



## Applying Fuzzy AHP to Evaluate the Impact of Virtual Reality Technology on Tourists' Behavioral Intentions

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### Abstract

This study aimed to examine and quantify the importance of virtual reality (VR) technology factors on tourists' behavioral intentions using fuzzy hierarchy analysis (FAHP). Based on the integration of foundational theories, including Presence Theory (Steuer, 1992), Flow Theory (Csikszentmihalyi, 1990), and Customer Experience Theory (Schmitt, 1999), it aimed to determine the influence of VR on tourists' behavioral intentions through five variables: Presence, Authenticity, Immersion, Focus, and Interaction. The questionnaire was constructed using the FAHP methodology, featuring comparative linguistic variables, and distributed to 15 experts, including tourism professionals, university lecturers, scientists with experience in researching tourist behavior, and representatives of businesses and tourist destinations in Vietnam. The survey data were processed using the FAHP method to determine the weights. Research results indicate that the factor "presence" has the highest weight (BNP = 0.39), playing a leading role in deciding tourists' behavioral intentions. The remaining factors are "authenticity", "vividness", "interaction", and finally "focus", in order of decreasing weights. Based on these results, the study offers several significant implications for destination managers and businesses developing smart tourism.

**Keywords:** Behavioral intention, FAHP methodology, Tourists, Virtual reality.

### 1. Introduction

Currently, in the context of Industry 4.0, the global tourism industry is undergoing a strong shift from traditional models to smart tourism models. Advanced technologies, such as AI, Big Data, and virtual reality (VR), are becoming key to the competitive advantage of travel companies. VR allows users to experience destinations beyond spatial and temporal barriers before deciding to visit.

Previous studies have acknowledged that subjective perception plays a central role in behavior. Specifically, both the Theory of Planned Behavior (Ajzen, 1991) and the Technology Acceptance Model (Davis, 1989) agree that human behavior is not random but rather a process of rational calculation. Theories of experience, such as Flow Theory (Csikszentmihalyi, 1990) and Presence Theory (Steuer, J., 1992), also agree that VR experiences are only successful when they truly impact the user's perception. The Technology Acceptance Model (TAM) (Davis, 1989) considers "usefulness" and "ease of use" as the main factors influencing decisions. Meanwhile, the Theory of Planned Behavior (TPB) (Ajzen, 1991) emphasizes "attitude" and "perceived control" as central factors influencing visitor behavior. Flow Theory (Csikszentmihalyi, 1990) suggests that in an experiential environment, purely functional elements are not considered the deciding factors; rather, immersion and challenge create a sense of exhilaration. Presence Theory (Steuer, 1992) also discusses that in a virtual environment, the authenticity of information is less important than the feeling of "being present" there. Recent research (Wei, 2019) has identified factors influencing visitor behavior in VR that must certainly include both functional convenience and emotional uplift. According to Customer Experience Theory (Schmitt, 1999), originating from the concept of "Experience Economy" by Pine and Gilmore (1998) and expanded by Schmitt (1999), this theory asserts that perceived value comes not only from product attributes but is primarily created from the total of cognitive, emotional, and sensory interactions.

Based on the problems posed, this study integrates foundational theories, including Presence Theory (Steuer, 1992), Flow Theory (Csikszentmihalyi, 1990), and Customer Experience Theory (Schmitt, 1999) to determine the influence of VR on the behavioral intentions of tourists. To assess importance and priority, the study used fuzzy hierarchy analysis (FAHP). This is an optimal method to address the methodological gap of previous studies, thanks to its ability to "softly" handle datasets with the "ambiguity" inherent in human thinking. This study aims

to examine and quantify the importance of VR factors influencing the tourists' behavioral intentions, thereby accurately determining the priority order of these factors to provide a basis for management decisions.

## **2. Overview of Research Theory and Construction of the Hierarchical Matrix**

### *2.1. Related Theories*

#### *2.1.1. Presence Theory*

Presence Theory (Steuer, 1992) originated from research on communication and immersive technology. Within the theory, the author introduced the concept of "telepresence" to describe the ability of technology to create the feeling of a human "being present" in a simulated space. This approach was later developed by Lombard and Ditton (1997) into the concept of "sense of presence," emphasizing the subjective experience when individuals perceive the environment mediated by technology as a real space. Presence is not simply a technical attribute but the result of the interaction between technology and the user's cognitive process (Wirth et al., 2007).

Presence Theory suggests that when technology creates a high level of presence, users tend to focus their attention on the virtual environment and reduce their awareness of the surrounding physical context (Witmer & Singer, 1998). In tourism research, Presence Theory is applied to explain how virtual reality technology helps tourists visualize destinations visually, thereby improving perception and promoting behavioral intentions (Tussyadiah et al., 2018). According to Slater (2003), presence is also subjective and intersects with concepts such as immersion or flow. Therefore, this theory needs to be combined with other approaches to enhance its explanatory value for tourists' behavioral intentions.

#### *2.1.2. Customer Experience Theory*

Customer Experience Theory originates from a shift in marketing thinking, with its theoretical foundation laid by Pine and Gilmore (1998) through the concept of Experience Economy, and expanded upon by Schmitt (1999) in his research on experiential marketing. According to this perspective, the perceived value of a customer does not only come from the function of a product or service, but is primarily created from the total of experiences that customers accumulate during interaction, including cognitive, emotional, and sensory elements.

A central focus of Customer Experience Theory is the role of sensory stimuli in shaping positive experiences (Brakus et al., 2009). According to Steuer (1992), in the context of virtual reality technology, vividness becomes a key factor reflecting the quality of the experience, expressed through the clarity, attractiveness, and realism of images, sounds, and simulated spaces. According to Tussyadiah et al. (2018), VR experiences with a high level of dynamism help tourists easily form a positive first impression of the destination, thereby increasing their enjoyment and behavioral intentions. The dynamism scale is often used to measure the richness of sensory stimulation and the perceived attractiveness of the experience (Yim et al., 2017). However, because customer experiences are multidimensional and strongly dependent on individual perceptions, the measurement lacks standardization (Lemon & Verhoef, 2016) and does not fully explain the cognitive and social factors influencing behavior.

#### *2.1.3. Flow Theory*

Flow Theory (Csikszentmihalyi, 1990) proposes to describe the optimal psychological state when an individual engages in an activity with a high level of concentration, feels intrinsic interest, and is minimally influenced by external factors. The state of flow emerges when the level of challenge in an activity matches the participant's ability, creating a sense of control and seamlessness in the experience.

In Flow Theory, focus is considered a core component reflecting the level of attention an individual devotes to an ongoing activity (Csikszentmihalyi, 1990). In a technological environment, especially in virtual reality experiences, factors such as high interactivity, instant feedback, and appropriate experience design can enhance focus, thereby promoting the state of flow (Hoffman & Novak, 2009). Applied to tourism research, this theory helps explain how engaging VR experiences can capture the attention of tourists, increasing positive emotions and influencing future behavioral intentions (Skadberg & Kimmel, 2004). Based on this, the focus scale is often used as an important indicator to reflect the level of flow in digital experiences (Yim et al., 2017). However, because flow is a temporary psychological state strongly influenced by context and individual characteristics, measurement remains challenging (Nakamura & Csikszentmihalyi, 2014). According to Zhou (2012), this theory mainly focuses on individual experiences without fully considering social factors.

### *2.2. Virtual Reality Technology and Tourist Behavioral Intentions*

#### *2.2.1. Virtual Reality Technology*

Virtual Reality (VR) is a technological platform that allows the creation of a three-dimensional simulated environment in which users can interact and experience in real time. Essentially, VR is not only defined by hardware but primarily by the psychological state of "telepresence," which is the feeling that the user exists in a virtual environment instead of a physical space (Steuer, 1992). The structure of VR is formed from three core attributes: immersion, interactivity, and the ability to stimulate imagination, also known as the three I models (Burdea & Coiffet, 2003), where immersion helps focus the perception on the virtual space and interactivity allows the user to actively navigate the experience. In the tourism sector, VR has become a strategic marketing tool, providing a "pre-purchase experience" mechanism, contributing to minimizing the intangibility and perceived risk of tourism products, while supporting tourists in forming initial perceptions and emotions during the decision-making process (Hobson & Williams, 1995; Guttentag, 2010; Huang et al., 2016).

#### *2.2.2. Tourist Behavioral Intentions*

According to the Theory of Planned Behavior (TPB), behavioral intention is the most direct predictor of actual behavior, reflecting an individual's readiness to perform a specific action (Ajzen, 1991). In tourism research, behavioral intentions are often measured through the desire to visit a destination and positive word-of-mouth

intentions, which respectively reflect the desire to take a trip and the tendency to recommend the destination to the community (Zeithaml et al., 1996). From the perspective of the Stimulus-Body-Response (S-O-R) model, the virtual reality environment acts as a stimulus, impacting the internal psychological state of tourists, such as the sense of presence and positive emotions, thereby promoting behavioral responses in the form of intention to visit and spread information (Mehrabian & Russell, 1974; Kim et al., 2020). Empirical evidence shows that high levels of immersion and interaction in VR experiences positively influence tourists' behavioral intentions, confirming the role of technology as a crucial lever in shaping tourism consumer behavior.

### *2.3. Constructing a Hierarchical Matrix of the Influence of Virtual Reality Technology on Tourist Behavioral Intentions*

Based on the exploration, approach, discussion, and inheritance of foundational theories related to VR, the study chose an integrated approach combining three theories: Presence Theory (Steuer, 1992), Flow Theory (Csikszentmihalyi, 1990), and Customer Experience Theory (Schmitt, 1999) to determine the influence of VR on tourist behavioral intentions, including: presence, authenticity, dynamism, focus, and interaction.

#### *2.3.1. Firstly, the Influence of Presence on Tourists' Behavioral Intentions*

According to Presence Theory (Steuer, 1992), "telepresence" is defined as the experience of being present in a different environment through media, in which users feel as if they are existing in a technologically transmitted environment rather than their real surroundings (Kim & Biocca, 1997). According to research by Yim et al. (2013), "telepresence" allows users to fully or partially immerse themselves in the environment created by virtual reality technology, leading to heightened concentration and better cognitive absorption (R. Agarwal and E. Karahanna, 2000). Thanks to this realistic sense of presence, users react and experience activities in the virtual environment exactly as in the real environment, Slater (1999) noted, thereby stimulating interest and promoting the intention to experience reality in the future.

#### *2.3.2. Secondly, The Influence of Authenticity on Tourists' Behavioral Intentions.*

Pine and Gilmore (2007) defined authenticity as a perception of experiences, services, or products that are perceived as novel, real, original, special, or unique. In this context, VR spaces need to be designed authentically, closely recreating the real-world context to create a sense of "being present." Simultaneously, images and sounds in the virtual environment must appear natural, consistent, and harmoniously coordinated with lighting to suit the senses, thereby enhancing the perception of continuity, logic, and increasing expectations and future behavioral intentions (Tussyadiah et al., 2018; Beck et al., 2019).

#### *2.3.3. Thirdly, The Influence of Vividness on Tourists' Behavioral Intentions*

According to Kim and Ho (2019), videos and images with vividness and high sharpness are one of the main factors driving customer behavior. It is perceived to influence the assessment of image quality as well as the feeling of realism in consumers when in a VR environment. Research by Wu and Lai (2022) shows that the rich information and images provided by VR also significantly impact customer attitudes and behavior. The diversity of contexts, details, images, and colors stimulates human thinking, making them believe that the real-life experience will be similar, thereby positively influencing future intentions.

#### *2.3.4. Fourth, The Influence of Concentration on the Behavioral Intentions of Tourists.*

Stephen Kaplan and Rachel Kaplan (1980) showed that VR is an environment capable of passively attracting attention without effort, known as enchantment. It allows for rest and sustained attention without requiring excessive awareness. VR creates a safe space for the mind, eliminating distractions from the external environment, allowing consumers to use their full awareness for the VR experience (Charbonneau et al., 2021). According to research by Csikszentmihalyi (1985) and the legacy of Novak et al. (2003), it is demonstrated that when a person is fully focused, they lose their sense of time, and a high level of concentration positively influences the intention to return.

#### *2.3.5. Fifth, the Influence of Multisensory Interaction on the Behavioral Intentions of Tourists*

According to Yim et al. (2017), interaction is measured in many aspects, but almost all aim at empowering users. People can decide for themselves the viewing direction, what information is displayed, colors, sounds, etc. According to Steuer (1992), control is a core element in creating interaction, helping people adjust the content. Information received in sequence not only increases the personalized experience but also reduces cognitive overload and positively influences consumer behavior (Jiang & Benbasat, 2007). VR's ability to quickly and effectively meet specific consumer needs is also demonstrated in the research of Yim et al. (2017).

Based on the hypotheses formulated, the hierarchical model is defined as follows:

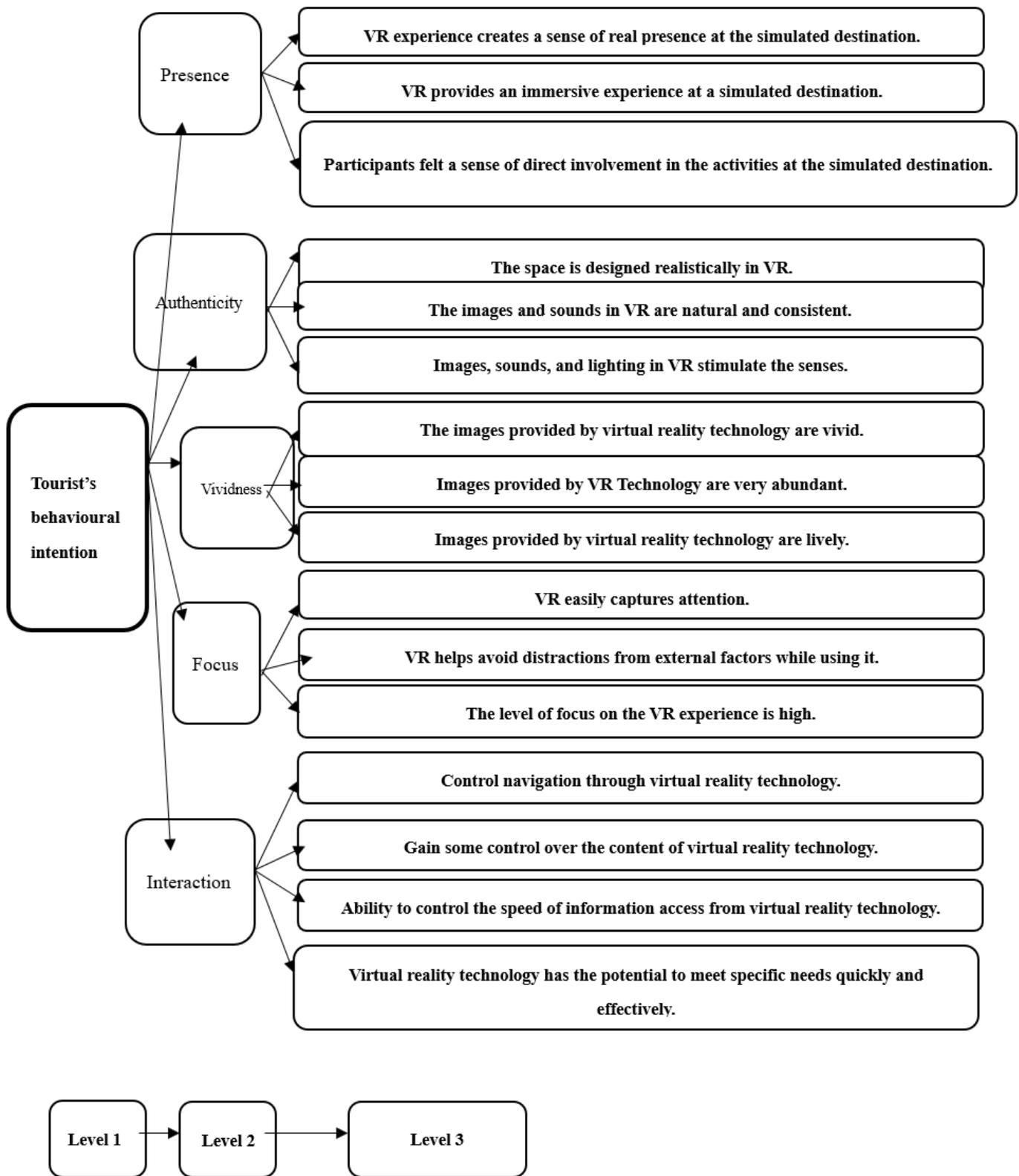


Figure 1. Hierarchical model of factors influencing the behavioral intentions of tourists by virtual reality technology.

### 3. Research Methodology

#### 3.1. Data Collection

To obtain data for evaluating the impact of virtual reality technology on the behavioral intentions of tourists, the authors conducted a survey using a methodology involving 15 experts, including professionals in the tourism field, university lecturers, scientists with experience researching tourist behavior, and representatives of businesses and tourist destinations in Vietnam. The survey method used in the study involved a questionnaire designed based on the FAHP method with comparative linguistic variables. Specifically, the questionnaire comparing the priority level of each pair of criteria in determining the factors influencing the behavioral intentions of tourists using virtual reality technology was established based on a nine-point scale, and the questionnaire determining the impact of virtual reality technology on the behavioral intentions of tourists was based on a five-point scale.

#### 3.2. Data Processing and Analysis

The collected data will be analyzed using the Fuzzy AHP model.

The implementation steps are as follows:

Step 1: Construct a pairwise comparison matrix based on expert opinions.

Research and construct a hierarchical structure and compare criteria using a fuzzy scale to build a pairwise comparison matrix:

$$\tilde{A}^k = \begin{bmatrix} \tilde{a}_{11}^k & \tilde{a}_{12}^k & \dots & \tilde{a}_{1n}^k \\ \tilde{a}_{21}^k & \tilde{a}_{22}^k & \dots & \tilde{a}_{2n}^k \\ \dots & \dots & \dots & \dots \\ \tilde{a}_{m1}^k & \tilde{a}_{m2}^k & \dots & \tilde{a}_{mn}^k \end{bmatrix}$$

$$\tilde{a}_{ij} = (\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \dots \otimes \tilde{a}_{ij}^{10})$$

In which, ij is considered the fuzzy comparison value between criterion i and factor j (i and j take values from 1 to n and i ≠ j). Accordingly, the new pairwise comparison matrix is obtained as follows:

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \dots & \tilde{a}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{a}_{m1} & \tilde{a}_{m2} & \dots & \tilde{a}_{mn} \end{bmatrix}$$

Step 2: Determine the fuzzy geometric mean and fuzzy weights. According to Hsieh et al. (2004), the fuzzy geometric mean and fuzzy weight of each criterion are determined by the formula:

$$i = (i_1 \otimes \dots \otimes i_j \otimes \dots \otimes i_n) / n \quad i = 1 \otimes [1 \oplus \dots \oplus \dots \oplus]^{-1}$$

i is the geometric mean of the fuzzy comparison between criterion i and the remaining criteria; i is the fuzzy weight of the i-th criterion.

Step 3: Defuzzification. Find the center of area (COA) values to optimally find the weights of the criteria using the BNP (best nonfuzzy performance) index as follows:

$$BNP = \frac{[(U_{wi} - L_{wi}) + (M_{wi} - L_{wi})]}{3} + L_{wi}$$

Step 4: Measure the consistency of the matrix. Use the Consistency Ratio (CR) of the data according to the following formula:

C.R. =(C.I./R.I) (To achieve consistency, the CR ratio must be less than 10%)

Where: CI is the Consistency Index, calculated as follows:

C.I. = (λmax-n) / (n-1) λmax is the eigenvalue of the comparison matrix; n is the number of factors

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n (AW)_i / w_i$$

RI is the Random Index.

### 4. Research Results

Virtual Reality (VR) is establishing a central position within the digital transformation of Vietnam’s tourism sector, widely adopted to maximize the promotional impact and the visitor experience. For some real-world examples, such as the Amazing Ha Long project, Hoi An Metaverse, and Can Tho’s digitization, have realized the pre-trip experience. This not only broadens the service landscape but also alleviates pressure on physical and natural resources. Even though there are still many infrastructure limitations, VR is acknowledged as a key driver to shape the smart tourism paradigm and enhance destination competitiveness.

After gathering survey results from 15 experts, the data are aggregated, categorized, and computed using the geometric mean method. The pairwise comparison matrix of factors within the hierarchical structure of VR’s influence on tourists’ behavioral intention is presented as the following table:

**Table 1.** Evaluation matrix of VR factors affecting tourists’ behavioral intention.

	PR			AU			LI			FO			IT		
PR	1.00	1.00	1.00	1.37	1.71	2.08	2.21	2.72	3.26	2.66	3.35	4.08	2.04	2.52	3.05
AU	0.48	0.59	0.73	1.00	1.00	1.00	1.48	1.85	2.29	1.71	2.23	2.76	1.35	1.67	2.02
LI	0.31	0.37	0.45	0.44	0.54	0.67	1.00	1.00	1.00	1.14	1.43	1.78	0.87	1.06	1.34
FO	0.25	0.30	0.38	0.36	0.45	0.58	0.56	0.70	0.88	1.00	1.00	1.00	0.76	0.95	1.19
IT	0.33	0.40	0.49	0.49	0.60	0.74	0.75	0.94	1.16	0.84	1.05	1.31	1.00	1.00	1.00

Based on the results from Table 1 regarding the evaluation of priority VR factors influencing tourists’ behavioral intention, the research team went on to assess the fuzzy geometric means and fuzzy weights for these five factors. The COA method was used to calculate these values and BNP indices for each criterion. The specific results are detailed below:

**Table 2.** Measurement results of fuzzy geometric means, fuzzy weights, and BNP indices.

	r			w			BNP
PR	1.75	2.08	2.43	0.27	0.37	0.52	0.39
AU	1.10	1.32	1.56	0.17	0.24	0.33	0.25
LI	0.67	0.79	0.94	0.10	0.14	0.20	0.15
FO	0.52	0.62	0.74	0.08	0.11	0.16	0.12
IT	0.63	0.75	0.89	0.10	0.13	0.19	0.14

After receiving the defuzzified weights via the BNP index, we proceeded to normalize them. The resulting defuzzification and normalized matrices are displayed below:

**Table 3.** Defuzzification matrix.

	<b>PR</b>	<b>AU</b>	<b>LI</b>	<b>FO</b>	<b>IT</b>
PR	1.00	1.72	2.72	3.36	2.53
AU	0.60	1.00	1.87	2.23	1.68
LI	0.37	0.55	1.00	1.44	1.08
FO	0.30	0.46	0.71	1.00	0.97
IT	0.40	0.61	0.95	1.06	1.00
	2.68	4.33	7.25	9.10	7.26

**Table 4.** Normalized matrix.

	<b>PR</b>	<b>AU</b>	<b>LI</b>	<b>FO</b>	<b>IT</b>	<b>Geometric Mean</b>
PR	0.37	0.40	0.38	0.37	0.35	0.37
AU	0.22	0.23	0.26	0.25	0.23	0.24
LI	0.14	0.13	0.14	0.16	0.15	0.14
FO	0.11	0.11	0.10	0.11	0.13	0.11
IT	0.15	0.14	0.13	0.12	0.14	0.14

Calculating the consistency coefficient based on the formula in Step 4, we obtained the following values:  $\lambda = 5.06$ ;  $CI = 0.09 \Rightarrow$  with  $n=5 \Rightarrow RI = 1.12$ ;  $CR = CI/RI = 0.01$ . Since  $CR < 0.1$ , the data meet the requirements for consistency and objectivity as established by Saaty (1980)..

Once the weights ( $\tilde{w}$ ); BNP values; and geometric means for each factor were calculated, and the final ranking of factors was shown in Table 5:

**Table 5.** Ranking of VR's influence on tourists' behavioral intention.

<b>Factor</b>	<b>BNP Value</b>	<b>Geometric Mean (GM) - Mean</b>	<b>Ranking</b>
PR	0.39	0.37	1
AU	0.25	0.24	2
LI	0.15	0.14	3
FO	0.12	0.11	5
IT	0.14	0.14	4

Table 5 detailed the BNP weights and geometric mean the BNP and geometric mean weights for the five VR factors within the research model to determine the hierarchy of VR factors affecting tourist behavior. Based on expert consensus, the priority ranking is established in the following order:

On top of the list is "Presence", this factor possesses the highest BNP value(  $BNP = 0.39$ ;  $GM = 0.37$ )

The second place belongs to "Authenticity"; this factor holds the second-highest BNP value( $BNP = 0.25$ ;  $GM = 0.24$ ).

Ranked third is the "Vividness", showing the third-highest BNP value ( $BNP = 0.15$ ;  $GM = 0.14$ ).

Occupying the fourth position is "Interactivity" with the fourth-highest BNP value ( $BNP = 0.14$ ;  $GM = 0.14$ ).

Rounding out the list, the " Focus" factor (FO), which holds the lowest BNP value ( $BNP = 0.12$ ;  $GM = 0.11$ ).

### 5. Conclusion and Implications

The research results demonstrate that all five investigated factors significantly influence tourists' behavioral intention, ranked hierarchically as follows: Presence, Authenticity, Vividness, Interactivity, and Focus. Through this study, a deeper insight has been gained regarding the drivers and the impact of these factors on tourists' behavioral intention. These factors shed light on tourists' behavioral intention to convert from a Virtual Reality (VR) experience to actual tourism.

The research findings highlight that understanding the factors influencing tourists' behavioral intention holds significant importance for tourism stakeholders. By analyzing the priority ranking of the factors - Presence, Authenticity, Vividness, Interactivity, and Focus - managers can utilize these results to evaluate the effects of these factors on tourists' behavioral intention.

As one of the pioneering works utilizing the FAHP method to investigate tourists' behavioral intention, this research offers unique insights. Based on the findings, several key implications are suggested below:

First, managers must pay special attention to creating "Presence" through investment in the development of modern hardware and software technologies. It is necessary to optimize the virtual environment to reduce the gap between the real and the virtual, thereby enabling tourists to feel as though they are truly "standing at" the destination, rather than merely observing through a screen.

Second, the displayed content needs to accurately and truthfully reflect the historical, cultural, and landscape values of the destination. The construction of the digital database must be based on actual prototypes to ensure "Authenticity" and build trust, thereby motivating tourists to transition from the virtual experience to actual visitation behavior.

Third, it is essential to apply the latest scientific and technical achievements in graphics and audio to generate high-resolution image quality, low latency, and multi-dimensional sound that strongly stimulate tourists' senses during the experience. This renders the tourist experience truly vivid and memorable.

Fourth, the development of virtual interactive features during VR usage should be promoted. Instead of allowing tourists to receive information passively, scenarios should be constructed that enable users to actively control their viewing angles, navigate within the virtual space, or interact directly with digital objects, thereby increasing interest and engagement with the destination.

Fifth, user experience design must be optimized to maintain "Focus" by constructing a seamless experience flow and removing disruptions such as technical errors or inappropriate advertisements. This allows tourists to reach a flow state and become fully immersed in the experience.

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