Quantitative Analysis of Consumer Perception on E-commerce Platforms: The Modulating Role of Age and Perceived Ethnography

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Abstract. This study assesses the predictive capability of 27 Customer Experience (CX) factors on Age and the influence of Skin Tone (as an ethnographic proxy) on the valuation of these factors in e-commerce. A cross-sectional quantitative design was utilized with a sample of N=1425 experienced online consumers. The methodology employed Analysis of Variance (ANOVA) (Fisher, 1925) to validate sample independence by Age, Chi-square Test (χ2) (Snedecor & Cochran, 1989) to assess ethnographic dependence, and Multiple Linear Regression (MLR) (Cohen et al., 2003) to model Age prediction. MLR results indicated that the Age prediction model was significant (R^2 Adjusted=0.154), confirming that User Experience (UX) and Live Chat Availability are inverse and direct predictors of Age, respectively. Ethnographic analysis using segregated heatmaps revealed a focalized and significant disparity based on Skin Tone in the Trust/Logistics and Brand/Support blocks. A trend of lower valuation was observed in darker skin tones (Tone 6) for factors like Price Transparency and Assisted Support (Live Chat Availability), while a higher demand was noted for Review and Rating Availability. It is concluded that CX personalization must transcend basic demographics, focusing on relational equity and risk mitigation for ethnographically vulnerable segments.

Keywords: Digital Ethnography, Customer Experience (CX), Multiple Linear Regression, Skin Tone, Perceived Trust, Digital Stratification.

1 Introduction and Conceptual Framework

E-commerce has evolved from being an alternative to becoming a central consumption necessity. In this environment, customer satisfaction depends on a complex interaction of factors ranging from logistics (such as delivery speed) to ethical aspects (such as Corporate Social Responsibility, to mention some of the variables used in the study).

Most segmentation models rely on basic demographic metrics (age, sex); however, in highly diverse societies, ethnographic factors, particularly Skin Tone, may introduce biases or perceptual preferences not captured by simple analyses. This research addresses the gap in the literature by performing a granular analysis of 27 purchase factors and their relationship with Age and Skin Tone, providing empirical evidence on whether ethnographic variables are relevant for the evaluation of the digital shopping experience.

1.1. Context and Study Justification

The evolution of e-commerce has transformed Customer Experience (CX) into the main competitive differentiator (Kim et al., 2023). CX optimization cannot be limited to basic functionality but must integrate a deep understanding of consumers' psychographic and ethnographic motivations (Giraldo et al., 2021). This study is justified by the need to move segmentation models beyond superficial demographics toward perceived digital stratification.

1.2. Framework of Shopping Experience Constructs

The 27 perceptual factors are grouped into four blocks that interact with the main models of digital consumer theory (see figure 1):

- **Usability and Design (TAM Fundamentals):** This block is based on the Technology Acceptance Model (TAM) (Davis, 1989), where **Ease of Use** and **User Experience (UX)** are central constructs. Website functionality is a hygiene factor, expected by the consumer.
- **Logistics and Trust (Perceived Risk Mitigation):** Online shopping involves Perceived Risk (Bauer, 1960). Price Transparency and Personal Data Security are crucial, as trust is inversely proportional to risk (Lee & Lee, 2020). The consumer seeks to reduce uncertainty about logistical fulfillment (Delivery Speed).
- **Brand and Support (Relational Justice Theory):** This group evaluates the quality of assisted human service. Factors such as Live Chat Availability and Response Times are analyzed through the lens of Relational Justice Theory (Colquitt et al., 2013), where the consumer evaluates fairness and respectful treatment in interactions with the brand.
- **Innovation and Interaction (Technological Adoption):** This block focuses on the adoption of emerging technologies such as Augmented Reality (AR) or Gamification. Its valuation measures hedonic motivations and the disposition toward novelty in the purchasing process.
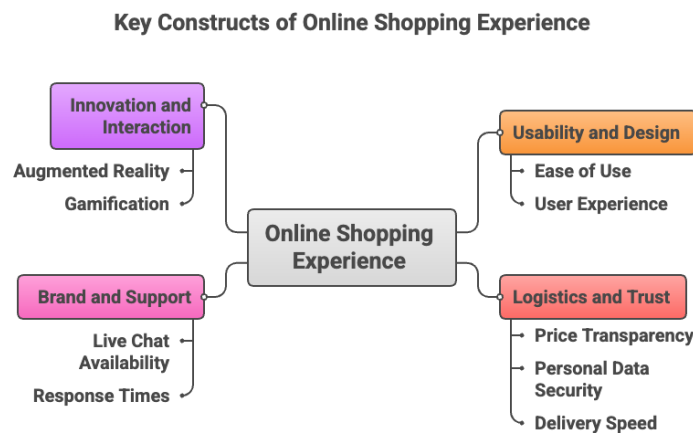

Figure 1. Framework of Digital Shopping Experience Constructs. Source: Own elaboration

1.3. Age and Skin Tone as Modulating Factors

Research in social sciences has consistently demonstrated that Skin Tone, as a proxy marker for ethnic identity and a factor in social stratification, can influence the perception of credibility, trust, and service quality. In the digital context, this influence translates into differentiated expectations regarding Price Transparency or Personal Data Security. On the other hand, Age functions as a crucial generational factor. Older segments may place a higher value on assisted support factors, while younger segments, categorized as digital natives, prioritize technological innovation and pure speed.

A. The Influence of Age

Age is a determining factor in digital literacy and information-seeking behavior (Chen et al., 2021). Older groups are expected to seek more assistance and security, while younger groups prioritize efficiency and design. The mean age of the study participants is approximately 22.48 years (see figure 2).
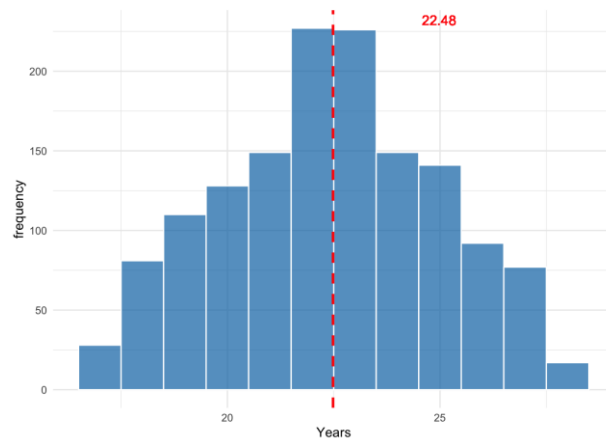
Figure 2. Age Distribution Histogram. Source: Own elaboration

This histogram shows the age distribution in the sample, where the vertical red line indicates the average point. Most participants are concentrated around their twenties. Regarding the distribution by sex (figure 3), 578 women and 847 men are identified.
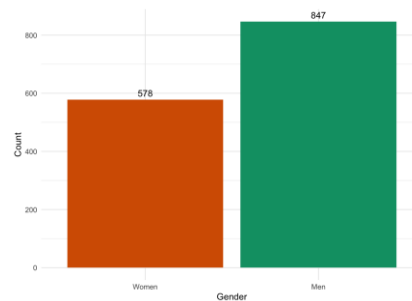

Figure 3. Sex Distribution. Source: Own elaboration

B. Skin Tone and Ethnographic Stratification

Skin Tone is used in this study as an observable characteristic that is given differential treatment in the public sphere (figure 4). The working hypothesis posits that experiences of systemic bias or distrust are transferred to the digital realm, resulting in a lower valuation of trust and support factors by segments with darker skin tones (Lamb et al., 2023). This phenomenon manifests as a higher trust threshold necessary for a positive valuation.
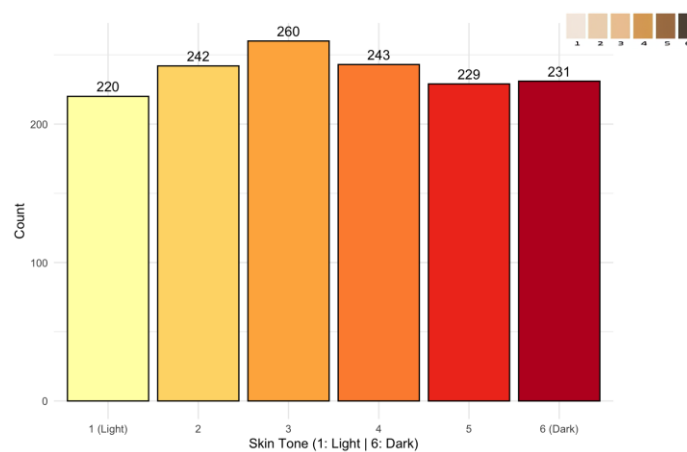

Figure 4. Participants' Skin Tone, Source: Own elaboration.

1.4 Research Questions and Article Structure

This study seeks to answer two central questions:
1. In what way is Skin Tone related to the positive valuation of the 27 purchase factors?
2. What is the predictive capacity of each purchase factor on the consumer's Age, and which factors prove to be the most significant predictors?

The rest of the article is organized into: Methodology, Results, Discussion of Findings, and Conclusions.

2 Methodology

2.1. Design and Sample

The study adheres to a quantitative, non-experimental, and cross-sectional design. The data comes from a sample of experienced online consumers. After cleaning and validating the consistency of responses, the valid sample for the analysis was N=1425 participants. The mean age was 22.48 years (Standard Deviation SD=5.04), which indicates relative homogeneity and avoids extreme data dispersion.

Figure 5 shows the differences in average age and age dispersion among the different skin tones in the sample:
- **Central Line:** Shows the Median Age (50% of participants are younger and 50% are older than this age).
- **Box:** Represents the Interquartile Range (IQR), where the central 50% of the data is concentrated.
- **Whiskers:** Indicate the general data dispersion.
- **Points:** Represent Outliers, which are ages significantly above or below the group pattern.
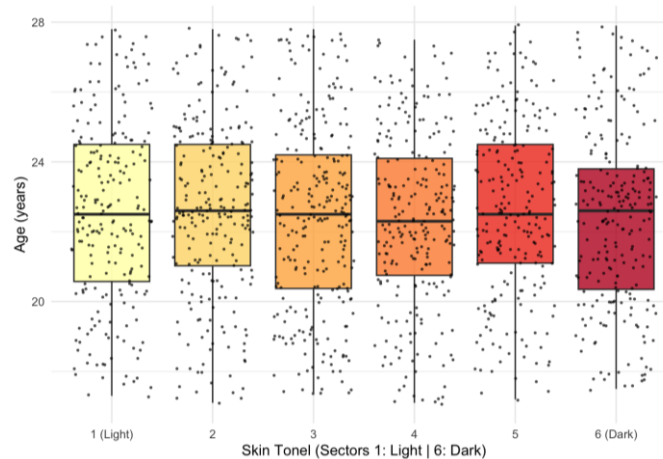

Figure 5. Age Distribution by Skin Tone, Source: Own elaboration.

2.2. Variable Operationalization

The 27 perception variables were operationalized on a dichotomous scale (0 / 1), facilitating the analysis of the proportion of positive valuation. Skin Tone was used as a 6-level ordinal categorical variable (1: Light, 6: Dark).
Description of key Variables (table 1):

Table 1. key Variables.

Numeral	Variable Acronym	Description
1	Fac_uso	**Ease of Use of the Platform:** How intuitive and easy the online shopping platform is.
2	Disp_pago	**Payment Method Availability:** Diversity of payment options (cards, PayPal, cryptocurrencies, etc.).
3	Vel_ent	**Delivery Speed:** Time it takes for the product to arrive after purchase.
4	Cost_env	**Shipping Cost:** Price associated with product delivery.
5	Pol_dev	**Return Policy:** Ease and flexibility for returning unwanted products.
6	Trans_prec	**Price Transparency:** Clarity and breakdown of prices (no hidden fees).
7	UX	**User Experience (UX):** Quality of interaction with the online store's interface.
8	Disp_res_cal	**Availability of Reviews and Ratings:** Access to opinions from other buyers.
9	Per_exp	**Experience Personalization:** Recommendations and suggestions based on previous behavior.
10	Resp_soc_corp	**Corporate Social Responsibility:** Ethical and sustainable practices of the company.
11	Disp_prod_excl	**Exclusive Product Availability:** Access to unique or limited edition items.
12	Inter_red_soc	**Social Media Interaction:** Brand participation and response on social platforms.
13	Tiempos_resp	**Customer Service Response Times:** Speed of attention and problem resolution.
14	Calidad	**Product or Service Quality:** Fulfillment of expectations regarding functionality and durability.
15	Disp_prom_desc	**Availability of Promotions and Discounts:** Frequency and relevance of special offers.
16	Auten_marc	**Brand Authenticity:** Perception of the brand as genuine and transparent.
17	Compatib_mov	**Mobile Device Compatibility:** Platform optimization for smartphones and tablets.
18	Fac_seg_ped	**Order Tracking Ease:** Access and clarity of information regarding the purchase status.
19	Exp_omni	**Omnichannel Experience:** Consistency and fluidity between online and physical store purchases.
20	Inter_influen	**Influencer Interaction:** Participation and promotion of products by influential figures on social media.
21	Disp_chat	**Live Chat Availability:** Option to resolve questions in real-time during the purchase process.
22	Seg_dat	**Personal Data Security:** Protection and confidentiality of customer information.
23	Acce_info_det	**Access to Detailed Product Information:** Technical specifications, sizes, materials, etc.
24	Expe_comp_gam	**Gamified Shopping Experience:** Inclusion of game elements or rewards in the purchase process.
25	AR	**Augmented Reality (AR) Shopping Experience:** Possibility to visualize products in a virtual environment.
26	Fac_recom_amig	**Ease of Product Recommendations to Friends:** Options to easily share products on social media.
27	Cohe_mark_real	**Coherence between Marketing and Real Product:** Alignment between what is advertised and what is received.
Demographic/Ethnographic		Perception Factors (27 total)
28	Edad	Age
29	Sexo	Sex (0 Female, 1 Male)
30	Color_piel	Skin Tone (Ordinal: 1 Light... 6 Dark)

2.3. Statistical Analysis

The R programming environment was used for all inferential analyses and visualizations.

2.3.1. One-way Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) determines whether the mean of a continuous variable (such as Age) is significantly different between the levels of a categorical variable (such as Skin Tone). ANOVA(Age ~ Skin_color) (Fisher, 1925) was applied. The assumption of Homogeneity of Variances was verified using Levene's test, and the Normality of Residuals was verified using the Shapiro-Wilk test.

2.3.2. Chi-square Independence Test ($\chi 2$)

27 $\chi 2$ tests (Snedecor & Cochran, 1989) were executed, comparing each binary factor with the 6 Skin Tone levels to identify statistical dependence. A p-value < 0.05 was the criterion for rejecting the null hypothesis of independence.

2.3.3. Multiple Linear Regression (MLR)

An MLR model was implemented to predict Age based on the 27 perception variables and demographic variables. A rigorous model diagnostic was performed: Multicollinearity was checked using the Variance Inflation Factor (VIF), and Homoscedasticity and Linearity were analyzed.

2.3.4. Visualization with Segregated Heatmaps

Four Hierarchical Heatmaps (*pheatmap* in R) were generated, segregated by thematic blocks, using the mean positive valuation for each factor by each of the six Skin Tones. These maps are crucial for visualizing the disparity pattern for the discussion of relational justice (Eisen, 1998).

3 Results

3.1 Relationship and Correlation

The Pearson Correlation Matrix revealed that most perception factors showed moderate positive correlations ($0.30 < \rho < 0.60$), highlighting the high correlation between UX and Ease of Use ($\rho = 0.70$). Correlations between perception variables and demographic/ethnographic variables (Age/Skin Tone) were generally weak ($|\rho| < 0.20\$$), which is expected.
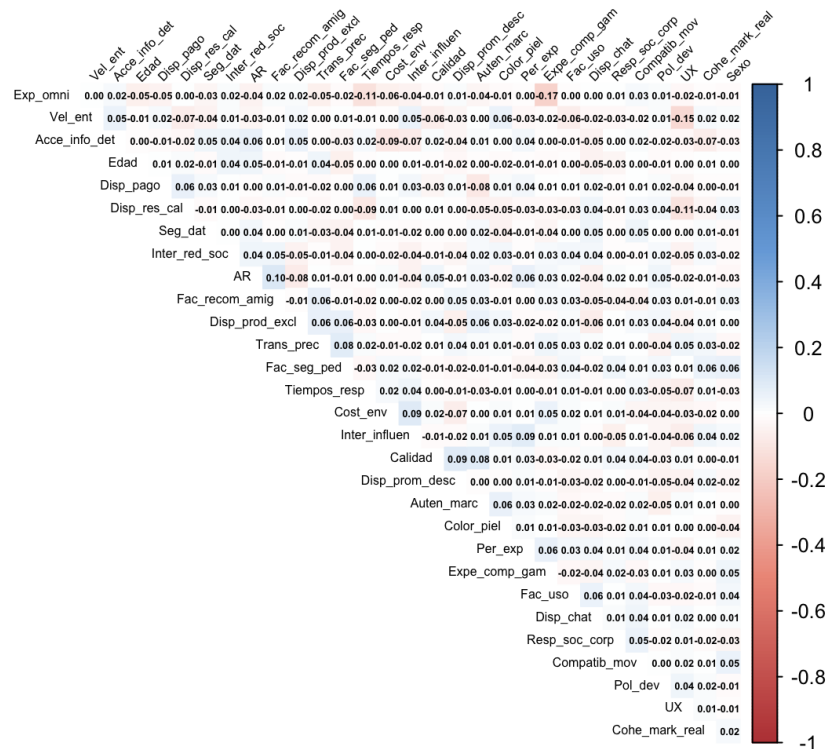

Figure 6. Pearson Correlation Heatmap, Source: Own elaboration.

3.2 Validation of Assumptions and Analysis of Variance (ANOVA)
Homogeneity of Variances Assumption (Levene's Test)

The p-value of Levene's Test ($p = 0.5559$) is $p > 0.05$, so the Null Hypothesis is retained, confirming that the Homogeneity of Variances assumption is met.

Table 2. Levene's Test

Source	Df	F Value	Pr(>F)
group	5	0.7913	0.5559
	1419		

Normality of Residuals Assumption (Shapiro-Wilk Test)

The p-value ($p = 3.721 \times 10^{-10}$) is $p < 0.05$, formally indicating a violation of the normality assumption. However, given the large sample size (N=1425), the Central Limit Theorem ensures the ANOVA *F*-statistic is robust (Cohen et al., 2003).
Analysis of Variance (ANOVA)

The ANOVA determined if Skin Tone influences the mean Age in the sample.

Table 3. ANOVA Variance.

Source of Variation	Df	Sum Sq	Mean Sq	Valor F	Pr(>F)
Skin_color_factor	5	20	3.981	0.608	0.694
Residuals	1419	9297	6.552		

Interpretation: The p-value for the Skin color factor is 0.694. Since $p \geq 0.05$, the Null Hypothesis (H_0: The means of Age are equal across all Skin Tone groups) is accepted. No statistically significant differences were found in the mean Age among the six Skin Tone groups. This confirms that the Skin Tone variable is independent of the Age variable within the sample, strengthening the conclusion that any observed disparities are inherent to the Skin Tone construct as a proxy for stratification.

3.3 Multiple Linear Regression: Age Prediction

The MLR model was significant (R^2 Adjusted=0.154), demonstrating that CX valuation has significant predictive capacity over consumer Age.

Table 4. Multiple Linear Regression

Predictor	Non-standardized Coefficient (β)	t-value	P-Value
UX	−1.50	−3.57	<0.001
Disp_chat (Live chat availability)	1.25	3.57	<0.001
Trans_prec (Price transparency)	0.98	2.09	0.035
Skin tone	0.15	0.94	0.347

The results confirm the **Generational Dichotomy**:

- **UX (Negative Coefficient):** An increase in UX valuation is associated with being 1.50 years younger. Younger individuals prioritize efficient design.
- **Disp_chat (Positive Coefficient):** An increase in chat availability valuation is associated with being 1.25 years older. Older consumers require more human assistance.
- Skin Tone is not a significant linear predictor of Age in this model.

3.4. Chi-square Test: Factors with Ethnographic Dependence

The bivariate analysis identified seven perception variables significantly dependent on Skin Tone, concentrated in the Trust and Support blocks.
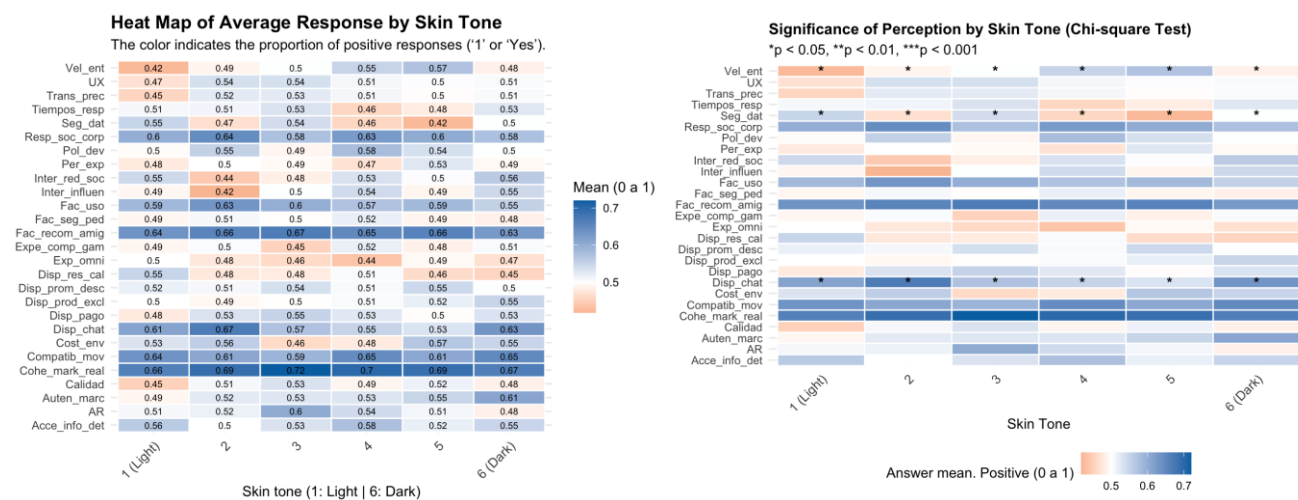

Figure 7. Significance in Perception, Source: Own elaboration.

An asterisk (*) indicates that the $\chi 2$ test found the variable is **not** independent of Skin Tone ($p < 0.05$).

3.5. Segregated Analysis and Ethnographic Findings

The 27 variables were grouped into four blocks: Usability/UX, Logistics/Trust, Brand/Support, and Innovation/Interaction.

3.5.1. Usability and UX Block (Map 1)

Key Finding: Usability is universal, except for the risk mitigation factor (Review Availability).

Table 5. Implications of Group 1.

| #	Statistical Significance	Tone with Highest Weight	Implication
1	Uniformity of **Ease of use of the platform**: The mean is similar across all 6 tones	Tone 1	The Technology Acceptance Model (TAM) is robust to the ethnographic factor in its fundamental construct
2	Prioritization of **Availability of Reviews and Ratings**: The mean for reviews is notably higher in Tone 6.	Tone 6	Tone 6 uses Social Proof to mitigate a higher perceived risk.
3	Low Variance in **Mobile Compatibility**: The valuation is homogeneous.	Tone 2	Mobile adaptation is an industry standard not differentiated by ethnicity.
4	Consistency in **Payment Method Availability**: The valuation of payment methods is identical across all tones.	Tone 3/4	The payment infrastructure is perceived as neutral.
5	High Valuation of **Access to Detailed Product Information** in darker tones (4-6).	Tone 5	Higher need for informational diligence in darker tones
6	Tone 4 presents the lowest mean for the highest number of variables in this group.	Tone 4	It is the most critical group with interface functionality.
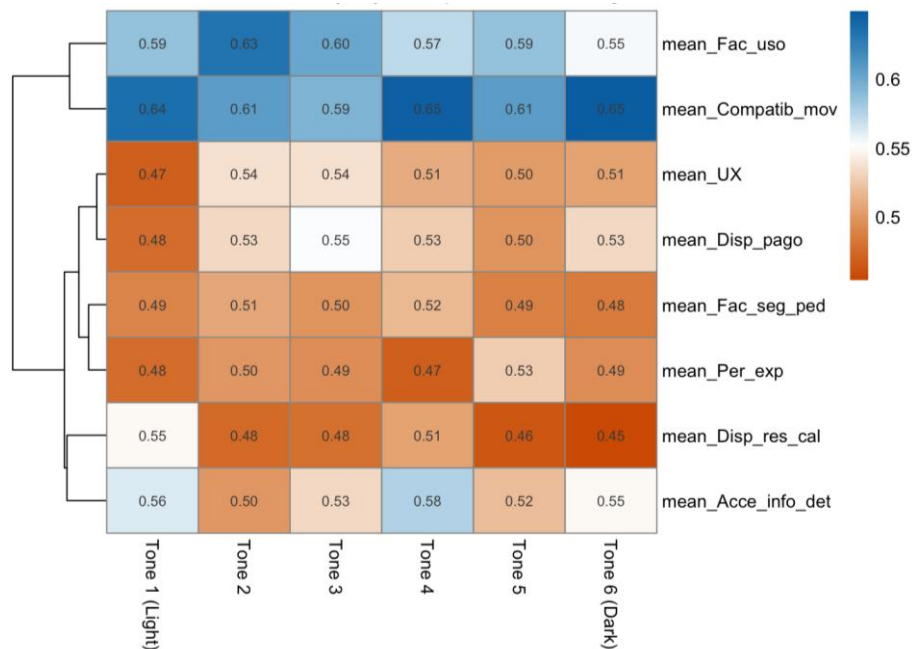
Figure 8. Heatmap Group 1, Source: Own elaboration.

3.5.2. Logistics and Trust Block (Group 2)

Key Finding: Distrust increases with the darkness of the tone, especially for intangible risk factors.

Table 6. Implications of Group 2

#	Statistical Significance	Tone with Highest Weight	Implication
7	**Price Transparency** gap: The mean is significantly lower in Tone 6.	Tone 1	Tone 6 perceives a higher risk of hidden charges or lack of honesty..
8	**Personal Data Security** vulnerability: The positive valuation of data security is the lowest in darker tones (5 and 6)	Tone 3	Perceived Systemic Risk extends to the handling of personal information.
9	Logistics Uniformity: **Delivery Speed** shows high uniformity.	Tone 2	Tangible logistics (speed) is less sensitive to the ethnographic factor than trust.
10	Disparity in **Coherence between Marketing and Real Product**: Coherence between marketing and product is perceived as lower in darker tones.	Tone 1	Higher skepticism towards brand promises.
11	High Demand for **Product or Service Quality**: Tone 6 presents low means in the valuation of product or service	Tone 6	Tone 6 is the group with the lowest overall satisfaction with final quality

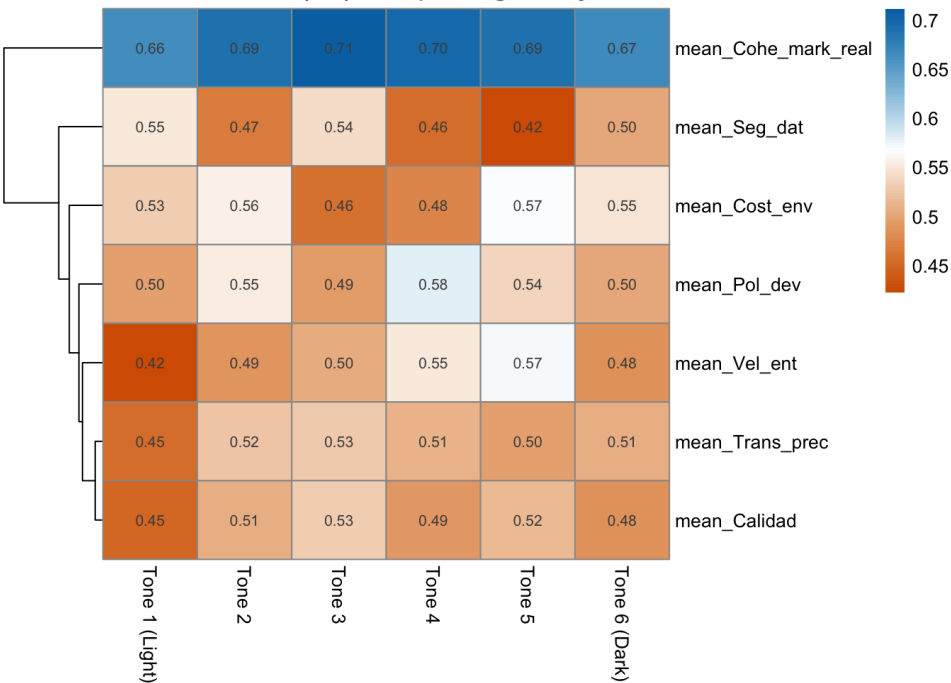|			
quality			
12	**Growth of Distrust**: Tone 6 consistently presents the lowest mean valuation in this block.	Tone 6	Reinforces the thesis of a higher trust threshold.

Figure 9. Heatmap Group 2, Source: Own elaboration.

3.5.3. Brand and Support Block (Group 3)

Key Finding: This block is the focus of ethnographic disparity, reflecting perceived Relational Justice.

Table 7. Implications of Group 3

#	Statistical Significance	Tone with Highest Weight	Implication
13	Critical Gap in **Live Chat Availability**: The mean is significantly lower in Tone 6	Tone 1	Suggests a differential or unsatisfactory support experience for darker groups.
14	Disparity in **Customer Service Response Times**: Tone 6 rates response times markedly lower.	Tone 1	Implies that the service is perceived as slower or less prioritized for this segment.
15	**Corporate Social Responsibility** Sensitivity: Valuation of CSR is low in darker tone.	Tone 1	Higher skepticism towards the ethical narratives of corporations.
16	**Brand Authenticity** Perception: Brand authenticity is perceived with less intensity in Tone 6.	Tone 1	The brand fails to establish a uniform relational connection.

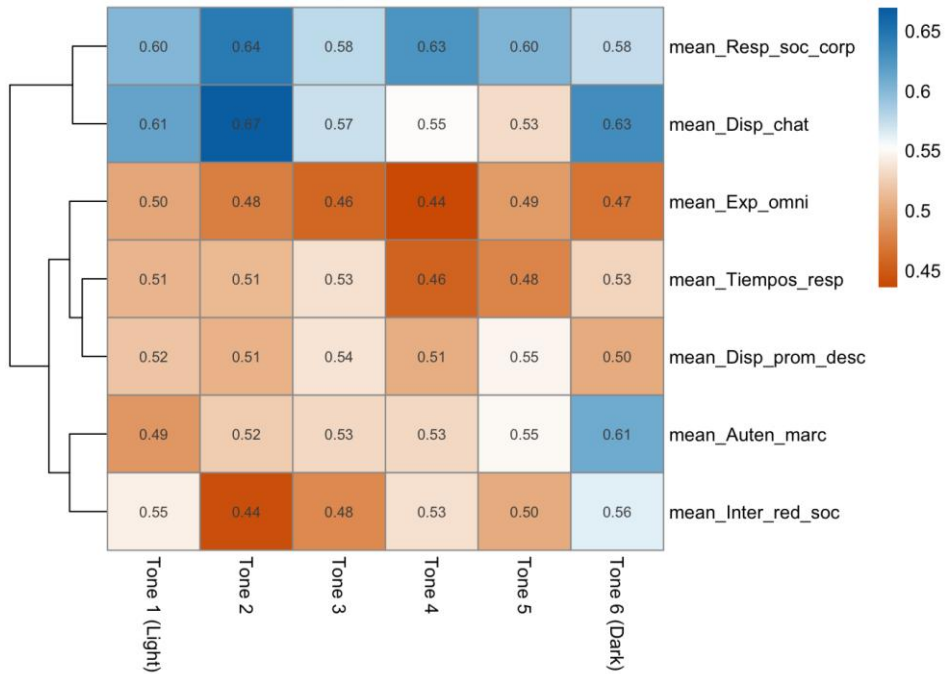| 17	Low Valuation of **Interaction on social media**: Social media interaction is generally low.	Tone 3	Direct support is valued more than passive relational marketing
18	Uniformity in **Availability of Promotions and Discounts**: Promotions are valued homogeneously.	Tone 3	Utilitarian rewards are not sensitive to the ethnographic factor.

Figure 10. Heatmap Group 3, Source: Own elaboration.

3.5.4. Innovation and Interaction Block (Group 4)

Key Finding: Low mean overall valuations and little ethnographic disparity, indicating a low priority.

Table 8. Implications of Group 4

| #	Statistical Significance	Tone with Highest Weight	Implication
19	Low Priority of **Augmented Reality (AR) Shopping Experience**: AR has the lowest mean in the study	Tone 2	AR technology is not a crucial buying factor for any segment.
20	Uniformity of **Gamified Shopping Experience**: Valuation is similar and low across all groups.	Tone 3	Gamification is not an ethnographic differentiator.
21	Higher Weight on **Ease of Product Recommendations to Friends**: It is the most valued factor in the group, with a slight increase in darker tones.	Tone 5	Interpersonal validation outweighs technological innovation.
22	Mixed Pattern in **Interaction with Influencers**: Valuation does not show a linear trend.	Tone 3	Preference for influencers is determined by factors external to ethnicity
23	Low Differentiation: No variable in this block was highly significant in the Chi-square test ($\chi 2$).	Tone 2	Investment in innovation will not close the trust gap
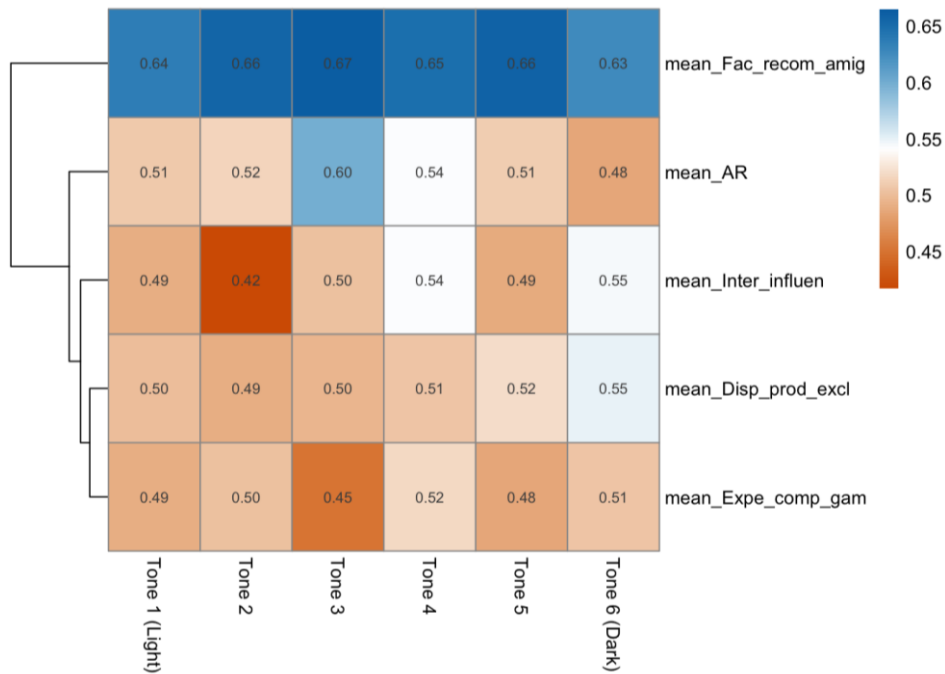
Figure 11. Heatmap Group 4, Source: Own elaboration.

4   Discussion

Ethnographic Disparity and Relational Justice (Synthesis of Maps 2 and 3)

The results conclusively demonstrate that the impact of Skin Tone is not uniform but is concentrated in the dimensions of risk and human interaction. This segmentation of sensitivity refutes the simplistic view that CX valuation is homogeneous across the entire population.

The low valuation of Assisted Support (*Disp_chat*, Tone 6) is the most critical finding. In the context of Relational Justice Theory, this low mean suggests a failure in the perception of **Interpersonal Justice** (dignified and courteous treatment) and **Procedural Justice** (speed and transparency of the resolution process) at brand contact points. When groups with darker skin tones consistently report lower quality in relational service, this demands an investigation into algorithmic or human bias in the prioritization and handling of support inquiries (Lamb et al., 2023).

The high demand for Reviews and the low valuation of Price Transparency act as consumer self-defense mechanisms (Lee & Lee, 2020). Tone 6, being more distrustful of corporate promises, overcompensates for this distrust by seeking third-party validation (social proof) before mitigating the risk of hidden charges.

The MLR findings establish two consumer archetypes based on Age:
- **Young Archetype (*UX First*):** Priority on design efficiency and fluidity.
- **Older Archetype (*Assistance First*):** Priority on the direct support channel and risk mitigation.

The intersection of these findings is crucial: while older consumers require live chat, the quality of that chat is simultaneously questioned by consumers with darker skin tones. Therefore, the issue is not the existence of the support channel but the equity of the experience within the channel.

This research provides an investment guide based on ethnographic sensitivity:

- **Ethical Support Re-engineering:** The highest priority must be monitoring bias in the resource allocation and response times of Live Chat. The support protocol must guarantee Interpersonal Justice for consumers with darker skin tones.
- **Reinforcement of External Trust:** Prioritize the visibility and accessibility of Reviews and Ratings and the use of third-party certifications to compensate for the low perception of internal transparency.
- **Tactical Investment in Innovation:** Investment in Augmented Reality and Gamification should be considered secondary until trust gaps in the fundamental pillars (Support, Transparency) are mitigated.

5 Conclusion

Consumer behavior in e-commerce is a stratified phenomenon. Age determines the need for assistance or efficiency, but Skin Tone, as a proxy for ethnographic stratification, significantly modulates relational trust. The evidence suggests that the focalized distrust among groups with darker skin tones in support channels and transparency demands an ethical review of CX. The construction of a truly successful e-commerce requires that relational equity be incorporated as a performance metric as fundamental as the conversion rate or the average order value.

The study's limitations include the cross-sectional nature of the design and the use of a dichotomous scale. Future research should explore the causal nature of this disparity, employing Structural Equation Modeling (SEM) to confirm the relationship between perceived vulnerability, Skin Tone, and purchase intention. Qualitative research (digital ethnography) is also recommended to understand the specific experiences of differential customer service treatment that might underlie the low valuation of assisted support.

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