Research article

Beyond borders: The transcendent effect of Korean celebrity credibility on brand perceptions among Malaysian youth - A necessary condition analysis

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A B S T R A C T

In recent decades, the Korean Wave has surged as a global cultural force, captivating audiences across diverse geographical, cultural and linguistic landscapes, particularly in Asia—including Malaysia. To contribute to knowledge on this dynamic cultural phenomenon, this paper introduces a new analytical approach known as necessary condition analysis (NCA). The study initially investigates how a celebrity's credibility, encompassing attributes such as attractiveness, expertise and trustworthiness, alongside consumer self-satisfaction, influences perceptions of the endorsed brand image. Furthermore, the research aims to pinpoint the essential factors shaping a celebrity's credibility and their impact on consumer perceptions. An online survey was conducted with 100 young Malaysian consumers, and their responses were examined using partial least squares structural equation modelling (PLS-SEM). The results indicate that credibility traits such as expertise and self-satisfaction significantly enhance perceptions of the endorsed brand. Additionally, NCA underscores the pivotal role of credibility traits (including expertise, trustworthiness and attractiveness) and self-satisfaction in shaping brand image. Notably, both self-satisfaction and expertise emerge as critical and substantial conditions influencing consumer perceptions. Conversely, whilst attractiveness and trustworthiness are not individually impactful on brand image, they are identified as necessary conditions for the outcomes. This study underscores the strategic importance of Korean celebrity endorsements in refining marketing and promotional strategies across diverse industries, leveraging the influential power of the Korean Wave in global consumer markets.

1. Introduction

The Korean Wave, also known as *Hallyu*, represents a cultural phenomenon originating from South Korean popular culture. It encompasses four primary categories, namely Korean drama (K-drama), Korean pop music (K-pop), Korean culture (K-culture) and Korean style (K-style) [1]. Over the past few decades, the Korean Wave has burgeoned into a global cultural phenomenon, captivating the imaginations of individuals across diverse geographic, cultural and linguistic landscapes, especially in Asia—including Malaysia [1]. According to a survey conducted by the Korean Foundation for Cultural Exchange, interest in Korean cultural content has expanded beyond just K-pop and K-drama. This interest spans a wide array of activities, such as music, TV drama, entertainment programmes, tourism, cuisine, the Korean language, beauty, literature, e-sports, traditional culture, webtoons, Taekwondo, animation and general *Hallyu* [2]. The survey also revealed significant growth in *Hallyu* communities, with an increase of 35 million from 121 million in 2020 to 156 million in 2021, with this trend persisting to reach 178 million in 2022 [3]. Despite the suspension of many K-pop performances due to the COVID-19 pandemic, the overall number of *Hallyu* communities in 2022 witnessed a 15 % surge when

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compared to the previous year [3].

As the landscape of *Hallyu* content evolved, the character of these fan communities transformed in tandem. Furthermore, the rise of artists forming new fan bases across diverse genres such as K-pop, K-drama and Korean cinema appears to be a driving force behind the expansion of community numbers and membership [3]. For instance, whilst established K-pop fandoms revolved around communities dedicated to specific groups such as BTS or BLACKPINK, new communities have also emerged around rising solo artists. Notably, the global influence of these K-pop idols and celebrities has gradually impacted the behaviour of Malaysian youth. The 2022 Survey on Overseas *Hallyu* Status [3] indicated that over 90 % of Malaysian respondents showed sustained or increased interest in Korean cultural content and a willingness to spend money on Korean products in the future, thus underscoring Malaysia's significant engagement with the *Hallyu* phenomenon. Young Malaysians find themselves emulating the trends set by their idols and expressing their admiration by imitating their lifestyles. This emulation can extend to various aspects, including skin care [4], cosmetic and beauty products [5], fashion, Korean automobiles, tourism (i.e. medical tourism), electronic gadgets and digital products [6].

Notably, the content associated with the Korean Wave significantly shapes the perception of Korea among foreigners [7]. The enhanced national brand value of Korea is intricately connected to the promotion of Korean product purchases abroad. When consumers perceive a brand as trustworthy and believe it can uphold its promises, it elevates its trustworthiness and fosters a deeper affective commitment. This trust in the brand legitimises consumers' positive feelings and their dependence on the brand [8,9]. The increasing popularity of the K-wave plays a pivotal role in influencing marketers' preferences for engaging Korean celebrities as brand endorsers. Korean celebrities are not only attractive but also immensely appealing to their target audiences. Their television presence wields the power to significantly impact the behaviours of their viewers, particularly young individuals who tend to emulate and replicate the actions of others [10].

The unwavering support from fans fosters the success of commercial partnerships between K-celebrities and companies, thereby contributing to enhanced product sales. An exemplary case in point is a partnership with BTS, which was the first Asian artist group to collaborate with McDonald's for a limited-edition set menu available worldwide, including Malaysia [11]. This partnership triggered remarkable responses from both fans and non-fans who willingly queued up in long lines and waited patiently on the launch day. Another notable example in Malaysia is the brand Milo, which enlisted the endorsement of a Korean star, Park Seo Joon, in a television commercial for their chocolate-flavoured malt drink [12]. Love and support from fans resulted in the rapid depletion of promotional tote bags and Milo packets within a single day, ultimately leading to temporary supply shortages.

The utilisation of celebrities in marketing is a widespread practice grounded in the notion that celebrities can captivate consumers' interest, and that their admirable traits can be passed on to the brands they endorse [13]. Celebrity credibility is widely explored as a central point in the celebrity endorsement literature [14]. Associations among the constructs in the theoretical model have been extensively investigated and elucidated, including consumers' attitudes towards ads [15,16], consumer satisfaction [8,17], purchase intentions [18,19], revisit intention and word-of-mouth [8]. Prior scholarly investigations have also underscored the enduring and constructive influence of credibility on brand-related constructs, including brand attitudes [16,20], brand and media trust [21], brand equity [22,23], self-brand connection [24], brand attachment [8,25] and brand commitment [26]. However, only a limited number of studies have investigated the impact of endorsements by well-known celebrities on global consumer behaviour [15]. Notably, there is a scarcity of studies that explore the impact of celebrity endorsement in marketing activities during disruptive circumstances [15]. To the best of our knowledge, only a limited number of studies have investigated how celebrity endorsement contributes to the enhancement of consumer perception regarding the endorsed brand image in Malaysia, especially after the COVID-19 pandemic. Furthermore, in previous empirical investigations, a strong emphasis has been placed on quantitative research methodologies [27]. During the period spanning from 1974 to 2018, it has been observed that structural equation modelling (SEM) and regression analysis serve as the primary analytical tools within the domain of quantitative techniques [14].

Therefore, this study incorporates necessary condition analysis (NCA). NCA is a robust analytical approach that allows researchers to determine the critical threshold of a necessary condition essential for achieving a specific desired outcome, without the need for prior calibration [28]. Whilst NCA is a relatively recent addition to the methodological tool, it has garnered substantial attention in the field of management research, as evidenced by notable studies [28–30]. Its application is strongly recommended for investigating necessary conditions across diverse research contexts [31]. This aligns with the recommendation by Halder et al. [32], who suggest that future research should utilise more robust quantitative methods to thoroughly examine the real-time impacts of influencer credibility. By integrating NCA, this study aims to identify the crucial thresholds that determine the conditions necessary for optimal outcomes in celebrity endorsements within the Korean Wave context. Through NCA, this study contributes to bridging gaps in the literature concerning celebrity endorsements amidst the global impact of the Korean Wave. By pinpointing the critical conditions necessary for successful brand endorsements by Korean celebrities, this research provides actionable insights for marketers navigating uncertain and evolving market landscapes. This approach underscores the study's novelty and potential to inform strategic decisions in effectively leveraging the influence of Korean celebrities.

This paper presents an innovative application of PLS-SEM and NCA to explore the influence of celebrity credibility—encompassing factors such as attractiveness, expertise, trustworthiness and self-satisfaction—on consumers' perceptions of a brand. Specifically, the study aims to uncover the key determinants of a celebrity's credibility in relation to consumer perceptions of a brand, with a focus on the Malaysian market. In today's digital age, where media and consumers are interconnected, celebrities have a remarkable persuasive power that transcends borders and infiltrates diverse consumer markets. The study seeks to unravel the intricate interplay between celebrities and brands and to shed light on the underlying factors that shape consumer perceptions and their impact on behaviour. This research adds a new dimension to the literature on marketing strategies for branding.

2. Literature review

2.1. Theoretical background

According to McCracken [33], a celebrity endorser is an individual who enjoys public recognition and leverages this recognition by appearing in advertisements on behalf of a consumer product. This endorsement serves as a brand communication channel in which the celebrity bestows their societal popularity, distinct personality traits and domain-specific expertise upon a brand, thereby serving as an authoritative spokesperson for the brand [34]. As proposed by McCracken in 1989, the meaning transfer model (MTM) offers a compelling proposition that celebrity endorsers can elicit a favourable response for a brand by transferring their own credibility to the product in question. In the initial stage, the focus is on the celebrity's appeals and ability to engage consumers, such as through their likability, attractiveness and personality, which capture the audience's attention and generate interest in the endorsed product or brand. In the second stage, trustworthiness becomes key. Here, the celebrity's credibility and believability are transferred to the product, enhancing consumer confidence in the endorsed brand. This stage emphasises the notion that the celebrity's positive traits can positively influence the perceived reliability of the product. Meanwhile, the final stage involves the transfer of the meanings associated with the celebrity to the product. This process is where the celebrity's qualities, values and attributes are imparted to the brand, creating a connection between the celebrity and the product in the minds of consumers. At this stage, the brand leverages the celebrity's image to enhance its own image and messaging.

In addition to the MTM, this study also considers the parasocial interaction theory (PIT) to examine the influence of celebrity endorsement in the form of their credibility on consumers' perceptions towards the brand image of the endorsed products or services. Rooted in the field of media and communication studies, Horton and Wohl [35] posit that audiences can develop intense and personal connections with media figures, even though these relationships are entirely one-sided and asymmetrical. These parasocial interactions are often characterised by emotional bonds, a sense of knowing the media personality intimately, and a genuine investment in their lives, despite the lack of any reciprocal interaction. The theory explains that these parasocial relationships are cultivated through repeated exposure to media personalities in various forms of media, such as television, radio or social media.

In the context of celebrity endorsements, the MTM posits that celebrities act as conduits for transferring meanings—such as lifestyle, status and values—from their personal brand to the products or services they endorse. This model suggests that consumers associate these meanings with the endorsed brands, thereby enhancing their attractiveness and appeal. Concurrently, PIT suggests that consumers form quasi-social relationships with celebrities through frequent exposure to media representations. These theories illuminate how attractiveness, expertise and trustworthiness function as the key credibility attributes of celebrities in the context of endorsements. By understanding and leveraging these attributes, marketers can strategically align celebrity endorsements with brand values and consumer expectations, thereby enhancing brand perception and consumer engagement. Celebrity endorsement typically involves three core credibility attributes: attractiveness, expertise and trustworthiness. These attributes serve crucial roles in shaping consumer perceptions and behaviours.

2.2. Attractiveness

According to Erdogan [36], the concept of attractiveness extends beyond mere physical aesthetics to encompass a broader spectrum of attributes. These include intellectual skills, personality traits, lifestyle choices, athletic achievements and the adeptness with which a celebrity endorses products or services. As a result, consumers' admiration for a celebrity is not solely predicated on their external beauty; it also stems from the reverence they hold for the celebrity's accomplishments and the virtuous characteristics they exemplify. Therefore, when an attractive celebrity endorses a brand, the emotional connection fostered through parasocial interaction can amplify the brand's appeal. Consumers aspire to emulate the qualities or lifestyle of the attractive celebrity, and this aspiration is projected onto the brand.

Attractiveness has emerged as the preeminent element of credibility, serving a pivotal role in enhancing consumers' attitudes towards advertisements and brands, along with their purchase intentions [37]. Wan Mat et al. [38] also indicated that celebrities' characteristics, particularly their attractiveness and trustworthiness, had both direct and indirect significance in influencing consumers' attitudes towards emulating celebrity endorsements. However, in a recent study focused on female millennials' purchase intention of beauty products, Macheka et al. [39] reported otherwise, noting that the attractiveness of celebrity influencers did not exert a noteworthy impact on consumer attitudes. This discrepancy can be attributed to several potential reasons. Firstly, the cultural and temporal contexts are relevant. Cultural dynamics are important in international marketing, especially in the domain of celebrity endorsements, where researchers emphasise the profound impact of these dynamics on shaping consumer behaviour and preferences across varying cultural landscapes [40,41]. Erdogan [36] conducted a study over two decades ago that may have been influenced by the cultural and societal norms of the late 20th century, where physical attractiveness held substantial sway in marketing and consumer perceptions. Media portrayals and the societal emphasis on physical beauty were more pronounced, possibly leading to stronger associations between attractiveness and positive consumer attitudes. Meanwhile, a more recent study by Wan Mat et al. [38] still predates significant shifts in societal attitudes towards inclusivity and diversity. The growing awareness and acceptance of diverse beauty standards may not have been fully reflected in their findings. Secondly, the evolution of beauty standards is an important factor. The definition and perception of attractiveness have evolved significantly over time. In the late 20th century, and even a decade ago, conventional standards of beauty were more rigidly defined. However, recent years have seen a broader acceptance of diverse and unconventional beauty standards. Macheka et al. [39] might have captured a period where consumers were less influenced by traditional attractiveness and more by other factors such as authenticity, relatability and personal values. Based on the findings of prior

studies, the present study tested the following hypothesis.

Hypothesis 1. The attractiveness of celebrity endorsers positively influences the perceptions of Malaysian youth consumers towards the endorsed brand image.

2.3. Trustworthiness

According to Yang [42], trustworthiness in celebrity endorsers is described as the perceived integrity, honesty and believability they convey. These traits, which also connect to credibility and authenticity [43], instil a considerable degree of trust in consumers [25]. When trust in a brand is cultivated, it deepens the consumer's affiliation with the brand, leading to a greater inclination to consume or recommend it. This inclination stems from the favourable interactions and experiences that consumers associate with the trusted brand, motivating them to share these positive sentiments with others. As a result, businesses and brands choose endorsers who project an image of consistency, honesty, reliability and security, all to maximise the value of celebrity endorsers.

Recent research conducted by Weidmann and von Mettenheim [44] recognised the importance of celebrity trustworthiness as a robust predictor of consumers' attitudes towards advertisements and their purchase intentions. Consumers rely on the trustworthiness and expertise of celebrities as a critical gauge for assessing the quality of both advertisements and products. Moreover, the empirical evidence provided by Khong and Wu [45], Chan et al. [46] and Lili et al. [47] affirms the direct and positive influence of a celebrity's trustworthiness on consumers' behavioural intentions. However, further investigation in Mohd Suki's [48] study revealed that trustworthiness is not as effective in predicting the behaviours of Muslim consumers. The trust and faith of Muslim consumers may be associated with the perception that the products and services endorsed by celebrities align with Shariah principles, reflecting a consistent adherence to Islamic values. Drawing from the conclusions of previous research, the following hypothesis was formulated for testing.

Hypothesis 2. The trustworthiness of celebrity endorsers positively influences the perceptions of Malaysian youth consumers towards the endorsed brand image.

2.4. Expertise

Expertise is defined by an individual's acknowledged levels of knowledge, skills and competencies. The recognition of expertise is typically based on an individual's ability to impart knowledge rooted in their personal competencies or mastery in a specific field [49]. According to a study conducted by Ohanian [50], the most effective measure of the endorser's expertise was found to be their knowledge related to the product. In the context of celebrity endorsement, expertise pertains to the celebrity endorser's familiarity with the product category and their proficiency in the relevant field [51]. Considering the significance of an endorser's competence in shaping consumers' brand perceptions and purchase intentions, a celebrity endorser perceived as highly knowledgeable holds greater appeal than one perceived as less competent [52]. An endorser who is well-versed in the subject matter, such as a celebrity, wields greater effectiveness in swaying consumers towards product purchases [53], thereby leading to a more positive brand attitude [20]. In light of these considerations, the following hypothesis was formulated for testing.

Hypothesis 3. The expertise of celebrity endorsers positively influences the perceptions of Malaysian youth consumers towards the endorsed brand image.

2.5. Self-satisfaction

Satisfaction is characterised as a mental state in which an individual's desires, needs and expectations—whether related to material possessions or life in general—have not only been met, but exceeded. This contentment leads to a propensity for repeated loyalty in the future [54]. Essentially, self-satisfaction is attainable when individuals achieve all that they desire in life. Human beings actively seek self-fulfilment to enhance their well-being and serenity, which has repercussions on both their physical and mental health. Furthermore, interpersonal support and a sense of belonging are integral to an individual's psychological well-being [53]. Previous studies have delineated two facets of self-satisfaction: individuals are inclined to derive satisfaction either by aligning their actions with personal aspirations and adapting to cultural elements, or by experiencing gratification through personal growth and development [55].

This sense of self-satisfaction can subsequently manifest in the consumer's attitudes and actions in their individual lives [56]. Similarly, Wan Mat et al. [38] established a connection between self-satisfaction and the disposition towards imitating celebrity endorsements. This connection is particularly strong when individuals derive self-satisfaction from celebrity endorsers who exhibit positive qualities and engaging personalities. Building upon the conclusions of previous research, this study examined the following hypothesis.

Hypothesis 4. Self-satisfaction positively influences the perceptions of Malaysian youth consumers towards the endorsed brand image.

2.6. Brand image

Brand image has been defined by Keller as 'perceptions of the brand that reflect consumer associations in the mind of the consumer'

[57]. In other words, it is the cognitive representation that forms in a consumer's mind when they encounter a brand. Simply put, it means that when customers assess a brand name, they instinctively think about the characteristics associated with that brand. Mohajerani and Miremadi [58] described an image as the comprehensive perception that takes shape in the collective mind of the public concerning a particular entity. This image takes shape within the customer's cognition through the combined influences of promotional efforts, advertising, public relations, word-of-mouth, and the customer's direct interactions with products and services [59]. Similarly, consumers develop their perceptions when they encounter brands that have received endorsements from celebrities in the media, particularly in light of the remarkable success of the K-wave in Asia.

An effective brand can solidify a positive perception of a product and enhance its recognition among consumers [60]. When a brand holds a prominent place in a consumer's mind, the products are likely to receive increased attention, potentially leading to a surge in purchases [61]. Wu and Wang [62] have identified three distinct constructs that contribute to the concept of brand image: functional image, which addresses consumer needs and anticipates potential issues; symbolic image, which fulfils intrinsic desires such as self-worth, social status and self-identity; experiential image, which caters to consumers' desire for variety and excitement by offering experiential pleasure.

All hypotheses proposed in this study are presented in Fig. 1.

3. Methodology

3.1. Study population

The primary objective of this study is to examine the impact of Korean celebrity endorsements on the brand perception of young Malaysian consumers. Consequently, the study's target group comprises individuals aged between 15 and 24 years. The selection of respondents employed the purposive sampling technique, enabling the researchers to deliberately select individuals from the population based on specific predefined criteria. These criteria encompass (i) individuals aged between 15 and 24 years and (ii) those who have previously viewed Korean celebrity endorsements. The choice of purposive sampling was strategic since it allowed the researchers to focus on individuals who were most likely to provide relevant insights into the study's objectives. This methodological approach ensured that the sample comprised individuals with firsthand experience or exposure to the phenomenon under investigation, thereby enhancing the relevance and applicability of the study findings. The required sample size was computed using G*Power (version 3.1.9), following the guidelines of Faul et al. [63]. By configuring the tool with a power level of 0.80, an effect size of 0.15 (representing a medium effect size per Cohen [64]), and considering four predictors, the estimated sample size for this research was 85. However, to mitigate the impact of any potential challenges associated with a small sample size, this study chose to acquire a larger sample.

3.2. Data collection

The survey was administered online, utilising the Google Forms platform for data collection. This approach is known for its convenience, speed and ability to engage a large number of respondents simultaneously. The questionnaire link was subsequently disseminated via popular social media platforms such as WhatsApp and Telegram. This choice aligns with the findings of the Internet Users Survey conducted by the Malaysian Communications and Multimedia Commission [65], which highlighted WhatsApp and Telegram as the top communication platforms preferred by Malaysians. A total of 100 responses were deemed complete for relevant data analysis.

3.3. Instruments

To construct the questionnaire for this study, established instruments from prior research were employed and slightly modified.
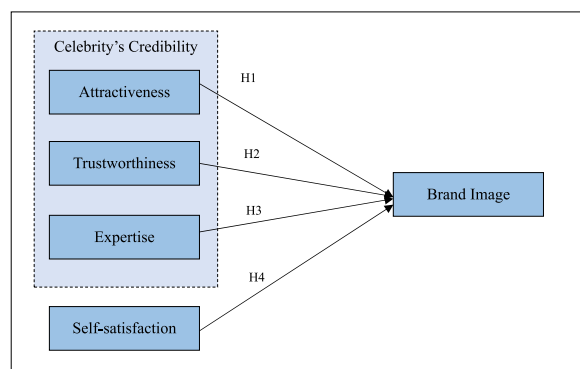

Fig. 1. Research framework.

The questionnaire was meticulously designed to be straightforward and unbiased, thereby enabling respondents to interpret the questions without difficulty. Attractiveness, trustworthiness and expertise were measured based on items adopted from Ref. [66]. Meanwhile, self-satisfaction was measured based on items adopted from Ref. [67]. Additionally, items that measured consumers' perceptions of the brand image were adopted from Ref. [68]. All the constructs were tested using a five-point Likert scale that ranged from 1 = strongly disagree to 5 = strongly agree.

3.4. Common method bias

This study made several significant efforts to mitigate the potential influence of common method variance (CMV). Firstly, we conducted a comprehensive collinearity analysis, as recommended by Kock and Lynn [69], to statistically assess any potential bias. Full collinearity refers to the assessment of multicollinearity in the data, which is crucial for ensuring the reliability and validity of the analysis. It is typically measured using the variance inflation factor (VIF), which quantifies how much the variance of a regression coefficient is inflated due to collinearity with other predictors. Referring to Table 2, the full collinearity examination resulted in VIF values ranging from 2.471 to 3.916, all of which were below the threshold of 5, as suggested by Hair et al. [70]. This analysis indicates that collinearity is not a concern in this study. Thus, CMV does not pose a threat to the validity of the results.

3.5. Data analysis

The research hypotheses were tested using SmartPLS4 software, employing partial least squares structural equation modelling (PLS-SEM). PLS-SEM is known for its effectiveness in handling intricate structural models, including those involving higher-order constructs, as discussed by Becker et al. [71] and Sarstedt et al. [72]. It is also suitable for predictive and exploratory studies, as demonstrated in this research, in alignment with the findings of Chin et al. [73]. In line with the guidance provided by Hair et al. [70], the data underwent analysis and interpretation through a two-stage approach, which consisted of (i) evaluating the measurement model and (ii) assessing the structural model.

3.6. Ethical considerations

All procedures performed in this study were conducted in accordance with the ethical standards of The National University of Malaysia (JEP-2023-932). The study included participants under the age of 18, and their inclusion was justified by the study's focus on youth perspectives on social media behaviour. To ensure that underage participants fully understood the study, discussions were held at their level of comprehension. These discussions were designed to explain the research purpose, the procedures involved, and the potential effects of the study in simple and age-appropriate language. Participants were encouraged to ask questions and express any concerns, which were addressed to ensure they felt comfortable and informed.

The privacy and confidentiality of all participants were rigorously protected by using a secure online survey platform, storing data in a password-protected file, and assigning anonymous IDs. Participants were clearly informed about the voluntary nature of their participation, their right to withdraw at any time without any consequences, and the confidentiality of their responses. Informed consent was obtained from all participants, ensuring they understood the study's objectives and their role in it before proceeding.

4. Results

4.1. Demographic characteristics of respondents

Table 1 presents the demographic profile of the respondents. Most of the respondents (87 %) were female. Additionally, 96 % of the

Table 1
Demographic characteristics.

Items		Frequency	Percentage
Gender	Male	13	13.0
	Female	87	87.0
Age	15–19 years old	4	4.0
	20–24 years old	96	96.0
Ethnicity	Malay	74	74.0
	Chinese	15	15.0
	Indian	1	1.0
	Other	10	10.0
Level of Education	SPM	3	3.0
	STPM	5	5.0
	Diploma	7	7.0
	Bachelor's Degree	83	83.0
	Master's Degree	2	2.0

Table 2

Assessment of reliability, convergent validity and full collinearity.

Construct	Item	Loading	CA	rho_A	CR	AVE	FC
Attractiveness	A1	0.886	0.883	0.889	0.919	0.740	2.471
	A2	0.856					
	A3	0.848					
	A4	0.850					
Trustworthiness	T1	0.859	0.734	0.762	0.881	0.788	2.628
	T2	0.915					
	T3	DEL					
	T4	DEL					
Expertise	E1	DEL	0.862	0.864	0.916	0.783	2.594
	E2	0.866					
	E3	0.891					
	E4	0.898					
Self-satisfaction	SS1	0.910	0.873	0.874	0.922	0.798	3.165
	SS2	0.875					
	SS3	0.894					
Functional Image	CP1	0.840	0.907	0.912	0.935	0.784	3.916
	CP2	0.853					
	CP3	0.915					
	CP4	0.929					
Symbolic Image	CP5	0.882	0.815	0.824	0.890	0.729	2.799
	CP6	0.841					
	CP7	DEL					
	CP8	0.839					
Experiential Image	CP9	0.916	0.909	0.910	0.943	0.846	3.566
	CP10	0.925					
	CP11	0.918					
	CP12	DEL					
Brand Image	Functional Image	0.933	0.904	0.905	0.940	0.839	
	Symbolic Image	0.896					
	Experiential Image	0.918					

Notes: DEL: deleted, CA: Cronbach's alpha, Rho_A: composite reliability, Rho_C: composite reliability, AVE: average variance extracted, FC: full collinearity.

respondents were between 20 and 24 years old. Most of the respondents were Malay (74 %), followed by Chinese (15 %), other (10 %) and Indian (1 %). In terms of level of education, most of the respondents had attained a bachelor's degree (83 %).

4.2. Assessment of the measurement model

4.2.1. Reliability and validity

In Tables 2 and it is evident that all loading values exceeded the 0.70 threshold, as outlined by Ref. [74]. Furthermore, all constructs met the recommended criteria for Cronbach's alpha (CA), rho_A, composite reliability (CR) and average variance extracted (AVE), with values surpassing 0.70 and 0.50, respectively, in accordance with [74], thus confirming the convergent validity of all constructs. To assess discriminant validity, the heterotrait-monotrait ratio of correlations (HTMT) technique was employed [75,76] (see Table 3). The results indicate no concerns with discriminant validity since none of the values exceeded the threshold of 0.90, in accordance with [77].

4.3. Assessment of the structural model

The subsequent step involved assessing the structural model to ascertain that no biases in the regression outcomes were attributable to collinearity concerns. During this phase, an examination of collinearity among the exogenous constructs was conducted using the VIF. As depicted in Table 4, it is evident that all VIF values were below 3.3, indicating that collinearity did not pose a problem in the

Table 3

Assessment of discriminant validity using the HTMT technique.

Construct	1	2	3	4	5	6	7
1. Attractiveness							
2. Experiential Image	0.636						
3. Expertise	0.738	0.657					
4. Functional Image	0.676	0.881	0.734				
5. Self-satisfaction	0.709	0.851	0.647	0.852			
6. Symbolic Image	0.592	0.819	0.683	0.872	0.845		
7. Trustworthiness	0.834	0.675	0.881	0.734	0.686	0.723	

Table 4
Assessment of structural model.

Relationship	Standard Beta	Standard Error	t-value	p-value	BCa CI LB	BCa CI UB	VIF	f^2	R^2	Q^2
H1: Attractiveness → Brand Image	0.005	0.097	0.048	0.962[ns]	−0.200	0.181	2.390	0.000	0.719	0.697
H2: Trustworthiness → Brand Image	0.133	0.100	1.339	0.180[ns]	−0.051	0.341	2.478	0.027		
H3: Expertise → Brand Image	0.219	0.112	1.960	0.050*	−0.013	0.423	2.341	0.074		
H4: Self-Satisfaction → Brand Image	0.615	0.080	7.698	0.000***	0.458	0.769	1.796	0.782		

Notes: VIF (variance inflation factor); Effect size ($f2$): T = Trivial, S=Small, L = Large, ns = p > 0.05, *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001.

structural model used in this study [74].

To evaluate the significance of the proposed model [78], a bootstrapping procedure involving 10,000 subsamples was employed. In summary, the results substantiated the hypothesis of self-satisfaction exerting a significant influence on consumers' perception of brand image, thus offering support for H4 (β = 0.615, t-value = 7.698, p < 0.001, CI = 0.458, 0.769). Similarly, the findings also indicate that expertise was significantly related to consumers' perception of brand image. Thus, H3 was supported (β = 0.219, t-value = 1.960, p ≤ 0.050, CI = −0.013, 0.423). However, contrary to earlier predictions, the results suggest that attractiveness was not significantly related to consumers' perception of brand image. Thus, H1 was not supported (β = 0.005, t-value = 0.048, p > 0.001, CI = −0.200, 0.181). Additionally, the study also determined that trustworthiness was not significantly related to consumers' perception of brand image. Thus, H2 was not supported (β = 0.133, t-value = 1.339, p > 0.001, CI = −0.051, 0.341).

The subsequent phase involved assessing various aspects of model performance, including the coefficient of determination (R^2) for the endogenous constructs (brand image), effect size (f^2) and predictive relevance (Q^2). To begin, attractiveness, expertise, trustworthiness and self-satisfaction demonstrated substantial explanatory power, elucidating 71.9 % of the variance in brand image—a level classified by Cohen [64] as robust explanatory power. Additionally, the results indicated that self-satisfaction ($f^2 = 0.782$) had a large effect size, whereas trustworthiness ($f^2 = 0.027$) and expertise ($f^2 = 0.074$) had small effect sizes. Conversely, attractiveness ($f^2 = 0.000$) had a trivial effect size in explaining the brand image. Finally, predictive relevance was assessed using PLSpredict [79]. The Q2predict values for brand image (0.697) exceeded 0, indicating the model's predictive capability, as affirmed by Chin et al. [73] and Shmueli et al. [79].

4.4. Necessary condition analysis (NCA)

Table 5 presents the NCA findings, which present the effect sizes of the determinants on brand image using ceiling lines (CE_FDH). In NCA, ceiling lines represent the boundary that separates the region of possible observations from the region of impossible observations in the scatter plot of a necessary condition. Essentially, it helps to identify the minimum level of a predictor (condition) that is required to achieve a certain level of an outcome. There are two main types of ceiling lines used in NCA [80]: (1) ceiling envelopment-free disposal hull (CE-FDH), which is a step function that envelopes the observations from below, ensuring that the observed points fall on or above the ceiling line. It is a non-parametric method that does not assume a specific functional form and allows for the free disposal of input, meaning that any value below the ceiling line is acceptable; (2) ceiling regression-free disposal hull (CR-FDH), which is a regression-based method that fits a boundary line to the data points in a more flexible manner. Like CE-FDH, it ensures that the observed points fall on or above the ceiling line; however, it allows for smoother transitions and can capture more complex relationships between the predictor and outcome.

This study selected the CE-FDH method for several reasons. Firstly, according to the NCA guidelines [80], when dealing with discrete variables that have few levels (e.g. fewer than five), the CE-FDH ceiling line technique is recommended. Additionally, its flexibility allows for the inclusion of a wide range of input values below the threshold without imposing stringent constraints regarding the ceiling line [80]. Lastly, CE-FDH is widely utilised in NCA studies, thereby enhancing the comparability of our findings with existing research in this field [80]. It is recommended as the default ceiling envelopment technique for NCA, leading to a piecewise linear function across the upper-left observations [81]. These ceiling lines are crucial for interpreting the NCA results. In this study, the CE-FDH lines were used to determine that attractiveness, expertise, self-satisfaction and trustworthiness are necessary conditions for achieving a strong brand image.

Dul [80] proposed that an effect size in the range of 0 < d < 0.1 can be described as small, whilst an effect size in the range of $0.1 \leq d < 0.3$ is considered medium. Furthermore, an effect size of $0.3 \leq d < 0.5$ is classified as large, whilst an effect size $d \geq 0.5$ is

Table 5
NCA effect size.

Determinant	Outcome	Ceiling lines	Effect size (d)	p-value
Attractiveness	Brand Image	CE_FDH	0.353	0.000
Expertise	Brand Image	CE_FDH	0.403	0.000
Self-Satisfaction	Brand Image	CE_FDH	0.301	0.000
Trustworthiness	Brand Image	CE_FDH	0.365	0.000

Notes: 0 < d < 0.1 = small effect; 0.1 < d < 0.3 = medium effect; 0.3 < d < 0.5 = large effect; d > 0.5 = very large effect.

categorised as very large. Notably, expertise ($d = 0.403$, $p < 0.05$), trustworthiness ($d = 0.365$, $p < 0.05$), attractiveness ($d = 0.353$, $p < 0.05$) and self-satisfaction ($d = 0.301$, $p < 0.05$) have a large effect size on brand image. The PLS-SEM and NCA results indicate that self-satisfaction is a meaningful ($d \geq 0.1$), significant ($p < 0.05$) and necessary condition for establishing consumers' perceptions of brand image. The effect sizes, which range from 0.301 to 0.403 with p-values of 0.000, indicate the significance of these conditions.

Meanwhile, the bottleneck table helps researchers assess and compare the sufficiency of various conditions by highlighting where constraints or bottlenecks occur [80]. This analysis is essential for understanding the minimal requirements or thresholds that must be satisfied to achieve a particular outcome in different contexts or scenarios. As shown in Table 6, the study specifies that achieving a relevant level of consumer perception (80 %) requires a minimum level of attractiveness (24 %) and trustworthiness (24 %). Additionally, to reach an 80 % level of brand image, necessary conditions must be in place, such as self-satisfaction not being less than 47 %. On average, an increase in the exogenous construct will increase the outcome. Similarly, the results indicate that expertise is a meaningful ($d \geq 0.1$), significant ($p < 0.05$) and necessary condition for consumers' perception of brand image. This implies that in order to reach an 80 % level of brand image, the necessary conditions need to be in place, with expertise not being less than 5 %. Further investments in these factors and other aspects that influence consumers' perceptions of brand image may not yield substantial benefits unless the necessary conditions are addressed.

Based on the results of a PLS-SEM analysis, the impact of attractiveness and trustworthiness on brand image is not significant. However, the NCA analysis reveals that some crucial determinants were not identified by the standard PLS-SEM analysis. The NCA findings suggest that attractiveness and trustworthiness are necessary conditions for achieving brand image outcomes. These findings are consistent with previous research by Fitriani et al. [82], Teng et al. [83] and Wan Mat et al. [38] suggesting that attractiveness and trustworthiness are necessary but insufficient conditions for brand image. The study also highlights that further investments can improve consumers' perceptions of brand image only after these bottlenecks have been appropriately managed. The results demonstrate that NCA can complement the PLS-SEM analysis in identifying necessary conditions, not only significant determinants. Therefore, using both the PLS-SEM and NCA approaches is essential for a comprehensive understanding of customers' technology and innovation acceptance.

5. Discussion

The present study highlights the significance of the credibility attributes of celebrity endorsers (i.e. attractiveness, trustworthiness and expertise) and self-satisfaction among Malaysian youth consumers towards the endorsed brand image. One of the central findings of this study is the significant influence of expertise on brand image, which is congruent with existing research [20,52,53]. The results indicate that when celebrities are perceived as possessing expertise in the domain they endorse, it has a positive impact on the brand image. This underscores the importance of selecting celebrity endorsers who are not only popular but also knowledgeable in the relevant product category. In the context of the celebrity endorsement process, this finding underscores that consumers are more likely to view a brand favourably when the endorsing celebrity is perceived as an expert, which bolsters the brand's image and appeal.

The study has also unveiled a positive relationship between self-satisfaction and brand image. Prior studies investigating the influence of celebrity endorsements have yielded comparable findings [1,56]. This implies that when consumers derive satisfaction from associating themselves with a brand endorsed by their favourite celebrity, it has a constructive effect on their perception of the brand. Such satisfaction is often linked to the psychological gratification and esteem derived from the association with a particular celebrity endorser. This aligns with the notion that consumers tend to develop a more positive attitude towards brands when their self-satisfaction is intertwined with their choice of products endorsed by celebrities.

Notably, the study's results indicate that attractiveness and trustworthiness do not significantly impact brand image in this context. These findings align with prior studies indicating that the attractiveness of a celebrity does not exert a significant impact on consumer attitude [84–86]. Similarly, trustworthiness was not found to be an effective predictor of consumer behaviour, which is consistent with the findings of Mohd Suki [48] and Karasiewicz and Kowalczuk [87]. According to these studies, the heightened attractiveness of an endorser does not translate into higher assessments of their likability, trustworthiness or credibility in word-of-mouth evaluations. As a result, the use of celebrity endorsements may not be justified in marketing communications aimed at building positive brand attitudes. This finding suggests that, among Malaysian youth consumers, these attributes may have a less pronounced effect on brand perception

Table 6
Bottleneck table.

Brand Image Percentile	Attractiveness	Expertise	Self-satisfaction	Trustworthiness
0.00 %	NN	NN	NN	NN
10.00 %	NN	NN	NN	NN
20.00 %	1.000	1.000	NN	1.000
30.00 %	1.000	3.000	NN	1.000
40.00 %	1.000	4.000	1.000	2.000
50.00 %	3.000	5.000	1.000	2.000
60.00 %	3.000	5.000	8.000	2.000
70.00 %	10.000	5.000	12.000	5.000
80.00 %	24.000	5.000	47.000	24.000
90.00 %	25.000	5.000	67.000	33.000
100.00 %	62.000	71.000	79.000	33.000

when compared to expertise and self-satisfaction. It is important to recognise that the impact of these attributes can vary based on cultural, social and demographic factors, which may explain their non-significant relationship with brand image in the present study. For instance, consumer values and preferences can evolve over time. In the era of the Korean Wave or *Hallyu*, consumers may be more focused on expertise and self-satisfaction, driven by their fascination with Korean culture and their favourite celebrities. According to Zhao et al. [88], idols receive significant enthusiasm from their fans, with the fan-idol relationship being characterised by a high degree of intimacy. Moreover, McCracken [33] posits that celebrities convey a wide array of meanings—including lifestyle, status and trendiness—that are transferred to brands during the endorsement process. As a result, a brand endorsed by a popular idol acquires the meanings and attributes associated with that idol. This phenomenon is further supported by the widespread acceptance of Korean products, especially television dramas, which have fostered a growing appreciation for Korean culture [89]. Notably, this shift in values can diminish the relative importance of attractiveness and trustworthiness.

The NCA results also reveal important insights into the impacts of different constructs on the outcome of interest. In this case, the study investigated the influence of four key constructs—expertise, trustworthiness, attractiveness and self-satisfaction—on the brand image outcome. The results indicate the effect sizes associated with each of these constructs, with expertise having the largest effect, followed by trustworthiness, attractiveness and self-satisfaction. Overall, these findings highlight the varying degrees of influence that each of these constructs has on consumers' perceptions towards the brand image in the context of Korean celebrity endorsements. The results underscore the multifaceted nature of consumer perceptions and the complex interplay of these attributes. The dominance of expertise suggests that, in the context of celebrity credibility in the present study, the knowledge of the celebrity endorser has a substantial impact on the brand image.

The results of the NCA also suggest that expertise and self-satisfaction are not only meaningful but also necessary conditions for achieving a desired outcome or effect. This implies that for positive consumer perceptions towards brands endorsed by Korean celebrities, a certain level of expertise and self-satisfaction is required. Notably, this implies that consumers tend to have more positive perceptions when they believe the celebrity endorser is knowledgeable about the products they are promoting. Additionally, self-satisfaction serves a key role, suggesting that consumers must derive a sense of contentment, pleasure or personal satisfaction from their association with the endorsed brand. If these conditions are not met, the desired consumer perceptions and attitudes may not be effectively achieved.

This study also found that whilst attractiveness and trustworthiness are not statistically significant, they still serve as meaningful conditions for influencing consumer perceptions towards endorsed brands. Although these characteristics may not directly lead to stronger consumer perceptions, they contribute to the overall context and consumer impressions. For instance, attractiveness may not be a significant predictor, but it can still serve a role in attracting consumer attention and setting the stage for further brand engagement. Moreover, despite not being directly linked to brand perception, trustworthiness can create a foundation of credibility and reliability that underlies consumer trust in the endorsement process. Essentially, even though attractiveness and trustworthiness may not be the primary drivers of consumer perceptions, they contribute to the overall complexity of consumer-brand relationships in this context. In summary, these results demonstrate the nuanced interplay of expertise, trustworthiness, attractiveness and self-satisfaction in the context of Korean celebrity endorsements and their impacts on brand image.

6. Conclusion

6.1. Summary of research and key findings

This study deepens our understanding of how Korean celebrity endorsements can influence the behaviour of young Malaysian consumers. In conclusion, our research has shed light on the intricate dynamics at play in the world of celebrity endorsements, particularly within the Malaysian youth market. We explored the multifaceted elements of Korean celebrity credibility, encompassing their attractiveness, trustworthiness, and expertise, and examined how these factors collectively shape consumer perceptions of the endorsed brand image. Our findings underscore the significance of these credibility dimensions (i.e. expertise) as crucial drivers of brand appeal, resonating deeply with the preferences and aspirations of Malaysian youth. Moreover, our research revealed that this nexus between celebrity credibility and brand perception is intricately intertwined with self-satisfaction, underlining the importance of personal gratification in the consumer decision-making process. In their pursuit of self-fulfilment and self-expression, Malaysian youth are not merely passive recipients of endorsements but active participants who seek to align themselves with brands that embody their own values, desires and aspirations. They are drawn to brands endorsed by Korean celebrities who embody the values and lifestyles they admire or aspire to emulate. This alignment reinforces positive perceptions of the endorsed brand as reflective of their own identity and aspirations. Moreover, self-satisfaction enhances the emotional connection consumers feel towards endorsed brands. This emotional bond fosters a deeper brand connection by associating it with positive feelings of admiration, trust and relevance in consumers' lives. Ultimately, self-satisfaction empowers Malaysian youth to express their identities and values through their purchasing decisions, further solidifying the brand's appeal and authenticity, from their perspective.

6.2. Theoretical contribution

The study underscores the need to consider a holistic approach to understanding celebrity endorsement. The combined use of the MTM and PIT offers a more comprehensive framework for assessing how multiple factors—expertise, trustworthiness, attractiveness and self-satisfaction—interact to shape consumer perceptions of the endorsed brand. The significance of expertise and self-satisfaction in shaping consumers' perceptions of brand image emphasises the model's effectiveness in explaining how certain attributes of

celebrity endorsers contribute to brand perceptions. The study augments existing branding theories by emphasising the significance of diverse attributes of celebrity credibility, such as attractiveness, expertise, trustworthiness and self-satisfaction in shaping consumer perceptions of brand image among Malaysian youth.

Moreover, by focusing on Malaysian youth, our study provides valuable contextual insights that address a gap in the literature related to regional and demographic variations in consumer responses to celebrity endorsements. The findings reveal how specific attributes—such as expertise and self-satisfaction—resonate differently with this demographic, contributing to a more nuanced understanding of celebrity endorsement dynamics in diverse cultural settings. This regional focus enriches the existing body of knowledge by incorporating perspectives from under-researched populations.

6.3. Practical contribution

The utilisation of NCA offers profound implications for brands seeking to optimise their strategies, particularly in effectively engaging Malaysian youth. The insights derived from NCA highlight specific conditions—namely attractiveness, expertise, and self-satisfaction—that are indispensable for shaping positive brand image perceptions. The study's outcomes hold diverse practical significance. To capitalise on the theoretical insights, brands should consider celebrities not only as endorsers but also as educators. Brands should carefully select celebrity endorsers who not only have a strong presence but also possess expertise related to the endorsed products or services. Brands can assess a celebrity's expertise by examining their professional background, industry knowledge and previous endorsements. Additionally, brands can conduct audience surveys and social media analyses to gauge public perceptions of the celebrity's expertise related to the product or service in question. These steps will help to ensure that the selected endorsers align well with the brand's objectives and resonate with the target audience. Celebrity endorsers with expertise in the target product category can actively engage in informative campaigns. This could involve conducting webinars, participating in Q&A sessions or sharing educational content to enhance consumers' knowledge. This strategy enhances the credibility of the brand and resonates with Malaysian youth. Acknowledging that youth are not passive consumers, brands should actively involve them in co-creating content. Encouraging user-generated content related to product knowledge and expertise-sharing can be a powerful strategy to deepen brand connections.

Moreover, recognising the role of self-satisfaction, brands should also strive to provide holistic satisfaction experiences. As revealed in the study, self-satisfaction serves a pivotal role in influencing brand image. Marketers should focus on strategies that enhance consumers' overall satisfaction, including product quality, user experience and customer service. Brands that prioritise comprehensive satisfaction experiences not only meet consumer expectations but also foster deeper emotional connections. Collaborating with endorsers who embody these values can further reinforce positive associations and enhance brand affinity among target demographics.

These implications offer actionable guidance for brands and marketers seeking to harness the power of celebrity endorsement within the specific context of Malaysian youth. In line with Lim et al. [90], professionals and marketers must attentively consider the preferences of young consumers in a competitive and swiftly evolving setting to effectively craft and promote their products. By emphasising expertise and self-satisfaction, brands can effectively engage youth and foster stronger, more authentic relationships that ultimately influence consumers' perceptions of brand image. This integrated approach not only aligns with contemporary marketing practices but also underscores the importance of understanding and addressing the conditions necessary to drive consumer behaviour and brand perceptions in dynamic market environments.

In today's rapidly evolving consumer landscape characterised by globalised entertainment and marketing, it is imperative for brand strategists, marketers and advertisers to fully recognise the profound impact of Korean celebrity credibility and self-satisfaction on shaping brand perceptions among Malaysian youth. These elements are crucial drivers in establishing genuine connections with the target audience and fostering deep engagement. By effectively harnessing these insights, brands can cultivate enduring emotional connections with consumers, thereby ensuring that their messaging and endorsements resonate authentically with the values and aspirations of Malaysian youth. This approach not only enhances brand relevance and loyalty but also positions brands strategically in a competitive marketplace. Moreover, this research serves as a foundational cornerstone for future studies, providing invaluable guidance for refining celebrity endorsement strategies and adapting branding tactics to meet the evolving preferences of Malaysian youth. As brands navigate this dynamic landscape, understanding and leveraging the influence of Korean celebrity credibility and self-satisfaction will be pivotal in driving sustained success and market leadership.

6.4. Limitations of the study

Despite these significant discoveries, the present study experienced several constraints. Firstly, this research involved a cross-sectional study. Thus, the data were taken at a single point in time, making it challenging to establish cause-and-effect relationships. Future research should consider conducting longitudinal studies to track changes in consumer perceptions over time and cross-cultural analyses to understand how cultural differences affect the impact of Korean celebrity endorsements on Malaysian youth. Secondly, this study does not centre on particular categories of Korean celebrities. Therefore, exploring the effectiveness of different types of Korean celebrities, such as actors, musicians and social media influencers can provide valuable insights. Additionally, researchers should investigate the role of social media in mediating the relationship between celebrity endorsements, self-satisfaction and consumer perceptions, as well as the long-term effects on brand equity and consumer loyalty. Segmenting the Malaysian youth population and employing experimental, qualitative and ethical considerations in research methods will offer a more comprehensive view of this dynamic. Additionally, while we ensured that all scales were carefully selected based on established literature and tested for reliability and validity, some potential concerns remain. For instance, the scales might not have fully captured the nuanced

perceptions of the constructs in different cultural contexts, or there might have been biases introduced by the self-reporting nature of the survey. A key limitation of NCA is its assumption that the identified conditions are necessary but not sufficient for the outcome. This may not apply in all situations, which could limit how our findings are used in different contexts. Additionally, interpreting NCA results can be complex, particularly when dealing with multiple necessary conditions and their interactions. This complexity might make it challenging to clearly communicate the findings. To address this, simplifying the results or combining NCA with other methods could be helpful. Despite these challenges, NCA still offers valuable insights into the necessary conditions affecting the outcomes studied.

Acknowledging these limitations demonstrates a comprehensive understanding of the study's constraints and provides a more balanced interpretation of the results. These diverse research avenues will help illuminate the intricate relationship between Korean celebrity credibility, self-satisfaction and consumer perceptions among Malaysian youth, thereby contributing to more effective marketing and branding strategies in the future.

6.5. Future research

Future research in the field of celebrity endorsements, particularly focusing on Korean celebrities and their impacts on consumer behaviour, could benefit from several avenues of exploration. Firstly, longitudinal studies could be conducted to track changes in consumer perceptions and behaviours over time, providing insights into the long-term effectiveness and sustainability of celebrity endorsements in diverse cultural contexts, including Malaysia. Secondly, comparative studies across different demographic segments within Malaysia could offer deeper insights into how perceptions of Korean celebrities vary among different age groups, genders and socio-economic backgrounds. Thirdly, qualitative research methods such as in-depth interviews or focus groups could complement quantitative findings by exploring the underlying motivations and psychological mechanisms driving consumer responses to Korean celebrity endorsements. Lastly, exploring the role of digital and social media platforms in amplifying the effects of Korean celebrity endorsements, particularly in the context of influencer marketing and online engagement, could provide valuable insights into rapidly evolving consumer behaviours in the digital age. These research directions would not only expand our understanding of the influence of Korean celebrities on consumer behaviour but also inform more effective marketing strategies tailored to the Malaysian market and beyond.

CRediT authorship contribution statement

Nadzirah Rosli: Writing – original draft, Visualization, Validation, Supervision, Software, Project administration, Methodology, Formal analysis, Data curation. **Akmal Dahlia Binti Mohamad:** Conceptualization. **Elaina Rose Johar:** Methodology. **Sharizal Hashim:** Writing – review & editing, Validation. **Xin-Jean Lim:** Methodology.

Consent

All participants provided informed consent to participate in the study.

Ethical declaration

All procedures performed in this study were conducted in accordance with the ethical standards of The National University of Malaysia (JEP-2023-932).

Data availability statement

Data will be made available upon request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. ASupplementary data

Supplementary data to this article can be found online at.https://doi.org/10.1016/j.heliyon.2024.e41155.

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