Do Numbers Have Shapes? The Matching Effect Between Numerical Information Precision and Brand Logo Shapes

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Abstract

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Full Text

Do Numbers Have Shape? The Matching Effect Between Numerical Precision and Brand Logo Shape

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Abstract

Numerical precision (precise vs. approximate) influences various psychological processes and inferences. Building on existing research, this paper proposes an association between numerical precision and shape. Specifically, precise numbers are more likely to be perceived as angular, whereas approximate numbers are more likely to be perceived as rounded. Study 1 and Study 2 confirm this effect through an Implicit Association Test and a consumption scenario, respectively. Study 3 further investigates the mediating role of processing fluency in this matching effect on consumer product evaluations. Study 4 identifies a boundary condition by reversing the gender symbolism of numbers: when people form an association of "precise = female, approximate = male,"the matching relationship reverses to precise numbers—rounded shapes and approximate numbers—angular shapes. These findings demonstrate a cognitive association between numerical and shape information, offering insights into how individuals process numerical and shape information and how firms can leverage these associations.

Keywords: numerical information; brand logo shape; processing fluency

1. Introduction

Numerical information is ubiquitous in human society—from what day of the week it is to the current temperature, from price changes that people care about to online reviews of questionable authenticity. Numbers play a vital role in our lives. As a representation of abstract concepts, numbers are associated with other types of representations, such as spatial position. Research has found that numerical magnitude is associated with left-right spatial positions, with small numbers corresponding to left positions and large numbers to right positions (Dehaene, Bossini, & Giraux, 1993). This cognitive association influences consumers' price estimates for products positioned on different sides (Cai, Shen, & Hui, 2012) and their assessments of product newness (冯文婷, 汪涛, 2017). This paper extends this line of inquiry by exploring whether numbers are associated with shape characteristics in space—specifically, whether numerical precision is associated with angular or rounded shapes. Do precise numbers that do not end in zero (precise numbers, such as 199.41 or 199; Janiszewski & Uy, 2008; Thomas, Simon, & Kadiyali, 2010; Yan, 2016) correspond to angular shapes? Do approximate numbers that more frequently end in zero (round numbers, such as 200) correspond to rounded shapes? In fact, the association between numerical precision and shape that we explore is already reflected in everyday life, as people commonly use shapes to express numerical precision. In English, precise numbers are often called "sharp numbers," which literally translates to "尖锐的数字" (sharp/pointed numbers) (Isaac & Schindler, 2014), while approximate numbers are called "round numbers," sharing the word "round" with rounded shapes (Zhu & Argo, 2013).

Specifically, this paper focuses on the connection between numerical precision and shape, examining the matching relationship between product numerical information precision and brand logo shape and its effects. Are precise numerical messages more compatible with angular brand logos (composed of straight lines and sharp angles, such as triangles)? Are approximate numerical messages more compatible with rounded brand logos (curvilinear, without sharp angles, such as circles)? Furthermore, does this matching relationship influence consumer product evaluations? That is, when a product uses approximate numerical information (vs. precise numerical information), do consumers evaluate products with rounded brand logos (vs. angular brand logos) more favorably? This paper makes two main theoretical contributions: (1) By demonstrating the association between numerical precision and spatial shape, it deepens our understanding of numerical information processing and provides new evidence for the relationship between numerical coding and spatial representation—showing that numbers are associated not only with spatial positions (e.g., Cai et al., 2012) but also with spatial shapes. (2) It offers new insights for brand logo research. As one of the most fundamental and core brand visual elements, brand logo characteristics influence consumer product evaluations (e.g., Jiang, Gorn, Galli, & Chattopadhyay, 2016). This paper complements existing research by showing that brand logo characteristics also interact with other brand information (such as numerical information) to jointly influence consumer product evaluations.

1.1 The Matching Relationship Between Numerical Precision and Brand Logo Shape

Numbers have spatial characteristics (徐晓东，刘昌，2006). For example, numerical magnitude is associated with left-right positions, with the left hand responding faster to small numbers and the right hand responding faster to large numbers (Dehaene et al., 1993). But is there an association between numbers (or their precision) and shape, another spatial characteristic? Several streams of literature provide a basis for proposing such a number-shape association.

First, linguistics provides direct evidence of a correspondence between numbers and shapes. For instance, in English expression, precise numbers (sharp numbers) and angular shapes (sharp shapes) share the same word "sharp," while approximate numbers (round numbers) and rounded shapes (round shapes) share the same word "round" (Isaac & Schindler, 2014; Schindler & Yalch, 2006). Although Chinese does not have direct linguistic correspondences between numbers and shapes, the terms "尖锐" (sharp/pointed) and "圆润" (rounded/smooth) are commonly used metaphorically to express "precise" and "approximate" meanings. For example, "看问题很尖锐" (viewing issues sharply) uses shape to describe someone' s accurate and profound insight, while "做事很圆滑" (doing things smoothly/roundly) refers to being tactful and non-confrontational. This linguistic correspondence between shape and number has been shown to influence people' s judgments. For example, rounded shapes are closely associated with concepts like "perfection," "completeness," and "completion." Jia, Krishna, and Li (2017) found that when participants were presented with six shapes (triangle, square, diamond, circle, rectangle, and trapezoid) and asked to choose the shape that gave them the strongest sense of "completion," 67.8% chose the "circle." Meanwhile, because approximate numbers are expressed with the roundnessrelated term "round numbers," Yan and Pena-Marin (2017) proposed that this creates a strong association between approximate numbers and a sense of "completion." Therefore, when buyers consider completing a transaction, they are more likely to experience a sense of goal completion and accept an offer when the quoted price uses an approximate number (vs. a precise number).

Based on this linguistic evidence, there appears to be a corresponding relationship between shape and number: precise numbers and angular shapes share similar linguistic expressions, creating a matching relationship, while approximate numbers and rounded shapes share similar linguistic expressions, creating another matching relationship.

Second, numerous studies from social cognition reveal that the symbolic meanings associated with numbers of different precision levels match the symbolic meanings represented by different shapes. Although numbers are abstract concepts representing quantitative relationships without specific sensory attributes, recent research shows that numbers of different precision levels can evoke different psychological states or emotional experiences. Specifically, precise numbers evoke associations with competence, rationality, confidence, masculinity, and aggressiveness, whereas approximate numbers evoke associations with emotion, inclusiveness, compromise, and femininity (Backus, Blake & Tadelis, 2015; Jerez-Fernandez, Angulo, & Oppenheimer, 2014; Wadhwa & Zhang, 2015; Xie & Kronrod, 2012; Yan, 2016). For example, Backus et al. (2015) found that sellers received lower counteroffers from buyers when they provided relatively high but approximate quotes (e.g., 200 yuan) compared to lower but precise quotes (e.g., 198 yuan). The authors argued that the precision of the quote signals the seller' s attitude: quotes containing approximate numbers suggest the seller is eager to close the deal, leading buyers to believe the seller would be more willing to compromise even with a lower counteroffer. Conversely, quotes containing precise numbers suggest the seller is not in a hurry to close the deal, leading buyers to infer that the seller will adopt a more aggressive stance. Thus, precise (approximate) number quotes give buyers a more confrontational (more compromising) impression. Similarly, Yan (2016) found that numbers have "gender" : precise numbers are more associated with male concepts, while approximate numbers are more associated with female concepts. When precise numbers (approximate numbers) were used to present information about a newborn' s birth date, height, and weight, people were more likely to judge the newborn as male (female).

These symbolic meanings derived from numerical precision align with the symbolic meanings represented by shapes. Extensive research in psychology, aesthetics, and marketing has shown that angular shapes are associated with abstract concepts such as competence, confrontation, seriousness, and masculinity, while rounded shapes are associated with warmth, compromise, emotion, and femininity (Arnheim, 2010; Hevner, 1935; Jiang et al., 2016; Liu, Bogicevic & Mattila, 2018). For example, aesthetic research has found that angular shapes are often associated with individualism, strength, aggressiveness, and power, and are perceived as a target stimulus confronting or not compromising with its environment. In contrast, rounded shapes are associated with harmony and friendliness and are perceived as a target stimulus compromising with its surroundings (Arnheim, 2010; Zhang, Feick & Price, 2006). Furthermore, Palumbo, Ruta, and Bertamini (2015) found through Implicit Association Tests that people generally associate rounded shapes with feminine names and angular shapes with masculine names.

In summary, research from social cognition provides substantial evidence for the number-shape matching relationship. Like angular shapes, precise numbers evoke associations with competence, rationality, confidence, masculinity, and aggressiveness. Approximate numbers, similar to rounded shapes, evoke associations with emotion, inclusiveness, compromise, and femininity (Backus et al., 2015; Jerez-Fernandez et al., 2014; Wadhwa & Zhang, 2015; Xie & Kronrod, 2012; Yan, 2016). Combining linguistic evidence with social cognition research, we propose the following hypothesis:

H1: Compared to rounded shapes, angular shapes are more compatible with precise numerical information; compared to angular shapes, rounded shapes are more compatible with approximate numerical information.

1.2 The Matching Effect and the Mediating Role of Processing Fluency

This paper further examines how the matching relationship between product numerical information precision and brand logo shape influences consumer product evaluations in consumption contexts, and the mediating role of processing fluency.

Extensive research has confirmed that when information matches individuals' current mental representations, they experience processing fluency. This fluency creates a sense of "rightness" about the consumption event, thereby enhancing evaluations (Reber, Schwarz, & Winkielman, 2004). For example, Lee and Aaker (2004) found that when message framing (gain vs. loss) matched individuals' regulatory focus (promotion vs. prevention), participants experienced higher fluency, which mediated the effect of regulatory fit on advertising persuasion. Building on this research, we predict that when precise numbers are paired with angular brand logos or when approximate numbers are paired with rounded brand logos, this matching relationship will enhance individuals' processing fluency, which in turn will improve product evaluations. Therefore, we hypothesize:

H2a: In the context of precise numerical information, presenting an angular brand logo (vs. a rounded brand logo) will elicit higher consumer evaluations.
H2b: In the context of approximate numerical information, presenting a rounded brand logo (vs. an angular brand logo) will elicit higher consumer evaluations.
H2c: Processing fluency mediates the joint effect of brand logo shape and

product numerical information on consumer evaluations.

The paper validates these hypotheses through four experiments. Experiment 1 uses an Implicit Association Test to compare reaction times across four pairing conditions (precise number + angular shape vs. precise number + rounded shape vs. approximate number + angular shape vs. approximate number + rounded shape). Experiment 2 further tests the matching effect by examining whether the compatibility between product numerical information and brand logo shape influences consumer product evaluations. Experiment 3 explores the mediating role of processing fluency. Experiment 4 provides boundary conditions for the matching effect by reversing the gender symbolism of numbers. We expect that when precise numbers match angular shapes and approximate numbers match rounded shapes, reaction times will be significantly faster and product evaluations will be higher than in the other two conditions. Furthermore, reversing the gender symbolism of numbers should reverse the matching effect.

Experiment 1

The purpose of Experiment 1 was to verify whether a matching association exists between numerical precision information and shape through an Implicit Association Test. The study employed a 2 (shape: angular vs. rounded) × 2 (number: precise vs. approximate) within-subjects design, with reaction time and accuracy rate as dependent variables.

2.1.1 Experimental Materials and Procedure

Thirty-nine university students participated in the formal experiment, including 19 males. The Implicit Association Test (IAT) program was programmed using E-prime 2.0, with stimuli presented on a computer and responses recorded. The experiment was administered individually, with participants following on-screen instructions to complete the seven steps of the IAT. All experiments used 14-inch ThinkPad computers with identical configurations to minimize extraneous influences. Experiment 1 used 25 angular images and 25 rounded images. The angular images were common planar geometric shapes from daily life, such as triangles and squares. The rounded images were created by using Photoshop to transform the sharp corners of angular images into rounded corners. Additionally, Experiment 1 used 25 precise numbers and 25 approximate numbers. Precise numbers included those with decimal points (e.g., 348.5, accounting for 46% of precise numbers) and those without decimal points (e.g., 2019, accounting for 54% of precise numbers). Approximate numbers ended with 0 (e.g., 3970). Both precise and approximate numbers were four-digit numbers to avoid differences in reaction times and accuracy rates due to varying digit lengths.

It is worth noting that in this experiment and the subsequent three experiments, we used Arabic numerals rather than verbal expressions (e.g., "六点零") to present numerical information for the following reasons: First, Arabic numerals are more common and align better with people's daily information processing habits. People constantly interact with Arabic numerals in daily life and production, and they have become accustomed to using them to represent simple arithmetic, calculations, and comparisons. Arabic numerals are the standard form of numbers. Compared to the unfamiliarity of numerals expressed in Chinese or English, processing Arabic numerals activates more effective information in a shorter time with fewer cognitive resources and lower error rates (曾细红, 2007). Second, previous literature examining how different levels of numerical precision activate different conceptual associations has used Arabic numerals rather than English or Chinese expressions. For example, Yan (2016) used 90.02 to represent precise numbers and 90 to represent approximate numbers (see Experiment 6). Jerez-Fernandez et al. (2014) found that people appear more confident when using more precise numbers (e.g., 2611) versus approximate numbers (e.g., 2600) to estimate things (see Experiment 1). Other numerical studies have also used Arabic numerals to express numerical information (Pena-Marin & Bhargave, 2016; Schindler & Yalch, 2006). Based on these considerations, we followed previous research by using Arabic numerals to express numerical information.

Participants were informed that the study aimed to understand people' s categorization processes. All participants were required to classify a series of stimuli into two corresponding category dimensions: number dimension and shape dimension. The experiment consisted of seven steps: In Step 1, participants classified 20 different shapes by pressing different keys (angular shapes: "F" key; rounded shapes: "J" key). In Step 2, participants classified 20 different numbers by pressing different keys (precise numbers: "F" key; approximate numbers: "J" key). In Step 3, participants performed a joint classification of 10 different shapes and 10 different numbers, categorizing angular shapes and precise numbers together (both using the "F" key) and rounded shapes and approximate numbers together (both using the "J" key). Step 4 was identical to Step 3 but with twice as many trials. In Step 5, participants again classified 20 different numbers, but with reversed key assignments from Step 2 (precise numbers: "J" key; approximate numbers: "F" key). In Step 6, participants performed another joint classification of 10 shapes or 10 numbers, but were required to categorize angular shapes and approximate numbers together (both using the "F" key) and rounded shapes and precise numbers together (both using the "J" key). Step 7 was identical to Step 6 but with twice as many trials. Steps 3 and 4 involved a consistent relationship between numbers and shapes, while Steps 6 and 7 involved an inconsistent relationship. The logic underlying these two different association blocks is that if precise numbers are indeed associated with angular shapes and approximate numbers with rounded shapes, participants should respond faster in the consistent blocks than in the inconsistent blocks. To avoid learning effects or cognitive inertia (Messner & Vosgerau, 2010), we balanced the presentation order of consistent and inconsistent blocks: half of the participants completed the consistent block first, while the other half completed the inconsistent block first. The experimental purpose was explained to participants after the experiment.

2.1.2 Statistical Analysis

Following the IAT data exclusion and analysis methods proposed by Greenwald, Nosek, and Banaji (2003) and 钱淼, 周立霞, 鲁甜甜, 翁梦星, and 傅根跃 (2015), participants meeting any of the following three criteria were excluded: (1) More than 10% of all trials had reaction times below 300ms; (2) Error rate greater than or equal to 35%; (3) Average reaction time more than three standard deviations above or below the mean of all participants. Based on these criteria, three participants were excluded due to error rates above 35%, leaving 36 participants for subsequent data analysis. Additionally, error responses within each task were replaced with the mean reaction time of correct responses plus 600ms, while trials with reaction times exceeding 10,000ms or below 300ms were excluded.

Preliminary analyses revealed no effects of gender or order (whether the consistent or inconsistent block was presented first), so these variables were not considered in subsequent analyses. Consistent with previous research, data from Steps 3 (practice phase) and Step 4 (formal phase) were analyzed as consistent relationship data, while data from Steps 6 (practice phase) and Step 7 (formal phase) were analyzed as inconsistent relationship data (Greenwald et al., 2003).

A 2 (shape: angular vs. rounded) × 2 (number: precise vs. approximate) repeated measures ANOVA on mean reaction time revealed no significant main effect of shape ($F(1, 35) = 0.84$, $p > 0.05$, $^2 = 0.003$) or number ($F(1, 35) = 0.19$, $p > 0.05$, $^2 = 0.001$), but a significant interaction between the two factors ($F(1, 35) = 16.94$, $p < 0.001$, $^2 = 0.20$; see left side of Figure 1 [Figure 1: see original paper]). Specifically, participants responded faster to precise numbers when they shared the same key with angular shapes (M_angular = 817.99, SD = 190.77) than with rounded shapes (M_rounded = 941.11, SD = 209.32; $F(1, 35) = 10.97$, $p < 0.01$, Cohen' s d = 0.61). Conversely, participants responded faster to approximate numbers when they shared the same key with rounded shapes (M_rounded = 811.25, SD = 170.90) than with angular shapes (M_angular = 971.67, SD = 238.45; $F(1, 35) = 14.14$, $p < 0.01$, Cohen' s d = 0.77).

A 2 (shape: angular vs. rounded) × 2 (number: precise vs. approximate) repeated measures ANOVA on mean accuracy rate revealed no significant main effect of shape ($F(1, 35) = 1.78$, $p > 0.05$, $^2 = 0.01$) or number ($F(1, 35) = 3.02$, $p > 0.05$, $^2 = 0.03$), but a significant interaction ($F(1, 35) = 4.42$, $p < 0.05$, $^2 = 0.05$; see right side of Figure 1). Specifically, participants showed higher accuracy for precise numbers when they shared the same key with angular shapes (M_angular = 0.94, SD = 0.11) than with rounded shapes (M_rounded = 0.87, SD = 0.17; $F(1, 35) = 9.46$, $p < 0.01$, Cohen' s d = 0.49). Conversely, participants showed marginally higher accuracy for approximate numbers when they shared the same key with rounded shapes (M_rounded = 0.88, SD = 0.17) than with angular shapes (M_angular = 0.86, SD = 0.16), though this difference did not reach significance at the 0.05 level ($F(1, 35) = 0.43$, $p > 0.05$, Cohen' s d = 0.12).

Figure 1. Mean reaction time (left) and mean accuracy rate (right) for different numbers under different shape contexts in Experiment 1 (M±SD). Note: * represents significance at $p = 0.05$ level, ** at $p = 0.01$ level, *** at $p = 0.001$ level.

To rule out the possibility that differences between precise and approximate numbers in the presence of decimal points affected the results, we categorized numbers into three types: precise numbers with decimal points, precise numbers without decimal points, and approximate numbers without decimal points, and conducted a one-way ANOVA on reaction times for these three number types. The results showed no significant effect of number type (M_precise_with_decimal = 812.90, M_precise_without_decimal = 891.73, M_approximate = 835.66, $F(2, 3917) = 2.04$, $p > 0.05$, $^2 = 0.001$). Thus, the characteristics of the numbers themselves did not affect participants' reaction times.

These results support Hypothesis 1, indicating that in individuals' conceptual networks, precise numbers are more closely associated with angular shapes, while approximate numbers are more closely associated with rounded shapes. Following the IAT data analysis method proposed by Greenwald et al. (2003), we calculated D values reflecting the strength and direction of implicit attitudes. The D value is obtained by dividing the difference between mean reaction times for inconsistent and consistent tasks by the standard deviation of all reaction times across both tasks. D values range from -2 to 2, with positive values indicating stronger consistent associations and negative values indicating stronger inconsistent associations (Greenwald et al., 2003). A one-sample t-test confirmed that the D value was significantly greater than 0 ($M = 0.71 > 0$, $t(71) = 5.38$, $p < 0.001$), indicating that consistent associations were stronger and further confirming the conceptual link between precise numbers—angular shapes and approximate numbers—rounded shapes.

Experiment 2

Experiment 1 supported H1, confirming the matching relationship between numerical precision and shape—participants perceived precise numbers as more closely linked to angular shapes and approximate numbers as more closely linked to rounded shapes. However, this experiment has some limitations. In the approximate number condition, all numbers ended with "0," whereas precise numbers contained relatively fewer zeros. This could provide an alternative explanation: approximate numbers might be more visually similar to rounded shapes due to containing more "0" s, while precise numbers, containing fewer zeros, are less visually similar to rounded shapes. To rule out this explanation, we increased the number of zeros in the precise number condition in subsequent experiments to match the number of zeros in the approximate numbers. Building on Experiment 1, Experiment 2 further tested the matching relationship between numerical precision and shape in a marketing context and its impact on consumer product evaluations.

Experiment 2 employed a 2 (logo shape: angular vs. rounded) × 2 (numerical information: precise vs. approximate) between-subjects design to test whether a matching relationship exists between logo shape and numerical precision information and whether it influences consumer product evaluations.

2.2.1 Experimental Materials and Procedure

The formal experiment invited 125 ordinary adult consumers to complete an online questionnaire, including 56 males. After verification, no unqualified questionnaires were deleted, resulting in 125 valid questionnaires. All participants were randomly assigned to one of four groups. First, participants were told that the study aimed to understand consumer preferences for products. They were then shown a product poster for a quilt. The poster contained no other information except the brand logo illustration, product image, and numerical information (weight and price). The brand logo illustration consisted of angular or rounded fonts and graphics, appearing on the product and in the lower right corner of the poster (Jiang et al., 2016). The product numerical information consisted of product weight and price. In the precise numerical information condition, the product weight was 4.05KG and the recommended price was ¥319.9; in the approximate numerical information condition, the product weight was 4KG and the recommended price was ¥320 (see appendix for specific experimental materials). After viewing the quilt poster, participants completed a 7-point scale measuring brand attitude (bad-good/dislike-like/negative-positive/completely untrustworthy-completely trustworthy, = 0.90; Chae & Hoegg, 2013; Jiang et al., 2016; Yan, 2016). Finally, participants provided personal information. It is worth noting that we chose quilts as the experimental stimulus because they are familiar to the general public and have no gender differences in usage, thus avoiding potential gender confounds. To avoid interference from brand familiarity, we used a fictitious brand name, Farber.

2.2.2 Statistical Analysis

A 2 (numerical information: precise vs. approximate) × 2 (brand logo: angular vs. rounded) ANOVA on brand evaluation revealed no significant main effect of brand logo ($F(1, 121) = 3.59$, $p > 0.05$, $^2 = 0.02$). The main effect of numerical information was significant (M_precise = 5.37, SD = 0.11; M_approximate = 5.05, SD = 0.11; $F(1, 121) = 3.97$, $p < 0.05$, $^2 = 0.03$). More importantly, this significant main effect was moderated by brand logo shape ($F(1, 121) = 21.69$, $p < 0.001$, $^2 = 0.14$; see Figure 2 [Figure 2: see original paper]). Specifically, when products used precise numerical information, participants evaluated products with angular brand logos more favorably than those with rounded brand logos (M_angular = 5.59, SD = 1.06; M_rounded = 5.14, SD = 1; $F(1, 121) = 3.90$, $p = 0.05$, Cohen' s d = 0.44). Conversely, when products used approximate numerical information, participants evaluated products with rounded brand logos more favorably than those with angular brand logos (M_angular = 4.52, SD = 0.61; M_rounded = 5.57, SD = 0.81; $F(1, 121) = 20.99$, $p < 0.001$, Cohen' s d = 1.46). These results support Hypotheses 2a and 2b.

Figure 2. The effect of product numerical information and brand logo on consumer brand attitude in Experiment 2 (M±SD). Note: * represents significance at p = 0.05 level, ** at p = 0.01 level, *** at p = 0.001 level.

Experiment 3

The findings of Experiment 2 supported H2a and H2b, confirming the matching effect between product numerical information and brand logo shape. When products used precise numerical information, consumers evaluated products with angular brand logos more favorably than those with rounded brand logos. Conversely, when products used approximate numerical information, consumers evaluated products with rounded brand logos more favorably than those with angular brand logos. Experiments 1 and 2 together validated the matching effect between numerical precision and spatial shape. In Experiment 3, we further tested the mediating role of processing fluency.

Experiment 3 employed a 2 (brand logo: angular vs. rounded) × 2 (numerical information: precise vs. approximate) between-subjects design. The study had two purposes: first, to further validate the matching effect between brand logo shape and product numerical precision using different product categories (laptop bags) and different manipulation methods; second, to test whether this matching effect is mediated by consumers' processing fluency of product information. The independent variables were brand logo shape and product numerical precision information, the mediating variable was processing fluency of product information, and the dependent variable was consumer product preference.

2.3.1 Experimental Materials and Procedure

The formal experiment invited 200 ordinary adult consumers to complete an online questionnaire (105 males). After verification, incomplete questionnaires and those with identical answers were excluded, resulting in 189 valid questionnaires. First, participants were told that the study aimed to understand consumer preferences for products. They were then shown a product poster for a laptop bag from the fictitious brand Farber. The poster contained no other information except the brand logo illustration, product image, and numerical information (size and price). The brand logo illustration consisted of angular or rounded fonts and graphics, appearing on the product and in the lower right corner of the poster (Jiang et al., 2016). The product numerical information consisted of product size and price. In the precise numerical information condition, the product size was 14.1~15.1 inches and the recommended price was ¥319.9; in the approximate numerical information condition, the product size was 14~15 inches and the recommended price was ¥320 (see appendix for specific experimental materials). After viewing the laptop bag poster, participants completed a 7-point scale measuring brand attitude (same as Experiment 2, = 0.86) and processing fluency of the advertisement (items adapted from Yan (2016): the advertisement is easy to understand/it gives a "this is right" feeling/the information is consistent and coherent/the information is organized/the information is credible, where 1 = completely disagree and 7 = completely agree; = 0.87). Finally, participants provided personal information.

It is worth noting that Experiment 3 used interval notation ("14.1~15.1 inches") in the advertising materials for three reasons: First, when designing the advertising materials, we referenced e-commerce websites' product descriptions for laptop bags, which typically provide a size range, so we adopted this realistic description to make the materials more authentic. Second, in the numerical research domain, Wadhwa and Zhang (2015) suggested that different levels of numerical precision can be expressed as a range, such as "this book costs about 10.35~12.35 yuan" for high precision and "this book costs about 10~12 yuan" for low precision/approximate numbers. Third, research has found that when processing ranges composed of numerical information, people focus more on the boundary numbers that constitute the range rather than the range itself (Shoham, Moldovan, & Steinhart, 2018). For example, Shoham et al. (2018) found that when hotel review scores increased from 8.3 to 9 (vs. from 8 to 9), people perceived a greater quality improvement in the former case because they interpreted it as crossing a category boundary from decimal to integer, despite the latter representing a larger absolute increase. The authors termed this effect the "decimal-to-integer effect," which further indicates that people focus on boundary information (numbers) rather than the size of the range. Based on these considerations, we retained the use of interval ranges to represent numerical precision in Experiment 3 and argue that although 14.1~15.1 inches represents a range rather than a precise number, because the boundary numbers composing the range are precise, people still process it using the precise number processing mode.

2.3.2 Statistical Analysis

First, a 2 (numerical information: precise vs. approximate) × 2 (brand logo: angular vs. rounded) ANOVA on consumer brand attitude revealed no significant main effect of numerical information ($F(1, 185) = 1.28$, $p > 0.05$, $^2 = 0.006$) or brand logo ($F(1, 185) < 1$, $p > 0.05$, $^2 = 0.000006$), but a significant interaction effect ($F(1, 185) = 19.26$, $p < 0.001$, $^2 = 0.09$; see schematic diagram in Figure 3 [Figure 3: see original paper]).

Specifically, when products used precise numerical information, participants evaluated products with angular brand logos more favorably than those with rounded brand logos ($M_{angular} = 5.41$, $SD = 0.88$; $M_{rounded} = 4.83$, $SD = 0.69$; $F(1, 185) = 9.71$, $p < 0.01$, Cohen' s $d = 0.73$). Conversely, when products used approximate numerical information, participants evaluated products with rounded brand logos more favorably than those with angular brand logos ($M_{angular} = 4.69$, $SD = 1.11$; $M_{rounded} = 5.26$, $SD = 0.78$; $F(1, 185) = 9.55$, $p < 0.01$, Cohen' s $d = 0.59$). These results replicate and support Hypotheses 2a and 2b.

Figure 3. The effect of product numerical information and brand logo on consumer brand attitude in Experiment 3 (M±SD). Note: * represents significance at p = 0.05 level, ** at p = 0.01 level, *** at p = 0.001 level.

To examine the mediating role of processing fluency, we first conducted a 2 (numerical information: precise vs. approximate) × 2 (brand logo: angular vs. rounded) ANOVA on consumers' perceived processing fluency of the advertisement. The results showed no significant main effect of numerical information ($F(1, 185) < 1$, $p > 0.05$, $^2 = 0.0003$) or brand logo ($F(1, 185) < 1$, $p > 0.05$, $^2 = 0.0008$), but a significant interaction effect ($F(1, 185) = 14.89$, $p < 0.001$, $^2 = 0.07$). Specifically, when products used precise numerical information, participants reported higher processing fluency for advertisements with angular brand logos than with rounded brand logos (M_angular = 5.39, SD = 0.87; M_rounded = 4.95, SD = 0.67; $F(1, 185) = 5.96$, $p < 0.05$, Cohen' s d = 0.57). Conversely, when products used approximate numerical information, participants reported higher processing fluency for advertisements with rounded brand logos than with angular brand logos (M_angular = 4.94, SD = 1.13; M_rounded = 5.47, SD = 0.66; $F(1, 185) = 9.10$, $p < 0.01$, Cohen' s d = 0.57). These findings align with our theoretical expectations.

Next, following Hayes' (2013, Model 8) mediation analysis model with 5,000 bootstrap samples and a 95% confidence interval, we used bootstrapping to test a mediated moderation model, examining whether processing fluency mediates the interactive effect of brand logo and product numerical information on product evaluation. As shown above, the interaction between brand logo and numerical information significantly affected perceived fluency (= 0.98; 95% CI = 0.48 to 1.48). Moreover, when fluency was included as a mediator in the model, it mediated the effect of brand logo on brand attitude under precise numerical information conditions (= -0.33, 95% CI = -0.58 to -0.10) and under approximate numerical information conditions (= 0.41, 95% CI = 0.14 to 0.70; see Figure 4 [Figure 4: see original paper]). Overall, the mediating effect of processing fluency was significant (= 0.74, 95% CI = 0.38 to 1.12).

Figure 4. Schematic diagram of the mediating role of advertising information processing fluency in Experiment 3. Note: * represents significance at p = 0.05 level, ** at p = 0.01 level, *** at p = 0.001 level.

Experiment 4

The results of Experiments 1-3 all validated the "precise–angular" and "approximate–rounded" matching effect between numerical information and brand logo shape. However, will this matching effect always exist? Under what conditions might this relationship disappear or even reverse? Exploring this question helps us understand the boundary conditions of the above effect. It is worth noting that this investigation does not aim to identify the exact cause of the association between numerical information and shape. Like previous numerical research (Yan, 2016), we believe that the association between numerical precision and shape may have multiple possible explanations. Therefore, our research focus is on discovering the existence of a connection between the two concepts, consistent with previous studies examining associations between concepts (e.g., Pena-Marin & Bhargave, 2016; Rozin, Hormes, Faith & Wansink, 2012; Yan, 2016).

As mentioned earlier, the symbolic meanings expressed by different levels of numerical precision match the symbolic meanings represented by different shapes. These symbolic meanings typically originate from everyday experiences that confirm the symbolic meanings of numbers and shapes. For example, the "confrontational" symbolic meaning of angular shapes derives from the psychological discomfort of interpersonal conflict and non-compromise, which is similar to the pain caused by angular shapes, leading people to assign angular shapes a "confrontational" symbolic meaning. However, counterexamples exist in life (e.g., sometimes precise numbers are associated with females rather than males). If we can increase the accessibility of these counterexamples in people' s minds, we may influence the symbolic meanings of numbers and shapes, thereby disrupting the "angular—precise and rounded—approximate" matching relationship and potentially weakening or even reversing the matching effect between numerical information and brand logo shape. Indeed, research in other domains has reversed conceptual associations by providing counterexamples. For example, Li, Haws, and Griskevicius (2019) found that after activating parenting motivation, men developed a future time orientation while women developed a present time orientation, stemming from gender-related parenting role stereotypes—stereotypically defining mothers as caregivers and fathers as breadwinners. Conversely, when atypical stereotypes were activated (e.g., mothers as breadwinners and fathers as caregivers), the results reversed: men developed a present time orientation while women developed a future time orientation. Similarly, Toure-Tillery and Fishbach (2017) found that the metaphorical link of "close spatial distance—strong impact/far spatial distance—weak impact" led people to be more willing to help close-distance recipients (because they perceived their help as having greater impact). When counterexamples were provided to reverse this metaphor to "far spatial distance—strong impact/close spatial distance—weak impact," the close-distance effect disappeared.

In short, we provide boundary conditions for the number-shape matching effect by presenting examples that contradict the existing symbolic meanings of different levels of numerical precision, thereby changing the association between precise numbers—angular shapes and approximate numbers—rounded shapes. In Experiment 4, we explore how reversing the gender symbolism of numbers (precise = male, approximate = female) can reverse the matching relationship between numbers and shapes. As mentioned, the association between shape and number may stem from their shared symbolic meanings (e.g., competence vs. warmth, confrontation vs. compromise, seriousness vs. emotion, masculinity vs. femininity). Lay theories of gender suggest that competence/confrontation/rationality represent male characteristics (Yan, 2016), while compromise and emotion represent female characteristics. Therefore, we selected the more inclusive symbolic meaning—numerical "gender" symbolism—to manipulate and reverse the number-shape matching relationship. Moreover, from an operational perspective, manipulating the association pattern between numbers and gender (e.g., changing the inherent "precise = male/approximate = female" to "precise = female/approximate = male") is much simpler and more feasible than manipulating associations between numbers and other concepts (e.g., numbers and emotion/rationality). Additionally, existing research provides references for manipulating the association pattern between numbers and gender (Yan, 2016).

According to previous research, the gender symbolism of numerical information, which originated as a calculation tool, is acquired through learning, and this learned symbolism is often influenced by context. For example, Yan (2016) proposed that one reason for the formation of "precise = male" and "approximate = female" symbolism may come from occupational stereotypes. Industries requiring high precision, such as scientists and programmers, are often male-dominated, while industries not requiring high precision, such as domestic service workers and cleaners, often have more female practitioners. This long-term association between "male" and "high precision" and "female" and "low precision" leads people to form "precise = male" and "approximate = female" symbolic meanings. However, this occupational stereotype can be reversed in certain contexts. For example, some female-dominated professions, such as accounting and bank tellers, require high precision, while some male-dominated professions, such as security guards and construction workers, do not require high precision. If we frequently present these types of occupations to people in a short period, individuals may temporarily form a symbolic link of "precise = female" and "approximate = male." Furthermore, when consumers who have activated this association see product posters with different levels of numerical precision and different brand logo shapes, the "female" symbolic meaning activated by precise numbers in the poster will match the "female" symbolic meaning also activated by rounded brand logos, thereby influencing their product evaluations. Similarly, the "male" symbolic meaning activated by approximate numerical information will match the "male" symbolic meaning activated by angular brand logos, influencing product evaluations. Based on this reasoning, we hypothesize:

H3a: Under the "precise = male" and "approximate = female" association, in the context of precise numerical information, products with angular brand logos (vs. rounded brand logos) will elicit higher consumer evaluations; conversely, in the context of approximate numerical information, products with rounded brand logos (vs. angular brand logos) will elicit higher consumer evaluations.

H3b: Under the "precise = female" and "approximate = male" association, in the context of precise numerical information, products with rounded brand logos (vs. angular brand logos) will elicit higher consumer evaluations; conversely, in the context of approximate numerical information, products with angular brand logos (vs. rounded brand logos) will elicit higher consumer evaluations.

Experiment 4 employed a 2 (numerical gender association pattern: precise =

male/approximate = female vs. precise = female/approximate = male) × 2 (brand logo: angular vs. rounded) × 2 (numerical information: precise vs. approximate) between-subjects design. The experiment aimed to test whether changing the numerical gender association pattern could influence the matching relationship between brand logo shape and numerical information, thereby affecting product evaluations. Specifically, when the numerical gender association pattern changed to "precise = female/approximate = male," angular brand logos would be more compatible with approximate numerical information, and rounded brand logos would be more compatible with precise numerical information. The independent variables were numerical-gender association pattern, brand logo shape, and product numerical precision, and the dependent variable was consumer product attitude. This study also used different methods to manipulate brand logo shape and numerical precision and tested the results from Experiments 2 and 3 in different product categories.

2.4.1 Pretest

Based on Yan (2016), this experiment used five female-dominated, high-precision professions and five male-dominated, low-precision professions to activate the "precise = female" and "approximate = male" association. Simultaneously, five male-dominated, high-precision professions and five female-dominated, low-precision professions were used to activate the "precise = male" and "approximate = female" association. The purpose of the pretest was to confirm whether the selected professions met the experimental requirements.

The pretest selected twenty professions and asked 26 participants who would not participate in the formal experiment to rate whether these professions were male-dominated or female-dominated (1 = "completely female-dominated," 7 = "completely male-dominated") and the degree of precision required by these professions (1 = "completely does not require precision," 7 = "very much requires precision"). The five female-dominated, high-precision professions were: accountant, bank teller, cashier, treasurer, and seamstress. The five male-dominated, high-precision professions were: scientist, programmer, financial analyst, securities manager, and engineer. The five female-dominated, low-precision professions were: clerk, domestic service worker, yoga instructor, preschool teacher, and librarian. The five male-dominated, low-precision professions were: security guard, soccer coach, mover, construction worker, and chef. First, we compared the "male-dominated vs. female-dominated" ratings for the 10 professions in the "female-dominated, high-precision" and "male-dominated, low-precision" categories. A paired-samples t-test showed that female-dominated, high-precision professions scored significantly lower (more female-dominated) than male-dominated, low-precision professions ($M_{female} = 2.71$ vs. $M_{male} = 6.18$, $t(25) = -19.59$, $p < 0.001$, $d = 6.43$). Next, we compared the "male-dominated vs. female-dominated" ratings for the 10 professions in the "male-dominated, high-precision" and "female-dominated, low-precision" categories. A paired-samples t-test showed that male-dominated, high-precision professions scored significantly higher (more male-dominated) than female-dominated, low-precision professions ($M\_male = 5.15$ vs. $M\_female = 2.63$, $t(25) = -12.44$, $p < 0.001$, $d = 4.16$).

Similarly, to compare "precision" scores, we first compared the "precision" ratings for the 10 professions in the "female-dominated, high-precision" and "male-dominated, low-precision" categories. A paired-samples t-test showed that female-dominated, high-precision professions scored significantly higher on precision than male-dominated, low-precision professions ($M\_female = 5.17$ vs. $M\_male = 3.87$, $t(25) = 5.30$, $p < 0.001$, $d = 1.55$). Then, we compared the "precision" ratings for the 10 professions in the "male-dominated, high-precision" and "female-dominated, low-precision" categories. A paired-samples t-test showed that male-dominated, high-precision professions scored significantly higher on precision than female-dominated, low-precision professions ($M\_male = 6.28$ vs. $M\_female = 4.04$, $t(25) = 11.30$, $p < 0.001$, $d = 2.84$). Through this pretest, we successfully identified the occupational information to be used in the main experiment to activate the precision-gender concept associations.

2.4.2 Experimental Materials and Procedure

The formal experiment invited 244 ordinary adult consumers to complete an online questionnaire, including 96 males. All participants were randomly assigned to one of eight groups: (precise = male/approximate = female vs. precise = female/approximate = male) × (rounded brand logo vs. angular brand logo) × (precise numerical information vs. approximate numerical information). First, participants were told that the study consisted of two unrelated small experiments. The first experiment purported to investigate people' s perceptions of different occupations. Participants were asked to rate ten different occupations on 7-point scales for "female-dominated vs. male-dominated" and "degree of precision required." Half of the participants were in the "precise = female" and "approximate = male" condition, rating the following occupations: accountant, bank teller, cashier, treasurer, seamstress, security guard, soccer coach, mover, construction worker, and chef. The first five occupations are female-dominated and require high precision; the last five are male-dominated and require low precision. The other half were in the "precise = male" and "approximate = female" condition, rating: scientist, programmer, financial analyst, securities manager, engineer, clerk, domestic service worker, yoga instructor, preschool teacher, and librarian. The first five occupations are male-dominated and require high precision; the last five are female-dominated and require low precision.

After completing the first experiment, participants evaluated a tablet computer. They were shown a product poster for a tablet from the fictitious brand LANE. The poster contained no other information except the brand logo illustration, product image, and numerical information. The brand logo illustration consisted of angular or rounded fonts and graphics, appearing on the product and in the upper left corner of the poster (Jiang et al., 2016). In the precise numerical information condition, the product information read: "5.99mm ultra-thin experience! Consumer Reports score: 90.02, performance 9.98% better than competing brands! Continuous battery life up to 48 hours.” In the approximate numerical information condition, it read: “6mm ultra-thin experience! Consumer Reports score: 90, performance 10% better than competing brands! Continuous battery life up to 2 days.” After viewing the product poster, participants completed product attitude evaluations (same items as Experiment 2, = 0.87) and provided personal information.

2.4.3 Statistical Analysis

A 2 (numerical gender association pattern: precise = male/approximate = female vs. precise = female/approximate = male) × 2 (numerical information: precise vs. approximate) × 2 (brand logo: angular vs. rounded) ANOVA on consumer brand attitude revealed no significant main effects or two-way interactions (ps > 0.05). However, as expected, the three-way interaction was significant ($F(1, 236) = 23.12$, $p < 0.001$, $^2 = 0.09$; see Figure 5 [Figure 5: see original paper]). Simple effects tests showed that when the numerical gender association pattern was “precise = female” and “approximate = male,” if the product used precise numerical information, participants evaluated rounded brand logos more favorably than angular brand logos (M_angular = 5.33, SD = 0.91; M_rounded = 5.90, SD = 0.73; $F(1, 134) = 7.25$, $p < 0.01$, Cohen’ s d = 0.69). Conversely, if the product used approximate numerical information, participants evaluated angular brand logos more favorably than rounded brand logos (M_angular = 5.82, SD = 0.91; M_rounded = 5.35, SD = 0.97; $F(1, 134) = 4.68$, $p < 0.05$, Cohen’ s d = 0.50). When the numerical gender association pattern was “precise = male” and “approximate = female,” if the product used precise numerical information, participants evaluated angular brand logos more favorably than rounded brand logos (M_angular = 5.75, SD = 0.8; M_rounded = 5.22, SD = 0.84; $F(1, 102) = 6.58$, $p < 0.05$, Cohen’ s d = 0.65). Conversely, if the product used approximate numerical information, participants evaluated rounded brand logos more favorably than angular brand logos (M_angular = 5.19, SD = 0.96; M_rounded = 5.74, SD = 0.47; $F(1, 102) = 5.64$, $p < 0.05$, Cohen’ s d = 0.73).

Figure 5. The effect of numerical information and brand logo on product evaluation under different number-gender association patterns (“precise = female” (left panel) and “precise = male” (right panel)) (M±SD). Note: * represents significance at p = 0.05 level, ** at p = 0.01 level, *** at p = 0.001 level.

General Discussion

3.1 Overall Conclusions

This paper conducted four experiments to validate the matching relationship between product numerical information and brand logo shape. This relationship influences consumer evaluations of products with different numerical information and brand logo shapes by affecting consumers’ processing fluency.

Experiment 1 used university student participants and an Implicit Association Test to confirm the existence of an association between numerical information and shape in people' s minds. Specifically, precise numbers were more closely linked to angular shapes, while approximate numbers were more closely linked to rounded shapes. Experiment 2 extended the sample to ordinary consumers and applied these findings to a consumption context, demonstrating that in the context of precise product numerical information, consumers evaluated products with angular brand logos more favorably than those with rounded brand logos; conversely, in the context of approximate product numerical information, consumers evaluated products with rounded brand logos more favorably than those with angular brand logos. Experiment 3 used different manipulation methods and product categories to replicate this effect and further explored the mediating mechanism—processing fluency. Experiment 4 directly manipulated the association pattern between numerical precision and gender, which not only tested a possible explanation for the number-shape association but also provided boundary conditions for the conclusions of Experiments 2 and 3. The results showed that when the gender symbolism of numbers changed from "precise = male, approximate = female" to "precise = female, approximate = male," it altered the matching relationship between numerical information and brand logo shape. In this context, precise numbers became more compatible with rounded brand logos, and approximate numbers became more compatible with angular brand logos, thereby influencing corresponding product evaluations.

3.2 Theoretical Contributions

The theoretical contributions of this paper are mainly reflected in the following aspects:

First, this paper provides new evidence for the spatial characteristics of numerical information, enriching knowledge in the numerical cognition domain. Humans possess unique numerical abilities distinct from animals: not only powerful counting and calculation abilities but also a complete numerical conceptual system. Researchers generally believe that numerical information, as an abstract conceptual representation, is often understood through more concrete conceptual representations such as spatial perception (徐晓东, 刘昌, 2006). The connection between numbers and space is a long-standing topic in numerical cognition. The most important metaphor currently exploring this connection is the mental number line metaphor, which examines the association between the comparability of numbers (different magnitudes) and spatial orientation. This paper further explores and discovers another comparability feature of numbers (different precision levels) and its association with spatial shape: different levels of numerical precision are associated with angular or rounded shapes, and people tend to link precise numerical information with angular shapes and approximate numerical information with rounded shapes.

Current research explains the formation of the association between numerical information and shape from two perspectives: linguistics and social cognition.

Linguistically, English uses "sharp" to express both precise numbers and angular shapes, and "round" to express both approximate numbers and rounded shapes (Isaac & Schindler, 2014; Schindler & Yalch, 2006). Chinese also uses sharp shapes metaphorically to express precision and rounded shapes to express approximation. This linguistic correspondence indirectly leads people to apply shape symbolism to specific decision-making contexts involving numbers, such as mapping the "successful completion" symbolism of rounded shapes onto approximate numbers, thereby influencing consumer judgments. However, this research only indirectly discovered and applied the relationship without directly exploring the direct association between precise numbers and angular shapes or approximate numbers and rounded shapes.

The social cognition perspective examines the reasons for the association from the shared symbolic meanings of numbers and shapes. When people process various numerical information in different contexts, the specific experiences in quantitative contexts activate various perceptions, emotions, and motivations, and these states are at least partially retained to form the symbolic meanings of numerical information. For example, precise numerical information evokes associations with confidence (Jerez-Fernandez et al., 2014), competence (Xie & Kronrod, 2012), masculinity (Yan, 2016), and aggressiveness (Backus et al., 2015), which are similar to the typical symbolic meanings of angular shapes. Meanwhile, approximate numerical information evokes associations with flexibility, femininity, compromise, and inclusiveness, which are similar to the symbolic meanings of rounded shapes. This similarity in symbolic meanings leads to an association between the two, thereby influencing information processing under different matching conditions: faster processing under matching conditions and slower processing under mismatching conditions. We further tested this speculation in Experiment 4: if one source of the association between shape and number is their shared symbolic meanings, then changing the symbolic meaning of one party should change their matching relationship. The results of Experiment 4 showed that changes in numerical symbolism indeed reversed the matching effect between numerical information and shape information.

However, we must acknowledge that other explanations may exist for the matching effect between numerical precision and shape discovered in this paper. For example, approximate numbers often end with the value "0," which may create visual similarity with rounded shapes, while precise numbers contain fewer "0" s, which may create greater visual similarity with angular shapes, leading to processing advantages in matching states. To rule out this explanation, we increased the number of "0" s in the precise number condition across experiments. For example, in Experiment 2' s precise number condition, we used the precise number "4.05" for product weight. Similarly, in Experiment 4, we used the number "90.02" to represent precise numbers, striving to match the number of zeros with the approximate number condition. Statistical results showed that the matching effect in this experiment was consistent with the results of Experiment 3, which did not use this manipulation. On the other hand, Experiment 4 introduced counterexamples of numerical gender symbolism and reversed the association pattern between gender and numerical precision concepts, thereby reversing the matching relationship between numerical precision and shape. The results of Experiment 4 largely rule out a visual mechanism explanation because if the association between numbers and shapes were due to visual similarity, the gender-precision association reversal manipulation in Experiment 4 would be unlikely to affect the association pattern between numerical precision and shape.

Second, this paper advances theoretical development in the brand logo domain (Hagtvedt, 2011; Jiang et al., 2016; 王海忠, 范孝雯, 欧阳建颖, 2017). Numerous studies in aesthetics and psychology have shown that people generally prefer rounded shapes over angular shapes (e.g., Moshe & Maital, 2006) because angular shapes are often associated with physical harm to individuals and evoke higher perceived threat. In visual brand design education, designers are often told that circles are elegant, their curves are feminine, they are warm and comfortable, and give others a feeling of sensuality and love. Some researchers have confirmed this preference for rounded over angular shapes in consumption contexts (Westerman et al., 2012). However, this preference may have multiple moderators. For example, some individual factors, such as self-construal type (independent vs. interdependent) or cultural type (individualistic vs. collectivistic), can moderate this preference (Zhang et al., 2006). This paper identifies another moderator from the perspective of product information factors—product numerical information. Our findings show that consumer preferences for angular and rounded shapes are influenced by product numerical information. In the context of precise product numerical information, consumers prefer products with angular brand logos; in the context of approximate product numerical information, consumers prefer products with rounded brand logos.

Third, this paper also supplements research on the effect of numerical information on product evaluations in the consumption domain. Some studies have explored how numerical precision influences consumer judgments and evaluations. For example, researchers have found that precise numbers are more persuasive than approximate numbers (Jerez-Fernandez et al., 2014; Schindler & Yalch, 2006) because people infer authenticity from precision. Other studies have found that approximate numbers are processed more fluently (King & Janiszewski, 2011), prompting consumers to adopt affective processing and leading to higher evaluations of hedonic products similarly processed affectively (Wadhwa & Zhang, 2015). This paper introduces brand logo shape as a new variable to the numerical processing domain, offering a new perspective for understanding how consumers process numerical information. Our results show that the persuasiveness of numerical information and the processing fluency of product information may depend on contextual information—whether the brand logo shape is angular or rounded. Experiments 2-3 and part of Experiment 4 all show that when the brand logo is angular, using precise numerical information is more persuasive—it leads to higher processing fluency for product information, thereby improving product evaluations. When the brand logo is rounded, using approximate numerical information is more persuasive.

Additionally, it is worth noting that Experiment 1 discovered the association between numerical precision and shape perception at the implicit level, while Experiments 2-4 reported at the explicit level in consumption contexts that people also exhibit matching between numerical precision and brand logo shape. That is, when deeper thinking rather than rapid responses is required, people still make different brand evaluations based on the matching relationship between numerical precision and shape information. This suggests that people may also explicitly recognize the matching of "angular shape—precise number" and "rounded shape—approximate number." Although we only found metaphorical shape expressions for different levels of numerical precision in English (e.g., sharp numbers or round numbers), Chinese also uses precision-related shape metaphors. For example, "看问题很尖锐" uses shape to describe accurate and profound insight, while "做事很圆滑" refers to being tactful and non-confrontational. Such expressions may also influence people' s explicit recognition of the relationship between the two.

3.3 Practical Implications

The practical implications of this paper are mainly twofold. First, it provides useful guidance for companies to set product numerical information expressions based on their brand logo shapes. For brands using angular shapes as brand logos, using more precise pricing may better promote consumer evaluations and purchases. Conversely, for brands using rounded shapes as brand logos, using approximate pricing may promote consumer product evaluations and purchases. Moreover, companies can proactively provide numerical information of different precision levels (e.g., consumer ratings, product weight, dimensions) to match different brand logo shapes. Second, our results can provide references for brand logo shape design in certain industries. For example, for brands or products that like to use numbers in their names (e.g., Boeing' s models 747/767/777; Airbus' s 300/310/340), designing brand logo shapes that match these numerical names may help enhance consumer evaluations from a subtle perspective.

3.4 Limitations and Future Research Directions

Like other studies, this paper has certain limitations that warrant future research.

First, although we used manipulation methods similar to existing research in Experiments 2-4 (e.g., in Pena-Marin and Bhargave' s (2016) study, 103.97 was used as a precise number and 100 as an approximate number), we cannot completely rule out the influence of digit length on our results. Future research could match digit length more precisely to manipulate these two types of numbers, such as using ¥320.0 for approximate numbers when precise numbers are ¥319.9.

Second, like existing research examining associations between numbers and other concepts (e.g., Yan, 2016), although this paper has discovered a link between numbers and shapes, the source of this link is not entirely clear. Experiment 4 explained the matching relationship from the perspective of shared symbolic meanings between numbers and shapes and proposed possible boundary conditions. However, other possible explanations remain, such as direct associations formed through linguistic similarity. Therefore, the occupational perception task in Experiment 4 (i.e., the association priming task) may not have reversed the number-shape matching relationship by changing numerical gender symbolism but may have simply primed participants' counter-stereotypical beliefs, leading them to consciously reduce their use of the number-shape stereotype. In other words, Experiment 4 may not have tested the explanation that numbers and shapes share symbolic meanings. Although current stereotype intervention research (e.g., 庞小佳, 张大均, 王鑫强, 王金良, 2011) has not derived that the occupational perception task in Experiment 4 can prompt individuals to form cross-domain counter-stereotypical beliefs that inhibit and correct stereotypes in other domains, future research still needs to rule out this "counter-stereotypical belief" possibility.

Additionally, the neural reuse hypothesis in cognitive neuroscience (Anderson, 2010) proposes that brain regions originally responsible for low-level cognitive functions can support the development of high-level cognitive functions. New cognitive functions can be integrated into original brain regions during phylogenetic or ontogenetic development while preserving the original functions. So, as a numerical concept that evolved relatively late in human evolution, does it share overlapping brain regions with earlier visual shape processing, leading to an association between the two? Future research may need to use brain imaging methods to explore this possible explanation. Finally, although we increased the number of "0" s in the precise number condition to match the number of zeros in approximate numbers, we cannot completely rule out visual similarity as an explanation. Future research could present numerical information in Chinese character form or auditory form (e.g., playing numerical information) to replicate and validate the matching relationship between numerical information and visual shape.

Third, this paper explored the application of the number-shape association in consumption practice through the joint influence of brand logo and product numerical information on product evaluation. However, besides brand logo shape, many other shapes exist in consumption contexts, such as product shape, packaging shape, and product shelf arrangement shape. Future research could further validate the number-shape association in these contexts.

Fourth, future research could further explore the associations between other attributes of brand logos, such as color, size, and pattern, and numerical information. For example, could the previously discovered red-blue effect (Mehta & Zhu, 2009) interact with numerical information to influence consumer product evaluations?

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Experimental Material Examples

Experiment 2 Material Examples:

"Angular-Precise" Group
"Rounded-Approximate" Group

Bad —1—2—3—4—5—6—7—Good
Dislike —1—2—3—4—5—6—7—Like
Negative —1—2—3—4—5—6—7—Positive
Completely untrustworthy —1—2—3—4—5—6—7—Completely trustworthy

Experiment 3 Material Examples:

"Angular-Precise" Group
"Rounded-Approximate" Group

Completely disagree —1—2—3—4—5—6—7—Completely agree
This advertisement is very easy to understand
Viewing this advertisement poster gives you a "this is right" feeling
The information contained in this advertisement is consistent and coherent
This advertisement is very organized
The information contained in this advertisement is credible

Experiment 4 Material Examples:

"Angular-Precise" Group
"Rounded-Approximate" Group

Occupation (e.g., accountant)
Completely female-dominated —1—2—3—4—5—6—7—Completely male-dominated
Completely does not require precision —1—2—3—4—5—6—7—Very much requires precision

Note: Figure translations are in progress. See original paper for figures.