(Araştırma)

SEXUAL DIMORPHISM IN THE BRAIN (2D:4D RATIO) AND ITS IMPACT ON GENERATION Z CONSUMER DECISION-MAKING & MARKETING STRATEGIES[1]

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ABSTRACT

This research examines the effects of brain gender on consumer decision-making behaviors in addition to biological sex. In the study in which the general survey model was used, a questionnaire was applied to 536 participants over the age of 18, and data were analyzed using independent samples t-tests. While the findings support the effects of biological gender on consumer decision-making styles, brain gender is also a determining factor in decision-making processes. The findings revealed that individuals with a low 2D:4D ratio (male brain) differed from other female or male consumers on the BCC, NFC, PCC, SAC, and IDC dimensions. In brain gender-based promotion efforts, it is concluded that more effective marketing strategies should be directed by segmenting consumers according to behavioral and cognitive tendencies as well as biological gender. The study suggests that brain gender should be taken into account in marketing strategies to better understand consumer decisions. In addition, it makes an innovative contribution to marketing communication by revealing that a distinction based solely on biological gender is not enough in gender-based marketing strategies, and at this point, communication should be established by focusing on the cognitive and behavioral tendencies of the genders in terms of the 2D:4D ratio.

Keywords: Consumer Decision-Making Styles, 2D:4D Ratio, Sexual Dimorphism on the Brain, Generation Z, Brain Gender, Marketing Communication

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BEYİNDEKİ CİNSEL DİMORFİZM (2D:4D ORANI) VE Z KUŞAĞI TÜKETİCİ KARAR VERME SÜRECİNE VE PAZARLAMA STRATEJİLERİNE ETKİSİ

ÖZET

Bu araştırma, biyolojik cinsiyetin yanı sıra beyin cinsiyetinin tüketici karar verme davranışları üzerindeki etkilerini incelemektedir. Genel tarama modelinin kullanıldığı çalışmada 18 yaş üstü 536 katılımcıya anket uygulanmıştır. Verilerin analizi sırasında bağımsız değişkenler t testinden faydalanılmıştır. Elde edilen bulgular, biyolojik cinsiyetin tüketici davranışları üzerindeki etkilerini desteklerken, beyin cinsiyetinin de karar verme süreçlerinde belirleyici bir faktör olduğunu göstermektedir. Bulgular BCC, NFC, PCC, SAC and IDC boyutlarında düşük 2D:4D oranına sahip bireylerin (erkek beyinli) diğer kadın ya da erkek tüketicilerden farklılaştığını ortaya koymuştur. Beyin cinsiyeti temelli tutundurma çalışmalarında tüketicileri biyolojik cinsiyet yerine davranışsal ve bilişsel eğilimlere göre segmente ederek daha etkili pazarlama stratejilerine yönelinmesi gerektiği sonucunu ortaya çıkmaktadır. Çalışma, pazarlama stratejilerinde tüketici kararlarını daha iyi anlamak için beyin cinsiyetinin dikkate alınması gerektiğini önermektedir. Ayrıca cinsiyet temelli pazarlama stratejilerinde yalnızca biyolojik cinsiyete göre yapılacak bir ayrımın yeterli olmadığı ve bu noktada cinsiyetlerin 2D:4D oranı açısından bilişsel ve davranışsal eğilimlerine odaklanılarak iletişim kurulması gerekliliğini ortaya koyarak pazarlama iletişimine yenilikçi bir katkı sunmaktadır.

Anahtar Kelimeler: Tüketici Karar Verme Tarzları, 2D:4D Oranı, Beyinde Cinsel Dimorfizm, Z Kuşağı, Pazarlama İletişimi, Beyin Cinsiyeti

1. Introduction

Generation Z stands out as a generation that grew up in a period of rapid technological development and lives intertwined with digitalization. The consumer behavior of this generation differs significantly from that of previous generations and offers a new perspective, especially in terms of shopping habits, decision-making processes, and brand preferences. Social media platforms (Fathinasari et al., 2023), video content sites, and mobile technologies (Beregovskaya & Grishaeva, 2020) play an important role in the shopping habits of this generation. Moreover, omnichannel strategies (Mulyani & Chang, 2019) and social media influencers (Bhuwaneshwari & Hemasuruthi, 2023) are important factors shaping Gen Z's shopping decisions. While Generation Z draws a profile that effectively uses digital channels in their shopping while at the same time remaining connected to traditional channels, focusing on individual preferences and experiences, they also stand out as consumers who make faster and more informed decisions (Şentürk, 2023). Their desire to be the first to try the latest products, influenced by social media (Thangavel et al., 2022), leads this generation to impulsive shopping (Jacobsen & Bernes, 2020), while instant discounts (Thangavel et al., 2022) lead Generation Z to make quick decisions. This makes it imperative to adapt various marketing strategies to this generation, while at the same time requiring an in-depth understanding of individual differences within the generation.

In the literature, gender has been considered an important variable in explaining consumer behavior. In studies, it was observed that women scored higher than men in areas such as hedonism, novelty seeking, and price-value consciousness (Anič et al., 2010; Mehta, 2020), with hedonistic and novelty seeking being more dominant in online shopping (Yang & Wu, 2006, 2007). Men, on the other hand, scored higher on factors such as satisfaction, variety seeking, fashion-discount seeking, time-constrained decision-making, and economy-seeking (Mitchell & Walsh, 2004), with decisions in online shopping more focused on economic and time constraints (Yang & Wu, 2007). Yeniçeri and Özal (2016) revealed that consumer decision styles differ in terms of gender identity (androgynous, feminine, masculine, and ambiguous) as well as biological sex. However, some studies have also found that there are no gender-based differences. For example, one study (Rahman, 2019) found no significant difference between male and female consumers in terms of decision-making processes, while another study (Mehta, 2020) found no difference between genders in brand loyalty.

It is known that sex chromosomes carry the genes that determine biological sex. Studies show that the Y chromosome has undergone genetic degeneration and lost the majority of its ancestral active genes (Bachtrog et al., 2011; Hughes et al., 2015; Schartl & Lamatsch, 2023). This degeneration suggests that the biological differences between the genders have changed over time and that genetically based gender differences are not as rigid as we think. In this context, traditional gender-based marketing approaches may be insufficient to explain consumer behavior.

Traditional gender-based marketing helps to understand the different needs and motivations of male and female consumers, making marketing strategies more targeted and effective. When gender differences are taken into account in product design and advertising, brands can gain a competitive advantage. However, the fact that biological gender is dynamic at the genetic level and changes over time shows that these approaches may be insufficient. Today, a marketing approach based solely on biological grounds may ignore individual differences and modern social changes. Biological changes, such as the degeneration of the Y chromosome, suggest that we need to reconsider the differences between males and females. This makes it imperative that gender-based marketing strategies become more flexible and individualized in the future.

Gender is not always an explanatory factor alone for consumer behavior and does not always stand out as a decisive variable in consumer decision-making processes. The content, effectiveness, and effects of gender-based advertising depend not only on demographic characteristics but also on psychographic factors such as gender identity, attitudes, subtypes, and stereotypes. Therefore, to understand consumer behavior, it is not enough to assess only biological differences in perception between males and females. Instead, Zawisza (2019, p. 22) argues that it is also necessary to consider male and female subtypes and individual differences in gender attitudes. Karaismailoğlu and Erdem (2013) emphasized that it is important to understand prenatal-based gender differences in order to understand the cause of gender-based behaviors.

In recent years, in addition to biological gender, gender differences based on brain structure, i.e., sexual dimorphism in the brain, have come to the fore as a potential variable to explain these discrepancies (Şentürk & Tarakçı, 2020). Sexual dimorphism in the brain refers to whether individuals have male or female brain structures, and this distinction can be measured by the length ratio between the index and ring fingers (2D:4D ratio) (Manning et al., 1998; Voracek, 2011; Karaismailoğlu, 2019). This ratio, which is shaped by the effects of hormones taken in the prenatal period (Richards et al., 2020, p. 1), can be crucial for the behavioral tendencies of individuals. In this context, it is believed that some consumer behaviors that cannot be explained by the gender variable can be better understood through sexual dimorphism in the brain.

Generation Z has recently attained the capacity to engage in consumer spending. In light of these considerations, recent studies have directed their attention toward elucidating the distinctive attributes of Generation Z in comparison to those of preceding generations. However, there is a paucity of studies that directly examine gender-based decision-making style differences specific to Generation Z. These findings demonstrate that gender is not a consistently determinative variable in consumer decision-making processes and is not a sufficient explanatory factor in isolation. This study investigates the relationship between brain gender and consumer decision-making styles of Gen Z, addressing the gap in the literature

on how neurobiological factors influence marketing strategies. Studies on the effects of sexual dimorphism in the brain on consumer behavior are limited, and this research argues that brain gender as well as gender differences can play a decisive role in consumer decision processes. Also, this research provides one of the first empirical analyses of the impact of brain gender on marketing decisions, filling a crucial gap in the literature. Generation Z, having grown up in the digital age, has different decision mechanisms than traditional consumer models and is a generation where both biological and cognitive differences can be observed more clearly. Therefore, this study aims to contribute to both the marketing and consumer behavior literature. This research, especially on the younger generation, Generation Z, aims to provide a new perspective on how biological and neurological factors shape consumer behavior. As a result of this study, it will be revealed that marketing strategies should go beyond traditional gender-based approaches and become more individualized and effective by taking biological and neurological differences into account.

2. Conceptual Framework and Hypothesis

Generation Z is a cohort that has been shaped by the digital age, having grown up in an environment where technology is pervasive. Consequently, they exhibit distinctive consumer behaviors compared to previous generations. The purchasing habits of this generation are based on more conscious and personal preferences, and they frequently utilize digital platforms for their shopping. This distinctive approach of Generation Z, founded upon individual preferences (Espejo et al., 2024, pp. 22–23), is transforming marketing strategies. It is therefore crucial to comprehend their purchasing decision-making styles. Decision-making styles can exert a direct influence on marketing strategies by reflecting consumers' attitudes and behaviors throughout the shopping process.

One of the scales frequently used in the literature to determine the decision-making styles of consumers is the consumer decision-making inventory (CSI) of Sproless and Kendall (1986). According to this inventory, consumers show eight different attitudes with three different tendencies (utilitarian, social motivation, and undesirable). Turkish consumers show these three tendencies with nine different attitudes (Dursun et al., 2013). These attitudes are; the consumer's tendency to buy the best quality possible within their own conditions (Perfectionistic, High Quality Conscious Consumer/PQC), the tendency to perceive the higher price as higher quality (Brand Conscious, Price Equals Quality Consumer/BCC), the tendency to shop according to new trends (Novelty and Fashion Conscious Consumer/NFC), the tendency to pay attention to the money spent and therefore follow discounts (Price Conscious “Value for Money” Consumer/PCC), the tendency to buy the product/service they like as soon as they like it without any other details (Impulsive, Careless Consumer/ICC), the tendency to become confused as detailed information about the same product/service increases (Confused by Over choice Consumer/COC), the tendency to identify oneself with

the personality of the brand/store and make similar decisions in general (Habitual Brand Loyal Consumer/HBC), the tendency to consider shopping appropriate in case of necessity (Shopping Avoided Consumer/SAC) and the tendency to have difficulty in deciding from whom to buy as the product/service provider increases (Indecisive Consumer/IDC) (Şentürk, 2023, p. 143).

Gender has long been considered a key variable in the study of consumer behavior. Studies that address differences in consumers' decisions based on gender stereotypes are defined as gender-based marketing approaches. This approach involves marketing products or services based on the gender role characteristics (Arsel et al., 2015), preferences, interests (Lyons et al., 2024), and social roles (Wolin, 2003) of a particular gender. Gender-based marketing is generally constructed according to consumers' biological and psychological gender identities (Pawlikowska, 2011). Often, advertising (Hess & Melnyk, 2016), product design (Petersson McIntyre, 2011), and packaging (Petersson McIntyre, 2018) are tailored to biological gender. For example, elegant, pastel colors are preferred for women, while strong, simple designs are preferred for men. For example, the Barbie brand's "Imagine the possibilities" campaign, which aims to empower girls, defines the female stereotype as a group that can be successful in different professions (Burns, 2015) and includes a visualization with a predominance of pink and pastel tones (Barbie, 2015). Even if stereotypical differences between men and women are made less stereotypical in advertisements for various reasons, advertisements for males and females are treated differently (Wolin, 2003). For example, women are often associated with domestic products, while men may be associated with outdoor activities or technology. Ariel's "Share the Load" campaign, in which Ariel takes a stance against the identification of women with household chores such as laundry, is also proof of the existence of advertisements that associate women with domestic responsibilities. Gender-sensitive social marketing approaches can lead to differentiated strategies for reaching consumers (Pastrana et al., 2022). Moreover, the use of gender stereotypes in gender-based marketing has been criticized for potentially reinforcing both traditional and evolving gender roles. For example, the "Lady Doritos" claim that PepsiCo is planning a chip for women that does not make a sound while eating has received a lot of reaction from women (Özöğretmen, 2018).

It is widely acknowledged in the academic literature that there are discernible differences in the decision-making processes of male and female consumers. For example, the argument has been made that women are more emotional and detail-oriented, while men are more rational and quick decision-makers (Bakshi, 2012, p. 6). However, studies on groups with similar demographic characteristics have demonstrated that these differences are not always consistent (Bakewell et al., 2006; Lin et al., 2019; Mehta, 2020; Mustafa et al., 2022; Rahman, 2019; Yang & Wu, 2007). For example, Manuel (2024) and Wei et al. (2025) found that female consumers' purchase intentions increased with messages emphasizing

entertainment, while men's purchase intentions increased with advertisements emphasizing product service values. In a study conducted by Tor Kadıoğlu and Bozyiğit (2025), it was concluded that female consumers, consisting of Generation Y and Generation Z, take reliability into consideration in luxury segment products, while men are only influenced by the attractiveness of celebrities used in advertisements in this dimension. Erden et al. (2025) state that women focus on faces in advertisements while men focus on calls to action.

Biological gender identity is a complex, multifactorial trait (Polderman et al., 2018) shaped by genetic, hormonal, and psychosocial influences (Fisher & Cocchetti, 2020). The genetic basis of biological gender is determined by the chromosomes they carry. The formation of an individual's gender occurs through the interaction of a series of genes (Slee & Bownes, 1990). Basically, it is stated that mammals carrying the XX gene are female and mammals carrying the XY gene are male (Wilhelm & Bagheri-Fam, 2019). However, recent studies show that the Y chromosome has undergone genetic degeneration and lost the majority of its ancestral active genes (Bachtrog et al., 2011; Hughes et al., 2015; Schartl & Lamatsch, 2023). This degeneration suggests that the biological differences between the sexes have changed over time and that genetically based sex differences are not as rigid as we think. It is also reported in the literature that gender may change over time in the direction of female dominance (Roy, 2023). The fact that biological sex has lost various features of the Y chromosome suggests that traditional gender-based marketing approaches may be insufficient to explain consumer behavior. In cases where gender alone is not sufficient, other variables are sought to explain the situation. Sex differences based on brain structure, i.e., sexual dimorphism in the brain, stand out as a new variable that can explain these inconsistent results.

The 2D:4D ratio is an indicator of whether the brain has a male or female sex, depending on an individual's prenatal hormone exposure (Kaczmarski et al., 2015). Studies on the 2D:4D ratio began to intensify in the medical field in the early 2000s (Hoag, 2008). Following the prominent consideration of sexual dimorphism in the brain, research on the 2D:4D ratio and personality traits gained momentum (Voracek, 2011). Male and female brains are size-dimensionally different from each other. It is known that the male brain is larger than the female brain (Sullivan et al., 2004) and has a higher nerve conduction velocity (Reed et al., 2004). These differences in brain structure cause individuals to differ in areas such as understanding emotions (Wager et al., 2003), perception (Naliboff et al., 2003), self-expression (Josse & Tzourio-Mazoyer, 2004), information processing and problem-solving (Rahman et al., 2004), remembering events (Kimura, 1996), and emotions. Moreover, even responses to hormones such as stress are affected by this dimorphism (Eşel, 2005). As it can be understood, sexual dimorphism in the brain is accepted as a factor that affects individuals' personality traits (Fink et al., 2004; Lippa, 2006), behavioral and cognitive tendencies (Karaismailoğlu,

2019), and even the way they react to hormones such as stress. For example, a study on women by Wade et al. (2004) found that female-brained women rated their own physical attractiveness higher. Another study by Weis et al. (2007) has similar results to these. In a study conducted by Millet and Buehler (2018), it was concluded that there might be relationships between the 2D:4D ratio and attitudes, traits, or behaviors. They concluded that the attitudes of male-brained biological men differ from female-brained biological men when it comes to status. They expressed their belief that this result could explain the differentiation of economic decisions. Nelson and Shultz (2010) suggest that prenatal testosterone exposure diversifies social behaviors. This diversity can manifest itself especially in the form of aggression and competition. They stated that the sense of competition is higher in societies with a low 2D:4D ratio. However, while the discussion of the concept is still new even in the medical literature, studies in the field of social sciences are very limited.

A study conducted at Harvard University in 2001 comparing the brains of healthy men and women showed that the frontal lobe and limbic cortex are larger in the female brain than in the male brain (Hoag, 2008). This finding supports that individuals with female brains may exhibit different approaches in areas such as decision-making, problem-solving, and regulating emotions. Similarly, in a study conducted by Şentürk and Tarakcı (2020) in the field of marketing, the effect of the 2D:4D ratio on consumers' decision-making behavior was examined, and it was concluded that female consumers differ in terms of brain gender. According to the study, women with male brain structures experience more information confusion with the new information they are exposed to and show indecision in their purchasing decisions. This shows that brain gender can be considered a determinant variable in cases where biological gender is insufficient to explain consumer behavior.

Generation Z is the last generation whose attitudes can be measured most clearly in terms of age cohorts. It is predicted that this generation may experience the change in the Y chromosome more intensely than other generations, and it is known that they differ from other generations due to the social, economic, and technological differences of the generation to which they belong. The association of intergenerational differences with biological indicators such as prenatal testosterone and estrogen exposure has not yet been sufficiently elucidated. It is thought that Generation Z may experience the interaction between biological sex and brain sex differently due to environmental factors, digital interactions, and increasing sociocultural diversity. In this context, it is predicted that the biological and brain sex differences of individuals in Generation Z may have different effects on consumer decision-making styles and change the consumer's perception of marketing messages and product presentation; however, brain differences due to prenatal hormone exposure among individuals of the same biological sex may create diversity in purchasing decisions.

***H_1**: Generation Z consumers with different brain genders in terms of the 2D:4D ratio show different consumer decision-making styles.*

***H_2**: Generation Z consumers who have the same biological gender but different brain gender in terms of 2D:4D ratio show different consumer decision-making styles.*

Sexual dimorphism in the brain may lead to differences in individuals' cognitive and emotional processes and affect their decision-making styles. This suggests that the differences observed between biological gender and decision-making processes may actually stem from the gender of the brain. In the literature, it has been suggested that male and female brains show structural and functional differences (Hoag, 2008; Sullivan et al., 2004) and that these differences are determinant of individuals' cognitive abilities (Josse & Tzourio-Mazoyer, 2004). However, biological gender and brain gender do not always coincide (Millet & Buehler, 2018). In addition, individual acceptance of biological gender has also changed over time. Notably, the number of individuals who identify as the opposite sex to their biological gender, as well as those who consider themselves genderless, has increased in society. Therefore, traditional approaches to consumer behavior based on biological gender may be insufficient to explain consumers' decision-making processes. If consumer decision-making styles were based solely on biological gender, one would expect to see sharp differences between males and females. However, when differences based on brain gender are analyzed, it is hypothesized that individuals with the same brain structure may show more similar tendencies in consumption decisions.

***H_3**: Generation Z consumers who have the same brain gender in terms of 2D:4D ratio but different biological genders show similar consumer decision-making styles.*

Although the impact of biological gender on consumer behavior has been frequently examined, the relationship between brain gender and consumer decision-making styles has not been sufficiently investigated in the literature. Existing research (Şentürk & Tarakçı, 2020) suggests that brain gender may also be a determining factor. Therefore, Hypothesis 4 examines whether consumer decision-making differences observed on the basis of biological sex overlap with differences observed on the basis of brain sex. If these two variables overlap, the role of biological gender in shaping consumer behavior may be largely dependent on brain structure.

***H_4**: Differences in consumer purchase decision-making styles based on biological gender are consistent with differences based on brain gender.*

The existing literature lacks studies linking brain gender to consumer behavior. In this context, this research aims to bridge this gap.

3. Methodology

The purpose of this research is to expand the theoretical framework by examining consumer purchase decision-making styles in terms of sexual dimorphism in the brain (2D:4D ratio). For this purpose, the study aims to examine the purchase decision-making styles of Generation Z consumers in the context of sexual dimorphism in the brain (2D:4D ratio). In the research, the general survey model, one of the descriptive research methods, was preferred because this model is the most appropriate approach to examine the existing patterns of Generation Z consumers' purchasing decision-making styles in detail and to understand the relationships between these phenomena (Karasar, 2014).

The population of the study consists of Hitit University Osmancık Ömer Derindere Vocational School's students within the normal education period. Due to time and resource limitations, the sample selection was carried out by convenience sampling, one of the non-random sampling methods. This method was preferred in terms of providing easy access to the participants by the researchers; however, it has limitations in terms of generalizability, as it carries the risk of not representing the entire population. This suggests that caution should be exercised in generalizing the results to all Generation Z consumers. Further studies on Generation Z individuals with different geographical regions, education levels, or socioeconomic status may increase the generalizability of the findings.

This study was conducted in accordance with the decision of the Hitit University Non-Interventional Research Ethics Committee dated 27.12.2023 and numbered 2023-22. The field study of the research was conducted between January 03 and 08, 2024, and 536 students participated in the study. The randomly filled questionnaires and those belonging to those outside the age range of Generation Z were eliminated from the obtained questionnaires, and 491 questionnaires were finally analyzed. The sample size represents the universe with ±5 sampling error at a 95% confidence interval. The demographic characteristics of the 491 students participating in the research are as follows: 52.5% of the participants were female, and 47.5% were male. The age distribution is between 18 and 27 years old, with an average age of 20. In terms of education level, all participants are vocational college students, and all of them are within their normal education period. It was observed that the participants mostly lived on family support and had a limited income level.

Face-to-face survey and CAPI (computer-assisted face-to-face interview) methods were used in the data collection process. The face-to-face survey method was chosen to ensure that the participants answer the questions more carefully and accurately, and to ensure measurement reliability by measuring the 2D:4D ratio by a single person. The CAPI method was chosen to reduce data entry errors by standardizing the data collection process. In addition, to determine sexual dimorphism in the brain, the lengths of the index finger (2D) and ring finger (4D)

were measured with a ruler, and a standardized procedure was followed for the accuracy of these measurements. Each measurement was made on the right hand of the participants, and the measurement was taken twice and averaged to account for possible measurement errors.

The questionnaire used consists of three sections. The first section includes demographic questions that define the participants. The second section includes measurement results for the index finger (2D) and ring finger (4D). The third section includes the Consumer Decision-Making Styles Scale (CSI) adapted to Turkish by Dursun et al. (2013). This scale consists of 9 sub-dimensions and 22 questions. In the reliability analysis, the Cronbach alpha value of the scale was calculated as .896, and it was shown to have a high internal consistency. The validity of the scale has been confirmed in previous studies.

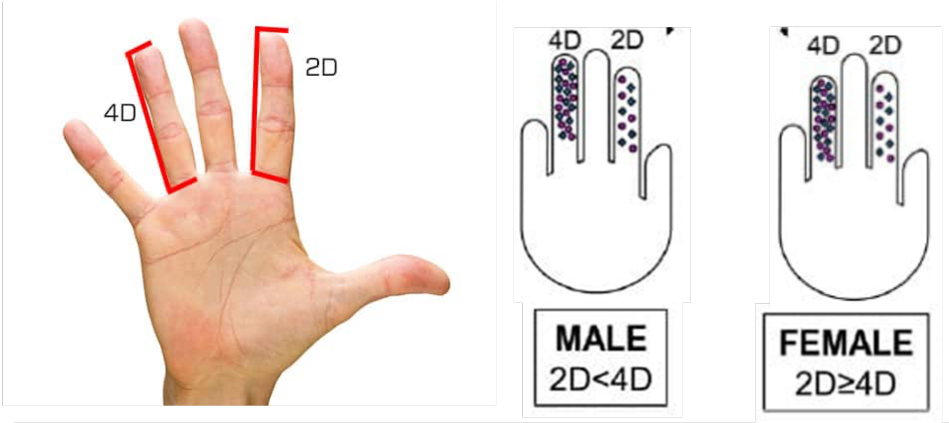

Figure SEQ Figure * ARABIC 1. 2D:4D Finger Ratio Determination Method

Sexual dimorphism in the brain was determined by the 2D:4D ratio. To ascertain sexual dimorphism in the brain, the lengths of the index finger (2D) and ring finger (4D) were measured. Subsequently, the gender of the brain was determined by calculating the ratio of the length of the index finger to that of the ring finger. A ratio of less than 0.980 indicates a male brain, while a ratio greater than 1,000 indicates a female brain (Karaismailoğlu, 2019; Nelson et al., 2006). However, it is not feasible to ascertain a definitive gender for ratios within the range of 0.980-1.000 through this methodology. Muscle and bone development may differ due to geographical and hereditary characteristics, and different results may occur in different geographies (Hurd & van Anders, 2007). Consequently, measurements within this range were excluded from the analyses (Karaismailoğlu, 2019, p. 207). The skewness and kurtosis values of the data obtained through questionnaires are between -1.5 and 1.5, according to Tabachnick and Fidell's (2013) criteria, and show a normal distribution. Therefore, the data were analyzed using t-tests to compare groups to examine the relationship between brain gender and consumer decision-making styles. Frequency analysis was used to describe the demographic

characteristics and response distributions of the participants. The general structure of the data set was summarized with basic statistics such as mean and standard deviation. An independent samples t-test was selected to test the differences between the 2D:4D ratios and purchasing decision-making styles of Generation Z consumers. This test is an appropriate method to determine whether there are statistically significant differences between the two groups.

The study includes several limitations. Only Hitit University Osmancık Ömer Derindere Vocational School students were involved, which makes it difficult to generalize the results to other Generation Z groups. The data collection process was carried out in a short period of time, January 03-08, 2024, preventing the observation of different dynamics that could occur in a wider time period. The risk of the convenience sampling method not fully representing the universe is another limitation in terms of generalizability. Although this method provides practical advantages, due to convenience sampling, the results cannot be generalized to the entire Generation Z population. In addition, although the CAPI method offers the advantages of face-to-face interviews, the possible effects of the survey implementer on the participants (e.g., the risk of manipulation) should not be ignored.

4. Findings

Table 1 shows the distribution of 2D:4D ratios of the participants in the study according to their biological gender. The data were evaluated in terms of both biological gender (female and male) and categories of sexual dimorphism in the brain based on the 2D:4D ratio (female, male, unidentified). In total, 491 participants took part, of whom 52.5% were female and 47.5% were male. There were slightly more women (n=258) than men (n=233), but the overall distribution was fairly balanced.

Table 1. Distribution of 2D:4D Ratios According to Participants' Biological Gender

		2D:4D Ratio							
		Female		Male		Undefinable		Total	
		n	%	n	%	n	%	n	%
Gender	Female	114	44.2	111	43.0	33	12.8	258	52.5
	Male	93	39.9	114	48.9	26	11.2	233	47.5
	Total	207	42.16	225	45.82	59	12.02	491	100.00

A distribution analysis according to biological sex revealed that 44.2% of female participants exhibited a female (2D:4D > 1,000) brain pattern, while 43.0% demonstrated a male (2D:4D < 0.980) brain pattern based on the 2D:4D ratio. A total of 12.8% of the female participants were classified as belonging to the undefinable category, with a 2D:4D ratio falling between 0.980 and 1.000. Among

male participants, 39.9% exhibited a female (2D:4D > 1,000) brain profile, 48.9% demonstrated a male (2D:4D < .980) brain profile, and 11.2% exhibited an undefinable brain profile (2D:4D .980 < 1,000). Overall, 42.16% of the participants were identified as exhibiting female-brained characteristics, 45.82% were classified as male-brained, and 12.02% were designated as unidentified. The data indicate that there is no exact correspondence between biological gender and 2D:4D ratios. Among those identified as female biologically, 43.0% exhibited a male 2D:4D ratio. Similarly, 39.9% of biologically male participants exhibited a female 2D:4D ratio, indicating that the 2D:4D ratio is not an accurate indicator of biological sex. This suggests that there may be different dynamics between brain gender identity determined by the 2D:4D ratio and biological gender identity. Consequently, gender-based studies in consumer decision-making styles may be more complex than the biological gender distinction. At the same time, Table 1 also shows that the sample group reached is suitable for testing H_1 and H_2.

Table 2. Investigation of CSI in terms of 2D:4D Ratio

	Group Statistics				Test Statistics		
CSI	**2D:4D Ratio**	**n**	$\underline{X}$	**s.d.**	**t**	**df**	**p**
PQC	Female	207	3.56	0.93	-1.882	430	.061
	Male	225	3.72	0.83			
BCC	Female	207	2.92	0.91	-1.848	430	.065
	Male	225	3.08	0.87			
NFC	Female	207	2.88	1.04	-3.157	430	**.002**
	Male	225	3.19	0.99			
PCC	Female	207	3.56	0.85	-2.616	430	**.009**
	Male	225	3.77	0.79			
ICC	Female	207	2.88	1.00	-1.497	430	.135
	Male	225	3.03	0.98			
COC	Female	207	3.56	0.91	.839	430	.402
	Male	225	3.48	0.91			
HBC	Female	207	3.33	0.97	-1.028	430	.305
	Male	225	3.42	0.92			
SAC	Female	207	2.84	1.03	-1.954	430	.051
	Male	225	3.05	1.17			
IDC	Female	207	3.12	0.98	-2.490	430	**.013**
	Male	225	3.35	0.98			

Table 2 illustrates the significant differences in decision-making styles based on brain gender. It is examined whether there is a significant difference between the consumer decision-making styles of consumers with different 2D:4D ratios. According to the results in Table 2, PQC (p=0.061), BCC (p=0.065), ICC (p=0.135), COC (p=0.402), HBC (p=0.305), and SAC (p=0.051) dimensions do not show a statistically significant difference in terms of sexual dimorphism in the brain. In other words, as shown in Table 2, there is no significant difference between female and male brains on the six dimensions of the CSI. On the other hand, it has been determined that male brains may have a significantly higher tendency than female brains on the NFC (p=0.002) dimension. This result suggests that male brains may be more inclined to try new products and seek novelty in consumer experiences. In the PCC dimension (p=0.009), it was also observed that male brains may tend to behave more consciously than female brains. It can be said that male brains may be more careful about price while shopping. In addition, the IDC dimension (p=0.013) was also found to be significantly higher in male brains compared to female brains, suggesting that male brains may experience more hesitation in decision-making processes. A study by Webber et al. (2018) revealed that low 2D:4D ratios tend to respond more to motivational stimuli. In this context, the fact that male brains tend to try new products and seek novelty more (NFC) and are more careful about price when shopping (PCC) may overlap with the tendency of low 2D:4D ratios to respond more to motivational stimuli. This inference suggests that male brains' interest in innovative products and their more conscious evaluation of price sensitivity may be related to their sensitivity to motivational stimuli. Therefore, it is thought that consumers with low 2D:4D ratios may give more dynamic and strategic responses in terms of consumer behavior.

As shown in Table 2, brain gender appears to influence consumer behavior, with significant differences observed between female and male brains in certain behavioral patterns, supporting Hypothesis 1. In other words, the findings indicate that male-brained consumers may act with different motivations in consumer behavior. This suggests that sexual dimorphism differences in the brain should be taken into account when creating marketing strategies and that it may be useful to shape approaches and strategies toward consumers in accordance with these differences.

Table 3. Investigating the CSI of Consumers of the Same Biological Gender with Different 2D:4D Ratios

		Group Statistics				Test Statistics		
Gender	**CSI**	**2D:4D Ratio**	**n**	***X***	**s.d.**	**f**	**df**	**p**
FEMALE	PQC	Female	114	3.54	0.92	-0.811	223	.418
		Male	111	3.64	0.93			
	BCC	Female	114	2.87	0.88	-0.514	223	.608
		Male	111	2.93	0.85			
	NFC	Female	114	2.87	0.93	-1.740	223	.083
		Male	111	3.09	0.98			
	PCC	Female	114	3.44	0.85	-2.713	223	**.007**
		Male	111	3.74	0.80			
	ICC	Female	114	2.81	0.95	-1.000	223	.319
		Male	111	2.94	1.00			
	COC	Female	114	3.52	0.96	0.136	223	.892
		Male	111	3.50	0.96			
	HBC	Female	114	3.36	1.01	-0.039	223	.969
		Male	111	3.36	0.97			
	SAC	Female	114	2.59	1.05	-1.038	223	.301
		Male	111	2.75	1.20			
	IDC	Female	114	3.54	0.92	-1.994	223	**.047**
		Male	111	3.64	0.93			
MALE	PQC	Female	93	2.87	0.88	-1.787	168.905	.076
		Male	114	2.93	0.85			
	BCC	Female	93	2.87	0.93	-1.914	205	.057
		Male	114	3.09	0.98			
	NFC	Female	93	3.44	0.85	-2.559	181.212	**.011**
		Male	114	3.74	0.80			
	PCC	Female	93	2.81	0.95	-0.747	205	.456
		Male	114	2.94	1.00			
	ICC	Female	93	3.52	0.96	-0.969	205	.334
		Male	114	3.50	0.96			
	COC	Female	93	3.36	1.01	1.141	205	.255
		Male	114	3.36	0.97			
	HBC	Female	93	2.59	1.05	-1.483	205	.140
		Male	114	2.75	1.20			
	SAC	Female	93	3.54	0.92	-1.394	205	.165
		Male	114	3.64	0.93			
	IDC	Female	93	2.87	0.88	-1.456	205	.147
		Male	114	2.93	0.85			

Another analysis conducted in the research was whether there is a difference in the decision-making styles of consumers with the same biological gender but different brain genders. Table 3 shows the differentiation of biologically same-gendered consumers in terms of brain gender. According to the results of the independent variables t-test analysis conducted in this direction, consumers whose biological gender is female do not differ significantly in PQC (p=0.418), BCC (p=0.608), NFC (p=0.083), ICC (p=0.319), COC (p=0.892), HBC (p=0.969), and SAC (p=0.301) dimensions. However, there is a statistically significant difference between female-brained women and male-brained women in terms of "price consciousness" in the PCC (p=0.007) dimension according to the 2D:4D ratio. Male-brained women differ from others in price-conscious behaviors. Likewise, there is a statistically significant difference in the IDC (p=0.047) dimension according to the 2D:4D ratio. It can be said that male-brained female consumers differ from others in terms of having difficulty in decision-making. Eşel (2005) states that the female brain is more successful in understanding emotions and empathizing than the male brain. In addition, it is known that language processing skills are higher in the female brain (Karaismailoğlu & Erdem, 2013), so it can be thought that they can distinguish various messages more clearly. Therefore, at this point, it seems to be an acceptable result that women with male brains experience indecision. It can be inferred that male-brained female consumers are more careful about price and may be more indecisive. These findings are consistent with the results of the study conducted by Şentürk and Tarakçı (2020) on women. In the related study, it was determined that male-brained women differed in COC and IDC dimensions.

According to the findings of the research, no significant difference is generally observed in the decision-making styles of consumers whose biological gender is male according to the 2D:4D ratio. No significant differentiation was observed in the PQC (p=0.076); BCC (p=0.057); PCC (p=0.456); ICC (p=0.334); COC (p=0.255); HBC (p=0.140); SAC (p=0.165); and IDC (p=0.147) dimensions of consumers whose biological sex is male. However, a significant difference was detected in the NFC dimension (p=0.011), indicating that male-brained men exhibit greater innovation and fashion awareness, supporting Hypothesis 2. Trying something new brings with it the risk of being disliked, criticized, or suffering financial loss. However, the literature shows that risk-taking propensity is higher in the lower 2D:4D ratio (especially in biological males) (Garbarino et al., 2011; Stenstrom et al., 2011; Xie et al., 2017).

These findings suggest that consumer segmentation based on the 2D:4D ratio can play an important role in marketing strategies. Especially in certain product groups, it is possible to develop personalized marketing campaigns and strategies by taking these differences into account. Since male-minded female consumers are price-conscious and indecisive, strategies that offer price advantages, comparison shopping, and discount opportunities in categories such as fashion,

technology, and food can be applied to this group, for male consumers with a male brain, trend- and innovation-oriented campaigns should be offered, especially in categories such as clothing, care products, and technology, in line with innovation and fashion consciousness. In this group, personalized marketing strategies can be developed by highlighting new products, fashion trends, and technological developments.

Table 4. Investigating the CSI of Consumers of Different Genders with the Same 2D:4D Ratio

		Group Statistics				Test Statistics		
2D:4D Ratio	**CSI**	**Gender**	**n**	$\underline{X}$	**s.d.**	**t**	**df**	**p**
Female	PQC	Female	114	3.54	0.92	-0.315	205	.753
		Male	93	3.58	0.95			
	BCC	Female	114	2.87	0.88	-0.927	205	.355
		Male	93	2.99	0.95			
	NFC	Female	114	2.87	0.93	-0.169	174.721	.866
		Male	93	2.90	1.16			
	PCC	Female	114	3.44	0.85	-2.354	205	**.019**
		Male	93	3.72	0.82			
	ICC	Female	114	2.81	0.95	-1.233	205	.219
		Male	93	2.98	1.05			
	COC	Female	114	3.52	0.96	-0.588	205	.557
		Male	93	3.60	0.85			
	HBC	Female	114	3.36	1.01	0.397	205	.692
		Male	93	3.30	0.94			
	SAC	Female	114	2.59	1.05	-4.000	205	**.000**
		Male	93	3.15	0.94			
	IDC	Female	114	3.07	0.96	-0.672	205	.502
		Male	93	3.17	1.01			
Male	PQC	Female	111	3.64	0.93	-1.387	207	.167
		Male	114	3.79	0.72			
	BCC	Female	111	2.93	0.85	-2.620	223	**.009**
		Male	114	3.23	0.87			

MALE	NFC	Female	111	3.09	0.98	-1.452	223	.148
		Male	114	3.29	0.98			
	PCC	Female	111	3.74	0.80	-0.566	223	.572
		Male	114	3.80	0.77			
	ICC	Female	111	2.94	1.00	-1.356	223	.177
		Male	114	3.11	0.96			
	COC	Female	111	3.50	0.96	0.363	223	.717
		Male	114	3.46	0.86			
	HBC	Female	111	3.36	0.97	-1.035	223	.302
		Male	114	3.49	0.86			
	SAC	Female	111	2.75	1.20	-3.965	218	**.000**
		Male	114	3.35	1.06			
	IDC	Female	111	3.33	0.99	-0.268	223	.789
		Male	114	3.37	0.98			

Another examination in the research is whether there is a difference in the decision-making styles of consumers with the same brain gender but different biological genders. Table 4 shows the differentiation of individuals with the same brain gender in terms of their biological gender. According to the results of the independent variables t-test analysis conducted in this direction, no significant difference was found in terms of biological gender in the PQC, BCC, NFC, ICC, COC, HBC, and IDC dimensions of consumers with different biological genders whose brain gender is female ($p>0.05$). However, it is observed that male consumers differ from female consumers in PCC ($p=0.019$) and SAC ($p=0.000$) dimensions. This situation can be interpreted as that male-minded female consumers pay more attention to price and tend to avoid shopping more than female-brained female consumers. From a biological gender perspective, it is known that women are more likely to shop. For example, a study conducted by Chetioui and El Bouzidi (2023) in Morocco shows that Generation Z female consumers' fear of missing out - also referred to as conformity (Webber et al., 2018) - increases their likelihood of engaging in hedonic and impulsive shopping behavior. This may suggest that the brain gender of female consumers who avoid shopping may be different.

No significant difference was found in terms of biological gender in the PQC, NFC, PCC, ICC, COC, HBC, and IDC dimensions of male-brained consumers with different biological genders ($p>0.05$). However, in the BCC dimension ($p=0.009$), and the SAC dimension ($p=0.000$), where male-brained men differed from male-brained women. While decision-making styles were generally similar among consumers with the same brain gender but different biological genders, the

presence of differing dimensions led to the rejection of Hypothesis 3.

While these findings show the influence of biological gender on some consumer behaviors, they also reveal that individuals with the same brain gender are similar in most consumption decisions. This supports the assumption that marketing strategies can be personalized in a more nuanced way by taking into account factors such as brain gender in addition to biological gender.

Table 5. Analyzing CSI in terms of Biological Gender

	Group Statistics				Test Statistics		
CSI	**Gender**	**n**	$\underline{X}$	**s.d.**	**t**	**df**	**p**
PQC	Female	225	3.59	0.93	-1.283	430	.200
	Male	207	3.70	0.84			
BCC	Female	225	2.90	0.87	-2.596	430	**.010**
	Male	207	3.12	0.91			
NFC	Female	225	2.98	0.96	-1.306	413	.192
	Male	207	3.11	1.08			
PCC	Female	225	3.59	0.84	-2.206	430	**.028**
	Male	207	3.76	0.80			
ICC	Female	225	2.87	0.97	-1.914	430	.056
	Male	207	3.05	1.00			
COC	Female	225	3.51	0.96	-0.096	430	.924
	Male	207	3.52	0.86			
HBC	Female	225	3.36	0.99	-0.501	430	.617
	Male	207	3.40	0.90			
SAC	Female	225	2.67	1.13	-5.743	430	**.000**
	Male	207	3.26	1.01			
IDC	Female	225	3.20	0.98	-0.795	430	.427
	Male	207	3.28	0.99			

Finally, consumer decision-making styles were examined in terms of biological gender as seen in Table 5. No statistically significant difference was found in PQC (p=0.200), NFC (p=0.192), ICC (p=0.056), COC (p=0.924), HBC (p=0.617), and IDC (p=0.427) dimensions by gender (p>0.05). However, men differ statistically from women in BCC (p=0.010), PCC (p=0.028), and SAC (p=0.000) dimensions. In other words, it can be said that men attach more importance to brand and quality-price equivalence, may be more sensitive to price and value for money

than women, and have higher shopping avoidance tendencies than women. When the results from Table 2 and Table 5 are evaluated together, it is observed that while some decision-making styles show consistency between biological gender and brain gender differences, inconsistencies exist in certain dimensions. Thus, Hypothesis 4 is supported.

Especially in the PCC dimension, consumers whose biological gender is male and consumers whose brain gender is male exhibited similar results. Both groups are more price-conscious and careful about price. This suggests that price sensitivity may be a determining factor for both biological gender and brain gender. However, only a significant difference based on brain gender was found in the IDC dimension. Male-brained consumers experience more hesitation in their decision-making process compared to female-brained consumers. However, there is no significant difference in terms of biological gender in this dimension, which suggests that the difference based on brain gender is more pronounced. In terms of BCC, there was a significant difference based on biological gender, while no such difference was observed in terms of brain gender. Males were found to attach more importance to brand and quality-price relationships than females, but this did not differ according to brain gender. Finally, while biological gender did not make a difference in the NFC dimension, in terms of brain gender, it was observed that male brains were more oriented towards novelty seeking. This finding suggests that brain gender may have different effects on consumer behavior independent of biological gender.

In general, while the results of biological gender and brain gender overlap in some consumer decision-making styles, it is concluded that brain gender is more determinant in some dimensions. This situation reveals that consumer behavior cannot be explained only by biological gender and that brain gender is an important variable to be taken into account.

5. Conclusion

This research aims to explore the dynamics between brain gender and consumer behavior by examining the relationship between biological gender and the 2D:4D ratio (the ratio of index and ring finger lengths) in Generation Z consumers. The results of the study show that there are mismatches between biological gender and brain gender and that these differences have significant effects on consumer decision-making styles.

A holistic analysis of the research findings reveals that male brain gender consumers differ from female brain gender consumers in the dimensions of BCC, NFC, PCC, SAC and IDC. These findings can be interpreted as that individuals who are biologically female but have a male brain gender may be influenced by more rational, performance-oriented and speed-advantaged approaches, unlike marketing messages for traditional female consumers. Individuals who are

biologically male and have a male brain sex may be more attuned to marketing messages that are already traditionally targeted at male consumers, but openness to technology, ease of shopping and elements that support decision-making processes may become more important for this segment.

In light of these findings, it emerges that consumer behavior cannot be understood only on the basis of biological gender and that brain gender is also an important factor to be considered.

5.1. Differences in Gender and 2D:4D-Based Consumer Decision-Making Styles

Table 6. CSI by Gender and 2D:4D Ratio Differentiation

	F-F	F-M	M-M	M-F
PQC				
BCC			✓	
NFC			✓	
PCC		✓		
ICC				
COC				
HBC				
SAC		✓	✓	
IDC		✓		

In Table 6, the results of the research can be seen comparatively in terms of biological gender-2D:4D ratio. The table suggests that consumers with a low 2D:4D ratio (male-brained), regardless of biological sex;

- May be more sensitive to brand awareness and may respond more to messages related to strong brand identity, status indicators, and brand loyalty,
- They may be price sensitive and feel the need to do more research on price-performance balance,
- They will be able to adapt to new technologies and products faster and therefore act as early adopter consumers,
- They are likely to hesitate during the purchase process and may prefer to postpone rather than make a decision,
- It can be interpreted that they may look for elements that facilitate quick decision-making in order to minimize time loss during shopping.

5.2. Brain Gender-Based Promotion Strategies

In gender-based marketing strategies, promotion strategies for female consumers emphasize emotional connection, emphasis on aesthetics and elegance, sense of trust, social interaction and community building (Li et al., 2015; Raman, 2019; Shi, 2024; Wu et al., 2024; Zhang, 2024), while strategies for male consumers emphasize themes such as strength, performance, endurance, speed, status and independence (De Meulenaer et al., 2018; Mustafa et al., 2022; Suvadarshini & Rout, 2024; Wiedmann et al., 2001). However, when using brain gender-based strategies, one should focus on the behavioral tendencies of individuals. Regardless of biological gender, it is recommended to focus on the following strategies in promotion and communication efforts for consumers with a low 2D:4D ratio:

- Luxury segment products should emphasize prestige and power by highlighting themes such as "class upgrade", "exclusivity", and "leadership".
- Personalized rewards, VIP memberships, and premium benefits should be diversified to increase brand loyalty.
- Brand ambassadors with a strong image should be used to reinforce brand perception.
- Ad strategies that prioritize technological innovation should be adopted.
- Transparent and clear discount policies, time-limited campaigns, content with cost-benefit analysis, and subscription-based shopping systems should be encouraged.
- First trial opportunities for early adopter consumers should be increased, and visuals that give the feeling of advanced technology should be used.
- The shopping process should be simplified to provide an experience that can be completed with minimal effort.
- Automate the shopping process by developing systems such as "automatic order renewal" and "call me back".
- Simple, clear, and understandable messages should be preferred over long and complex explanations.
- Social proof and customer reviews should be emphasized to support the consumer's decision process.

5.3. General Evaluation

Research findings reveal that individuals with a low 2D:4D ratio show significant differences in terms of consumer decision-making styles. These individuals are more brand-conscious, price-sensitive, adapt quickly to new technologies, may

hesitate during the purchase process, and try to minimize time loss during the shopping process. This research supports the necessity of shaping marketing strategies not only on the basis of biological gender, but also with a brain gender-oriented segmentation approach. Focusing on the cognitive and behavioral tendencies of individuals regardless of their biological gender, especially in marketing strategies for Generation Z, may enable the development of personalized campaigns. Unlike traditional gender-based marketing, factors such as status, speed, analytical thinking, adaptation to technology, and time efficiency should be emphasized for female consumers.

5.4. Future Directions

This research highlights the need for a deeper examination of the relationship between consumer behavior and brain structure, providing an important foundation for future studies. The primary limitation of this study is the use of convenience sampling, which restricts the generalizability of the findings. Future research can explore the effects of brain gender on consumer decision-making styles more comprehensively by examining different generations and utilizing diverse sampling methods. Additionally, investigating the responses of individuals with different brain structures to advertisements based on the 2D:4D ratio using neuroscientific methods, such as fMRI or eye tracking, will further strengthen the theoretical foundation in this field.

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