2 and 3). The phone is inserted into virtual reality device to project videos of tourist sites containing architectural heritage; additionally, a computer records all the data.

**Figure 1. Electrode placement and Electroencephalogram placement.**

**Figure 2. Smartphone in VR glasses and VR glasses.**

**Figure 3. Physiology laboratory, getting the waves.**

**Method-brain electromagnetic waves studied**

The information generated by the electroencephalogram (EEG) is complex (González-Morales et al., 2020); therefore, it should be organized in a way that facilitates visual analysis. The EEG has a series of oscillations that, given specific characteristics, are called rhythms. Its generation is due to a complex set of cellular and synaptic mechanisms that occur in the brain. The EEG is the graphic registry of rhythmic cerebral activity arranged in several timelines known as channels representing the areas of the brain where they were obtained. In other words, using electroencephalography equipment provides a record of rhythmic brain activity.

The oscillations produced on paper or digital registry are the results from the sum of the excitatory and inhibitory postsynaptic potentials. These signals are of low amplitude but can be analysed using a series of differential amplifiers.

Rhythmic activity is obtained through electrodes placed on the scalp and is electronically amplified. It generates a registry that enables visualization and analysis. A typical EEG record consists of several strokes arranged in horizontal lines. Each of these corresponds to a channel and the oscillations per unit of time (one second), to different rhythms or brain waves. Conventionally, the same method is used to place electrodes on human skulls; this system is known as the international 10-20 electrode placement system. Through this system, we ensure that the electrodes are placed on the same areas of the head.

The nomenclature uses uppercase letters and numerical subscripts. The frontal, central, temporal, parietal and occipital electrodes recognized with the characters: F, C, T, P and O respectively (see figure 4). The even subscript indicates the right hemisphere while the odd one the left hemisphere. For example, F3 refers to the left frontal electrode while T4 to the right temporal. Lastly, the channels are identified according to the electrodes that feed it.

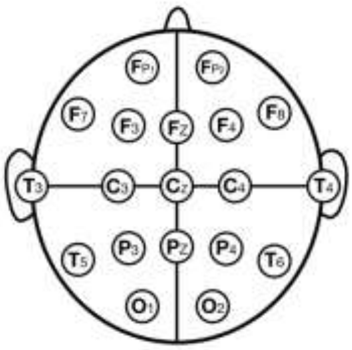


**Figure 4. International system 10-20**

To approve the hypotheses, wave amplitude must be high; that is, a stronger stimulus will produce a steeper wave.

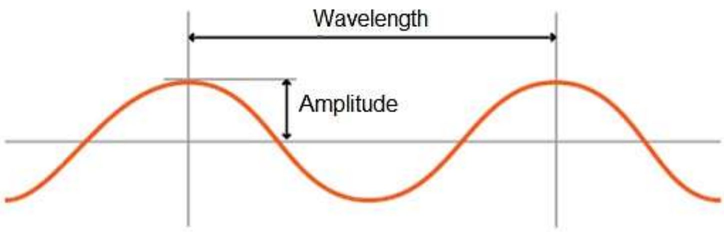

**Figure 5. Wave example.**

This experiment focuses on the investigation of alpha and beta waves, an important characteristic inherent to the behaviour of alpha activity, is the variation that is usually visible in its amplitude. The amplitude is variable with an increase and decrease of the amplitude measured peak to peak or from maximum positivity to maximum negativity (see figure 5). The term used to describe this phenomenon in literature is that of ‘waxing and waning’ or modulation. The alpha rhythm is the most critical finding to declare a subject as alert or awake. Alpha α waves are electromagnetic oscillations in the frequency range of 8-12 Hz.

Beta waves are in the frequency range of 12 to 30 Hz as a result of strong neuronal activity. These waves represent more complex brain activity related to states of awareness and focus. Frequency is the first step to identify a cerebral rhythm and classically; they are represented in characters of the Greek alphabet and expressed in cycles per second or Hertz (Hz). The electric brain waves: delta, theta, alpha, beta and gamma, coexist in the brain and vary in frequency according to the amount of electricity generated by a stimulus (see figure 6 and table 1). This makes it possible to break down the waves into high, medium or low frequencies; the more significant the impact achieved by the stimulus in a human, the more electricity will be generated in the brain and the higher the frequency recorded by the electroencephalography equipment.

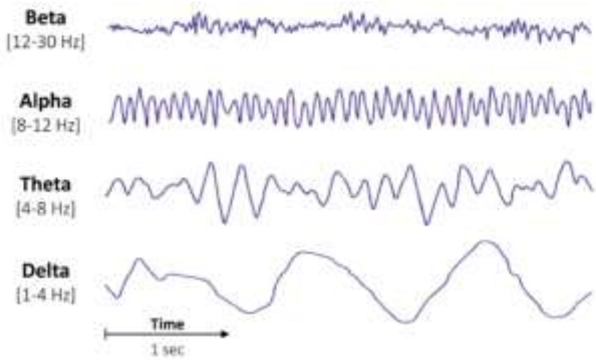


**Figure 6.** Beta, alpha, theta and delta waves.

**Table 1.** Types of brain wave frequencies captured by the electroencephalogram and their interpretation.

| **Name of the band** | **Frequency range [Hz]** | **Detail** |
|---|---|---|
| δ (delta) | 1 – 4 | Deep sleep |
| θ1 (theta low) | 4 – 6 | Relaxed |
| θ2 (theta high) | 6 – 8 | Imaginative relaxed |
| α1 (low alpha) | 8 – 10 | Break, but not sleep, |
| α2 (high alpha) | 10 – 12 | Relaxing, emotionally pleasant |
| β1 (low beta) | 12 – 18 | Relaxed, lax, even depressive. |

| | | |
|---|---|---|
| β2 (medium beta) | 18 – 22 | An optimal level of cognition these waves helps us to be much more receptive |
| β3 (high beta) | 22 – 30 | Intense |
| γ (gamma) | 30 – 40 | Challenging to grasp it in electroencephalograms, high cognitive processing, tension, stress, happiness, euphoria. |

**Obtaining the metric data**

Brain areas and frequency distribution are fundamental in identifying different brain rhythms correctly. The former implies that brain activity has a specific placement in different areas of the brain, and the latter displays rhythmic brain activity adopting various frequency bands. The electroencephalogram shows this information in timelines called channels. The combination of several channels and their respective sources create a register known as assembly, which averages the ranges of each type of wave to manage data and straightforwardly (see figure 7).

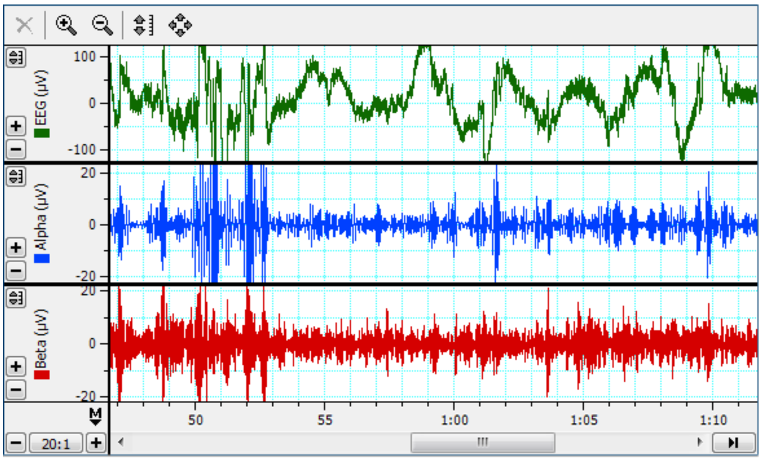


**Figure 7.** Image of the frequency waves taken from one of the participants in the experiment. A 29-year-old man.

It is important to work with the frequency distribution information to obtain the quantitative data and achieve the analysis in the structural equation model. Primarily the combinations of all channels are taken, alpha from 8Hz to 12Hz and beta from 12Hz to 30Hz (see table 3). Subsequently, two wave points from each range (alpha and beta) are randomly taken from the combined waveforms. Information is gathered in this manner to analyse the variables in the system of structural equations. These data are measured in Hertz (Hz symbol).

**Table 2. Measures the brain waves for each construct.**

| Construct | Name of the band | Frequency range [Hz] | Detail |
|---|---|---|---|
| | α1 (low alpha) | 8 – 10 | Break, but not sleep, |

| | | | |
|---|---|---|---|
| Affective imagen | α2 (high alpha) | 10 – 12 | Relaxing, emotionally pleasant |
| (Cognitive image) Cognitive imagen | β1 (low beta) | 12 – 18 | Relaxed, lax, even depressive. |
| | β2 (medium beta) | 18 – 22 | An optimal level of cognition these waves helps us to be much more receptive |
| | β3 (high beta) | 22 – 30 | Intense |

The structural model is composed of cognition (cognitive image), emotion (affective image) and image (global image), the beta points are associated with cognition, the alpha points, with emotion and, the general image is the result of a compound of cognition plus one of emotion; the construct is created with the sum of the average of the alpha and beta waves (see figure 8).

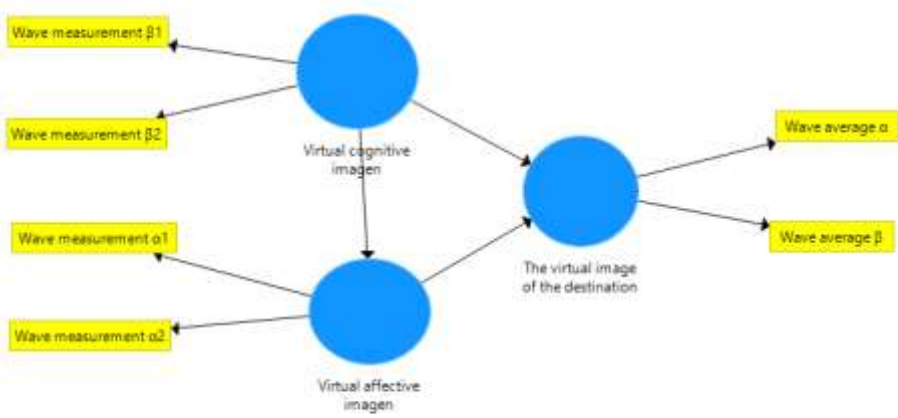


**Figure 8.** Structural model.

Variables α=Emotion
Variables β=Cognition

$$\bar{X}\alpha + \bar{X}\beta = \frac{\sum_{i=1}^{N} \propto}{N} + \frac{\sum_{i=1}^{N} \beta}{N} = \text{image}$$

In other words, the metric data of the observable variables in the structural model are taken directly from the participants' brains. They are associated with the constructs depending on what they represent for the human mind, and the general image is measured with the summation of the metric variables cognition plus emotion. α + β.

**The virtual reality multimedia stimulus**

The images perceived by visitors are fast, efficient, and convenient, (Zhang et al., 2021) we live in a multisensory world, our experiences are constructed by the stimulation of all our senses. Nevertheless, digital interactions are mainly based on audio-visual elements, while other sensory stimuli have been less explored. Virtual reality (VR) is a sensory-enabling technology that facilitates the integration of sensory inputs to enhance multisensory digital experiences (Flavián et al., 2021; Samah et al., 2021; Yuce et al., 2020) Technology may be important in customer satisfaction and must be explored and used to create a superior experience (Lakshmi & Ganesan, 2010). Brain activity and visual stimulation provided by virtual reality can be quantitatively studied to identify the impact of architectural and cultural heritage (ASSAS, 2020; Deng et al., 2020; Jung et al., 2020)

The tourist virtual destinations that were assessed in this experiment are detailed in table 3 with the respective projection times in the VR devices. All are in Spain.

**Table 3. Virtual destinations evaluated in the experiment.**

| **No.** | **Accumulated time** | | **Destination** |
|---|---|---|---|
| | Start | End | |
| 1 | 00:00 | 00:37 | Plaza de la Santa Cruz |
| 2 | 00:37 | 01:39 | Plaza Mayor of Madrid |
| 3 | 01:39 | 02:00 | Arco de Cuchilleros |
| 4 | 02:00 | 02:30 | Doors of the market of San Miguel |
| 5 | 02:30 | 03:01 | Street Mayor and church del Sacramento |
| 6 | 03:01 | 03:33 | Plaza de la Villa |
| 7 | 03:33 | 04:02 | Viaduct of Segovia |
| 8 | 04:02 | 04:33 | Temple of the Employer Madrileña |
| 9 | 04:33 | 04:59 | Plaza de la Armería |
| 10 | 04:59 | 05:23 | Solar of the Plaza de la Armería |
| 11 | 05:23 | 05:54 | Royal Palace of Madrid |
| 12 | 05:54 | 06:19 | Centre of the Plaza de East |
| 13 | 06:19 | 06:50 | Monastery of the Incarnation |
| 14 | 06:50 | 07:21 | Plaza de Ramales |
| 15 | 07:21 | 07:48 | Plazuela de Santiago |
| 16 | 07:48 | 08:15 | Castle of the Adrada |
| 17 | 08:15 | 09:15 | León |
| 18 | 09:15 | 10:15 | Casa Botín |
| 19 | 10:15 | 11:11 | Basilica of San Isidro |
| 20 | 11:11 | 12:08 | Cathedral of León |
| 21 | 12:08 | 13:06 | Plaza de la Paja |

**Structural equation modelling. PLS procedure, confirmatory path analysis, and data adequacy.**

In accordance with (Chin, 1998) The PLS procedure is designed to explain the variance - R2 - of the dependent construct, this procedure is robust in small and medium samples. In terms of the data, an initial concern is related to the sample size, depending on the number of relationships to be evaluated, the widely used empirical rule states that the total sample size is 10 times the greater of two possibilities 1) The block that has the largest number of indicators or 2) the dependent variable that is affected by the largest number of independent variables. In the present model, the first possibility is equal to 2 since the latent variables have two observable variables each, both the α variables and the β variables, and in the second possibility it is also equal to two, since the number of hypotheses that arrive at the dependent variable image is equal to 2. (Chin, 1998)

That means that the minimum size of the sample in this investigation is 2 x 10 = 20, however the sample under analysis contains 25 cases.

To implement the PLS technique, it is necessary to verify the adequacy of the data as well as the test power for the dependent variable - R2 -; For this, it is necessary (to evaluate the reflective model, the reliability of the indicator, the reliability of internal consistency, the convergent validity as well as the discriminant validity), It is also necessary to consider the formative evaluation of the internal model (endogenous constructs, the variance, the size of the effect, the relative predictive relevance of the indirect and total path as well as the coefficient of effect and significance) -. (Hair et al., 2012)

The processing data software is SMART-PLS. (Ávila & Moreno, 2007) the modelling of structural equations with partial least squares PLS-SEM is a method of multivariate analysis of the second generation that currently has a significant acceptance in the scientific community, mainly in the areas of social sciences and economics. Being a robust and flexible alternative, it allows working with estimates of simultaneous equations through multiple regressions. It aims to increase the explanatory capacity of the empirical verification of the theory, the development of computer programs has also contributed to its use.

In the configuration, a full Bootstrapping used with 5000 subsamples applied, in the bootstrap confidence interval method with correction of bias and acceleration (BCA). The type of two-tailed test, the significance level of 0.05, the schism of route weights (route), 5000 maximum interactions and the stop criterion (10 ^ -X) = 7.

The latent variables evaluated are cognition, emotion and image. The investigated model proposes that cognition is hierarchical to emotion and, in turn, these two constructions hierarchically influence the image of the destination.

According to the classification shown in table 2, the α waves, associated with emotion, are between 10Hz and 12Hz and the β waves, associated with cognition are between 22Hz and 30Hz. Outside this range, the impact is passive or very stressful. In other words, cognitive and emotional components structure the image of destination measured from brain waves, by the use of the electroencephalogram, four random metric data are taken as observable variables. Two points are for alpha emotion (α) and Two points for beta cognition (β). For the structural analysis in the smartPLS software, observable variables (points taken from brain waves) are associated with each latent variable.

Then the database is normalized with the following variables and equations (see table 4).

**Table 4.** Equation variables.

| Variable | Signified |
|---|---|
| ∝= | Alpha wave value |
| ∝normalized= | Normalized alpha value |
| ∝min = | The minimum value of alpha waves recorded by the EEG |
| ∝max = | The maximum value of alpha waves recorded by the EEG |
| β= | Beta wave value |
| βnormalized= | Normalized Beta value |
| Bmin = | The minimum value of beta waves recorded by the EEG |
| Bmax = | The maximum value of beta waves recorded by the EEG |
| X = | The minimum value of the normalized scale |
| Y = | The maximum value of the normalized scale |

$$\propto \text{normalized} = \left(\left(\frac{\propto - \propto \text{min}}{\propto \text{max} - \propto \text{min}}\right) \times \text{X}\right) \div \text{Y}$$

$$\beta\text{normalized} = \left(\left(\frac{\beta - \beta\text{min}}{\beta\text{max} - \beta\text{min}}\right) \times \text{X}\right) \div \text{Y}$$

## 6. Results

The implicit objective of this research is to demonstrate that an analysis PLS-SEM can be carried out with data obtained from brain electrical waves by applying neuroscience techniques to measure a stimulus, this fact has been proven. On the Pearson correlation coefficient (R2), a measure of linear relationship between two quantitative random variables, it can be said that the adjusted (R2), for the endogenous variable virtual image of the destination, the variable is 0.687, which means that 68% of the variance of this variable is explained by the model. (See figure 8)

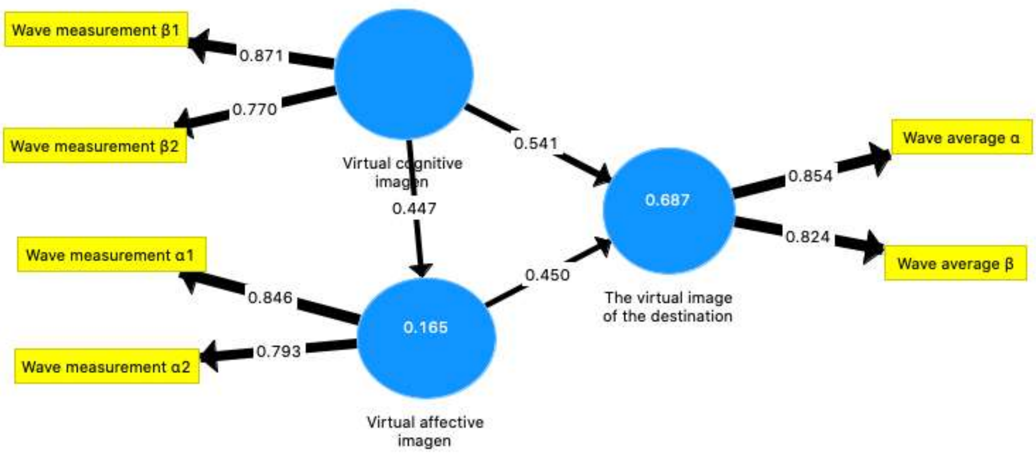


**Figure 8.** Structural model, the constructs show adjusted (R2).

The study shows that the emotional and cognitive impact of destinations endowed with historical architectural, cultural heritage, emulated with virtual reality, positively influence the image of the virtual destination.

Since the observable variables respond to completely interchangeable and correlated indicators, since they are taken from the same frequency waves of the brain, the model is reflective.

The structural model is composed of cognition (cognitive image), emotion (affective image) and image (global image), the beta points are associated with cognition, the alpha points, with emotion and, the general image is the result of a compound of cognition plus one of emotion; the construct is created with the sum of the average of the alpha and beta waves (see figure 9). The results of the discriminant or divergent validity analysis verified that the constructions determined in the model measure their concept and not the rest of the constructions. Below is a graph with the complete results of Bootstrapping.

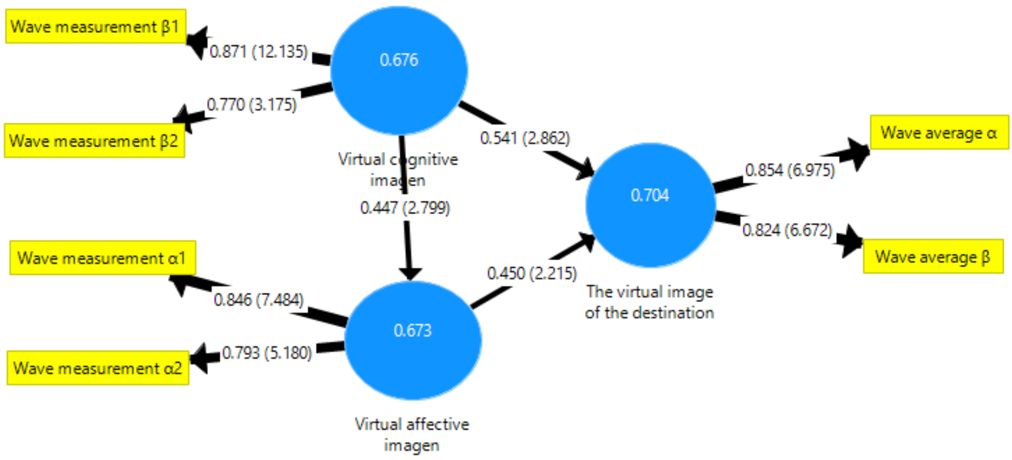


**Figure 9.** Structural model results.

The variance between the same constructs shows that they correlate more significantly with their same indicators than the others. The convergent reliability and validity analysis shows that the average extracted variance is> 0.5, which indicates that the construction explains more than half of its variation than the other composing indicators.

**Table 5.** Discriminant validity of the model.

| | | F1 | F2 | F3 |
|---|---|---|---|---|
| F1. | Virtual affective imagen | 0,820 | N/A | N/A |
| F2. | Virtual cognitive imagen | 0,447 | 0,822 | N/A |
| F3. | The virtual image of the destination | 0,692 | 0,742 | 0,839 |

**Table 6. Convergent reliability and validity of the measuring instrument used by the model.**

| Factor | Indicator | Load | Weight | P-Value | Value t | CR | AVE |
|---|---|---|---|---|---|---|---|
| F1. Virtual affective imagen | α1 | | 0,846 | 0,000 | 7,484 | | |
| | α2 | | 0,793 | 0,000 | 5,180 | 0,804 | 0,673 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| F2. Virtual cognitive imagen | β1 | | 0,871 | 0,000 | 12,135 | 0,806 | 0,676 |
| | β2 | | 0,770 | 0,002 | 3,175 | | |
| F3. The virtual image of the destination | X̄α | 0,854 | | 0,000 | 6,975 | 0,826 | 0,704 |
| | X̄β | 0,824 | | 0,000 | 6,672 | | |
| Note: CR = Compound Reliability; AVE = Average extracted variance | | | | | | | |

In composite reliability (CR), the indicator of all constructions is > 0.8, so they are acceptable. The values of t also are significant since having a value> 1.96; the average extracted variance is substantial >0.67 in all factors. The loads are significantly higher than 0.82, and the standardized factor weights are significantly greater than 0.77.

**Table 7.** Convergent reliability and validity of the measuring instrument used by the model.

| **Hypothesis** | | **Beta Standardized** | **P-Value** | **Value t (bootstrap)** |
|---|---|---|---|---|
| H1: | Virtual cognitive imagen --> Virtual affective imagen | 0,447 | 0,005 | 2,799 |
| H2: | Virtual cognitive imagen --> Virtual image of destination | 0,541 | 0,004 | 2,862 |
| H3: | Virtual affective imagen --> Virtual image of destination | 0,450 | 0,027 | 2,215 |

All hypotheses are favourable the t value is > 1.96. and P-values less than 0.05 The study shows that emotional and cognitive impact of a destination characterized by the heritage and emulated with virtual reality positively influences the image of the virtual destination. The positive emotional and cognitive impact of heritage on the virtual tourist is confirmed.

Regarding hypothesis number 1. H1: The virtual cognitive image (cognitive response) influences the virtual affective image (emotional response) the t value is 2,799 the P-Value is 0,005 and the beta standardized is 0,447; the values are favourable, for this reason, hypothesis No.1 is approved

About hypothesis number 2. H2: The virtual cognitive image (cognitive response) positively influences the image of the destination. the t value is 2,215 the P-Value is 0,027 and the beta standardized is 0,450; the values are also favourable; hypothesis No.2 is approved.

Regarding hypothesis number 3. H3: The virtual emotional image (emotional response) positively influences the image of the destination. the t value is 2,862 the P-Value is 0,004 and the beta standardized is 0,541; likewise, the values are also favourable and hypothesis No.3 is approved.

The model ratifies all quality indicators and approve the three hypotheses.

## 7. Conclusions

The findings suggest greater conceptual work, in this sense, research on the TDI framework that use simultaneously virtual reality, multivariate analysis and neuroscience to investigate urban or rural cultural destinations, in which heritage is present, is innovative.

Intangible culture, as well as, the tangible culture such as historical and architectural heritage can increase the cognitive and emotional response to a destination and consequently, its image, its attractiveness and its competitiveness, it can be stated through this study that that the cognitive and emotional components can be studied through the historical, architectural, and cultural heritage.

This research shows that it is possible to measure, the impact of the cultural and architectural heritage emulated with virtual reality, on the mind of a tourist, in the form of cognitive and emotional responses through brain bio-electric waves with the help of electroencephalography. Therefore, this article has sought to open a debate as a means to significantly evaluate several important developments in modern tourism communication.

The positive emotional and cognitive impact of heritage on the virtual tourist has been confirmed, as well as, that the model is possible, it was also discovered that brain waves can vary according to the stimulus design, which significantly affects the results in the multivariate analysis In other words, the brain's bioelectric waves can vary according to the importance that the subject gives to the stimulus, the stimuli can have specific objectives and their impact can be measured with the EEG.

It has been demonstrated that it is possible to measure TDI with neuroscience tools and techniques, since audio-visual stimuli can be analysed psych-physiologically by the impact they cause on brain bioelectric waves, thanks to this technique it was identified that virtual trips generate a favourable TDI in the virtual tourist.

## 8. Limitations

The limitations of the research can be focused on the design of stimulus and the data collection tools.

One factor that would improve the stimulus is to include manual interaction in the virtual reality stimulus through joysticks.

For data collection electroencephalogram tool can be improved, with state-of-the-art EEG equipment, even more specific information about the human brain's reactions to virtual reality stimuli can be identified, with this improvement, data can be accurately identified for studying the synchronization of electroencephalography equipment with virtual reality and determine at which moments in the video the stimulus increase, as well as the specific area of the brain that is activated. This idea can be combined with the design of specific stimuli, enhancing possible lines of research in the future.

## 8. Future lines of research

Deconstruction of the model is proposed analysing hypotheses from other perspectives, for example, when the virtual emotional image is hierarchical to the virtual cognitive image and the virtual destination image. Another possibility is to analyse the virtual cognitive image and the virtual emotional image, influencing in parallel the image of the virtual destination.

Familiarity is another topic that can also be investigated in the future using two samples to compare brain waves as well as structural equation models; one sample may be familiar with the location and the other not.

In this study virtual reality videos are used considering that the main attraction is heritage and not multimedia production, the videos principally show heritage infrastructures without any other specific objective in stimulation design, therefore, a potential line of future research is the design and analysis of virtual reality videos with more specific communication and stimulation objectives. A hypothesis to be investigated in the future is that brain waves increase if the stimulus is better, leading to favourable results in the modelling of structural equations.

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