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ACADEMIC PAPER

How language affects consumers' processing of numerical cues

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Abstract

We show that linguistic numeral structures affect consumers' comparative evaluations of numbers, prices, and alphanumeric brand names. For example, 80 (eighty) in English is perceived as 4 × 20 (*quatre-vingts* or four twenties) in French and as 8 × 10 (*ba-shi* or eight tens) in Chinese. Thus, the difference between 80 and 20 is expressed with different degrees of numerosity, the number of units into which a stimulus is divided: (a) 2 × 10 versus 8 × 10 in Chinese, (b) 20 versus 4 × 20 in French, or (c) simply 20 versus 80 in English. In four studies involving a total of 732 bilinguals who speak two of these three languages, we examine how different linguistic properties can lead to differences in comparison of numerical values and inferences made about product attributes. We demonstrate the mediating role of numerosity induced by certain linguistic structures while ruling out alternative explanations for this phenomenon such as cultural differences, processing fluency, and numeracy. Our research contributes to literatures on number cognition, numerosity, branding, and linguistics while providing insights for international marketers by encouraging practitioners to use different numbers in their marketing, branding, and pricing efforts in ways that best fit the linguistic structure of the country in which they sell a product.

1 | INTRODUCTION

Consumers frequently need to make comparisons using various forms of numerical information ranging from product attributes to price discounts (Chen & Rao, 2007) to alphanumeric brand names (ABNs) that include numbers (Gunasti & Ross Jr., 2010). Importantly, numbers are processed differently in different languages, and this can have a significant effect on consumer judgments, especially in the global marketing domain. For instance, Sony's Cybershot-WX20 and WX80 are marketed worldwide and, thus, are subject to decision-making (e.g., what model to buy, whether to upgrade from a previous model, and how much to pay for the upgrade) by consumers who use different languages that have very different numerical structures.

It is significant that how consumers' process numbers is related to differences in numerosity caused by different language structures. Numerosity is defined as "the number of units into which a stimulus is divided" (Pelham, Sumarta, & Myaskovsky, 1994, p. 103). An increase in the number of units can lead to more numerous structures in different languages, and the linguistic properties of a language can make its numeral system more or less "numerous." For example, the number "80" in English is processed as "4 × 20" in French and "8 × 10" in Chinese. The preceding example illustrates that the exact same number (80) can be verbalized in (a) a more numerous structure (eight 10s) in Chinese, (b) a less numerous structure (four 20s) in French, or (c) minimal numerosity (simply 80) in English. Previous research has documented the effect of numerosity on consumer decision-making and the evaluation of quantitative information in various contexts (Gamble, 2006; Marques, 1999; Pandelaere, Briers, & Lembregts, 2011; Wertenbroch, Soman, & Chattopadhyay, 2007). In this research, we propose that such linguistic properties can lead to variations in numerosity when consumers compare prices, product attributes, and brands (e.g., comparison of the Cybershot-WX20 and the Cybershot-WX80).

We explore whether, when, and how the differences in numerical structures of different languages affect consumers' comparative evaluations of numbers. We demonstrate how structural differences across languages can make the same numbers seem more or less numerous and how this can affect consumers' comparative

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evaluations. Our research provides important theoretical and managerial contributions to the growing literatures on (a) the effect of language on consumer behavior and branding (Alcántara-Pilar, Del Barrio-García, Crespo, & Porcu, 2017; Alcántara-Pilar, Del Barrio-García, Porcu, & Crespo-Almendros, 2017; Klink, 2000; LeClerc, Schmitt, & Dubé, 1994; Li & Kalyanaraman, 2012), (b) numerical processing and numerosity (Pandelaere et al., 2011), and (c) ABNs (Gunasti & Ozcan, 2016; Kara, Gunasti, & Ross Jr., 2015). Previous research has documented the effects of language on consumer behavior, such as online information processing, evaluations of advertisements (Li & Kalyanaraman, 2012), purchase intentions (Alcántara-Pilar, Del Barrio-García, Crespo, & Porcu, 2017; Alcántara-Pilar, Del Barrio-García, Porcu, & Crespo-Almendros, 2017), and numerical processing (Colome, Laka, & Sebastian-Galles, 2010; Pica, Lemer, Izard, & Dehaene, 2004). Our examination integrates these two research streams on language and numerical processing and provides a unique angle by documenting the effect of linguistic numeral structures on consumers' evaluations of numerical information in the context of a product's brand names, prices, and attributes. Thus, our findings contribute to the literature considering the effect of ABNs on consumers' brand evaluations (Gunasti & Devezer, 2016; Kara et al., 2015) by elucidating how numerosity acts as the underlying mechanism for the effects of linguistic numeral systems on consumer judgments.

Our research focuses on three major world languages, English, French, and Chinese, and over four studies we show how linguistic structures related to numbers affect consumers' comparative evaluations of numbers (e.g., brand names, prices). We also rule out alternative explanations for this phenomenon, including cultural differences, processing fluency, and numeracy. From a theoretical perspective, our findings enrich our understanding of the effect of language on numerical processing by providing evidence that linguistic characteristics are prominent factors in creating between-language differences in the evaluation of prices and ABNs, over and above sociocultural and economic differences. From a managerial perspective, we show that using the same numerical cues across global markets results in different consumer reactions across different languages and that these are sometimes favorable and sometimes unfavorable.

2 | CONCEPTUAL BACKGROUND

The Whorfian Hypothesis (Whorf, 1956) proposes that language affects and indeed shapes human thought (Lakoff & Johnson, 2008). However, other scholars deviate from Whorf's strong linguistic determinism, so-called because it suggests that "language determines thought entirely."

(De Cruz, 2009, p. 327), and argue that the scope of the hypothesis is too broad (Hardin & Banaji, 1993). Instead, they propose that language affects cognition in more limited ways (Hunt & Agnoli, 1991), such as numerical cognition (Colome et al., 2010; Pica et al., 2004), online information processing (Alcántara-Pilar, Del Barrio-García, Crespo, & Porcu, 2017; Alcántara-Pilar, Del Barrio-García, Porcu, & Crespo-Almendros, 2017), and purchase intentions (Li & Kalyanaraman, 2012). The majority of the extant literature has approached the effects of language from two perspectives: sociolinguistics and psycholinguistics (Carnevale, Luna, & Lerman, 2017). Sociolinguistics investigates how language influences collective (e.g., societal) and individual relational dynamics by focusing on the effect of linguistic variables/structures in relation to culture and other social factors, while psycholinguistics investigates how individuals process language by focusing on the effect of linguistic variables/structures on how the mind works in relation to memory, information processing, and knowledge (Alcántara-Pilar, Del Barrio-García, Crespo, & Porcu, 2017; Alcántara-Pilar, Del Barrio-García, Porcu, & Crespo-Almendros, 2017).

Hence, as also stated in the extant literature (Carnevale et al., 2017), psycholinguistics studies how language influence "inside" the mind, while sociolinguists studies how the influence of language is reflected "outside" the mind.

As summarized in Table 1, the extant literature focusing on the effects of language from both the marketing and consumer psychology perspectives is rather rich. Past studies have documented sociolinguistic effects on consumer behavior in various domains, such as the influence of translated brand names on brand favorability, the effectiveness of culturally adapted foreign slogans on advertising likeability, and the effect of the display of a foreign language in marketing materials in relation to the country of origin and code-switching on advertising effectiveness (see Table 1). The psycholinguistic approach to the effects of language on consumer behavior, the approach taken by this research, also provides rich insights into branding, advertising, information processing, and numerical processing/cognition. One example is the effect of sound symbolism, which refers to how certain sounds and phonemes carry meaning and information that have an influence on consumers' evaluations of brand preferences and evaluations such as brand personality (Klink et al., Table 1). Other linguistic characteristics of brand names, such as auditory versus visual representation or having an unusual spelling, have also been shown to influence consumers' brand evaluations and memory (Schmitt et al., Table 1). Another example is the research that suggests that online information processing is influenced by the language congruity between the banner ad and the editorial content (Alcántara-Pilar et al., Table 1). A final example is the research on the psycholinguistic effects of numerical processing on consumer decision-making. The effect of language on numerical processing has received attention in various disciplines, such as the cognitive sciences, linguistics, and behavioral studies (Gelman & Gallistel, 2004; Gordon, 2004; Wiese, 2003).

As shown in Appendix A, most languages use a decimal (10) *base*, but many (e.g., English, Spanish, and Turkish) introduce a new word for each unit of 10, thus changing the base units from 10 to 20, 30, 50, etc. (Justus, 2004). For example, 10 is "ten" but 20 is "twenty" (as opposed to two tens) in English while 10 is "*on*" but 20 is "*yirmi*" in Turkish. Conversely, some languages, such as Chinese and Korean, more regularly stick to the units of 10 for a wide range of numbers. For example, 20 is "2×10" (*er-shi*), 50 is "5×10" (*wu-shi*), 80 is "8×10"(*ba-shi*) in Chinese, where 2, 5, 8 and 10 are "*er*, *wu*, *ba*, and *shi*," respectively. For larger numbers, however, Chinese uses a base of 10,000 as opposed to 1,000. For example, 200,000 is "$20 \times 10{,}000$" and 20,000,000 is "$2{,}000 \times 10{,}000$."

TABLE 1 Summary of past research

Domain			Findings	References
Linguistics and consumer behavior	Sociolinguistics	Branding	Favorability of international (translated) brand names vary based on sociolinguistic traits	Li and Shooshtari (2003)
		Advertising	Cultural adaptation (e.g., to convey cultural values) of foreign ad materials like slogans enhances ad effectiveness	Alcántara-Pilar, Sánchez-Duarte, Rodríguez-López, and Rojas-Lamorena (2019), Hornikx and O'Keefe (2009)
			Effectiveness of foreign language display and mixing languages in ad materials on advertising likeability and persuasiveness, and signaling brands' country-of-origin	Hornikx and van Meurs (2015), Hornikx, van Meurs, van den Heuvel, and Janssen (2020), Koslow, Shamdasani, and Touchstone (1994); Luna and Peracchio (2005)
	Psycholinguistics	Branding	Sound symbolism in brands influences consumers' brand preferences and evaluations (e.g., brand personality and attribute values)	Athaide and Klink (2012), Klink (2000), Klink and Athaide (2012), Lowrey and Shrum (2007), Shrum, Lowrey, Luna, Lerman, and Liu (2012), Yorkston and Menon (2004)
			Auditory and visual representation of brand names in different languages influences brand evaluations and memory	Schmitt, Pan, and Tavassoli (1994), LeClerc et al. (1994)
			Linguistic properties of brands, such as unusual spelling and semantic appositeness (e.g., suggestive brand names) affects brand recall	Lowrey, Shrum, and Dubitsky (2003), Keller, Heckler, and Houston (1998), Sen (1999)
		Advertising	Effects of foreign ad materials and ease-of-comprehension on advertising effectiveness, and signaling brands' country-of-origin	Hornikx, Van Meurs, and de Boer (2010), Hornikx and van Meurs (2015), Hornikx et al. (2020)
		Information processing	Online experience and information processing are influenced by the language manifested in congruity between (i) the banner ad and editorial content, and (ii) website content and visitors' cultures	Alcántara-Pilar, Del Barrio-García, Crespo, and Porcu (2017); Alcántara-Pilar, Del Barrio-García, Porcu, and Crespo-Almendros (2017); Alcántara-Pilar, Del Barrio-García, and Rodríguez-López (2018), Li and Kalyanaraman (2012), Luna, Peracchio, and de Juan (2002)
		Numerical processing	Sound symbolism influences numerical magnitude perceptions in prices	Coulter and Coulter (2010)
			Linguistic numeral systems display different characteristics across languages such as base which influence cognition, perception of numerical concepts, and arithmetic performance	Colome et al. (2010), De Cruz and Pica (2008), Gordon (2004), Gelman and Gallistel (2004), Justus (2004), Pica et al. (2004), Wiese (2003)
Numerical Processing & Consumer Behavior		Numerosity	Effect of numerosity on spending in different currencies, consumer-level loyalty programs, reward points, attribute evaluations.	Gamble (2006), Marques (1999), Nejad and Onay (2014), Pandelaere et al. (2011), Pelham et al. (1994), Ramoniene and Brazys (2007), Wertenbroch et al. (2007)
		Alphanumeric brand names	Inclusion of numbers in brands influences consumers' brand evaluations such as attribute inferences, quality expectations, line extension assessments, and heuristic-based judgements	Gunasti and Ross Jr. (2010), Kara et al. (2015), Gunasti and Ozcan (2016), Gunasti and Devezer (2016), Ozcan and Gunasti (2019)

Similarly, French, Danish, and Irish partially adopt a vigesimal (20) base and express certain numbers in units of 20 instead of 10. For example, 80 is "4 × 20" in French (4: *quatre*, 20: *vingt*, 80: *quatre-vingts*) whereas in Danish, 50 is "2.5 × 20" and 90 is "4.5 × 20," and, in Welsh, 60 is "3 × 20." Other bases are partially adopted by various languages at different numerical ranges.

For example, French also uses a sexagesimal (60) base, referring to 70 as "60 + 10."

Holding the actual numbers identical, differences in numerical structures (i.e., how numbers are constructed and expressed in languages) can cause speakers of different languages to perceive numbers differently within specific ranges, producing a bias in consumption decisions. We explore this proposition through the lens of *numerosity* bias, which suggests that people focus on the *number of units* to evaluate a difference, that is, judge a specific quantity, and ignore the *size* of the unit (Pelham et al., 1994). Previous research has documented the effects of numerosity in various contexts, such as the amount of spending in different currencies (Wertenbroch et al., 2007), the so-called compression effect (i.e., the perception of greater price differences in smaller currencies) (Gamble, 2006; Marques, 1999), and loyalty programs (Nejad & Onay, 2014). Despite the fact that all of the aforementioned effects include the translation of one unit to another, the effect of numerosity has been observed in evaluations of quantitative information that does not include preferential targets for translation, such as comparative attribute evaluations (Pandelaere et al., 2011).

Specifically, when a quantity is expressed in more (vs. less) numerous units, individuals overestimate the quantity (Ramoniene & Brazys, 2007). Consider someone comparing the Canon S20 and the Canon S80. In French, the numbers are perceived as "20 versus 4 × 20s," whereas in English they are perceived as "20 versus 80." Thus, the linguistic architecture (i.e., how numbers are constructed and expressed) of a language affects how consumers perceive the features of products labeled with ABNs. Because the number (vs. the size) of units receives more attention, we propose that the difference between attributes of the S20 and the S80 brands will be perceived as larger in French than in English.

Another example, in Chinese, is that \$50 versus \$70 will be processed as "5 × \$10 versus 7 × \$10," leading to greater numerosity and thus to perceptions of greater differences than in English. However, at larger numbers, Chinese adopts base 10,000 (*wan*), shifting the numerosity. For example, while in English the difference between 150,000 and 180,000 is processed as "150 × 1,000 and 180 × 1,000," in Chinese it is "15 × 10,000 and 18 × 10,000." Because 30 units (of 1,000) will be more numerous than three units (of 10,000), the numerical difference will be perceived as larger in English than in Chinese. By contrast, when we reach the tens of millions level, the 10,000-base in Chinese might lead to perceptions of greater differences. For example, 30,000,000 versus 40,000,000 is processed in Chinese as "3,000 × 10,000 versus 4,000 × 10,000" (1,000 units of 10,000 difference) as opposed to "30 × million versus 40 × million" (10 units of a million difference) in English.

Figure 1 summarizes how linguistic numeral structures (i.e., changes in *base*) affect the numerosity of quantitative comparisons. Accordingly, the perceived differences of numbers in different languages is not due to a simple cultural difference (i.e., speakers of one language do not constantly perceive larger/smaller differences than the speakers of another language), but it is dynamically based on each language's numeral structures. As the base of the numeral system gets larger for the specific range of a numerical comparison, the perceived numerical differences become smaller. For example, the difference between 20 and 70 is perceived as greater in Chinese (vs. English), whereas the difference between 20,000 and 70,000 is greater in English (vs. Chinese), with both examples being due to the perceived changes in numerosity.

Hypothesis 1 *When comparing two numbers, languages that use smaller bases for a specific range of numbers will have a greater amount of perceived numerical differences*.

Hypothesis 2 *The effect of languages on numerical comparisons (H1) is mediated by the perceived numerosity of the differences between the numbers*.

3 | OVERVIEW OF THE STUDIES

As summarized in Table 2, we ran four experiments with 732 bilingual participants mostly from two widely used online-panels: mTurk.com (Amazon Mechanical Turk) and Qualtrics.com. Although some online participants respond unconscientiously (Downs, Holbrook, Sheng, & Cranor, 2010), there is considerable research that establishes the effectiveness of using online platforms and shows how constructing careful instruments can achieve optimal results (Goodman, Cryder, & Cheema, 2013; Kara, Vredeveld, & Ross, 2018; Nikolinakou & Phua, 2020). Our recruitment of bilingual respondents enabled us to make random assignments between languages, which minimized the confounding effects of individual characteristics or sociocultural predispositions while increasing the robustness of our findings.

To minimize the idiosyncratic and cultural effects associated with specific numerical information (e.g., prices) and to maximize the generalizability of our findings, we used a wide range of numerical cues, including attributes, populations, prices, and ABNs, as our stimuli in the different studies. Because language is a part of culture, its effects might not be completely separable from that of culture. However, we utilized subjects who did not differ in their geographic locations or cultures, but only in their spoken language, which helps us delineate the effect of language on the processing of numbers.

4 | STUDY 1

4.1 | Method

In this study, we compare numerical evaluations performed in English and Chinese to test H1. Because Chinese and American consumers

Panel A – Bases Used within Number Range of 0-100

Language	*Base*	20 vs. 80	70 vs. 90
Chinese	10 (decimal)	2x10 vs. 8x10 *two-tens vs. eight-tens*	7x10 vs. 9x10 *seven-tens vs. nine-tens*
French	10 (decimal), 20 (vigesimal), 60 (sexagesimal)	20 vs. 4x20 *twenty vs. four-twenties*	60+10 vs. 4x20+10 *Sixty-ten vs. four-twenties-ten*
English	Changing for every decade (10, 20, 30, 40, … etc.)	20 vs. 80 *twenty vs. eighty*	70 vs. 90 *seventy vs. ninety*

Decreasing Numerosity

Panel B – Shifts of Bases within Larger Number Range of 10,000-100,000,000

Language	*Base*	*20,000*	*300,000*	*20,000,000*
English	1000	20 x 1000 *twenty thousand*	300 x 1000 *Three hundred thousand*	20 x 1,000,000 *Twenty million*
Chinese	10,000	2 x 10,000 *two ten-thousands*	3x10 x 10,000 *Three-ten ten-thousands*	2000 x 10,000 *Two-thousand ten-thousands*

Increasing Numerosity

FIGURE 1 Linguistic numeral structures and numerosity

TABLE 2 Summary of the studies

			Sample characteristics				
Study	*N*	Hypothesis tested	Female (%)	Avg. age	Languages (bilinguals)	Location	Online panel
1	226	H1	41	30	Chinese–English	USA	mTurk.com
2	104	H1	65	20	Chinese–English	Hong Kong	Not online
3	192	H1, H2	51	48	French–English	Quebec/Canada	Qualtrics.com
4	210	H1	51	46	French–English	Quebec/Canada	Qualtrics.com

might perceive larger or smaller differences among prices for non-linguistic, cultural reasons (Ackerman & Tellis, 2001), we used comparisons of alphanumeric brands, which are less susceptible to such effects (Gunasti & Ross Jr., 2010). To minimize cross-country differences, we recruited 226 bilingual Chinese-Americans (Table 2) who completed the survey either in Chinese or English.

We first introduced two vacuum cleaners by Derin (a fictitious brand) via a short print advertisement, as shown in Appendix B. Participants were informed that Derin-36 had a suction power of two air watts and were asked to judge the power of the Derin-92 using a scale ranging from 1 to 20 air watts. Because of the higher numerosity of these numbers in Chinese (3 units of 10 vs. 9 units of 10) in comparison to English (30 vs. 90), we expected to observe differences in inferences about attributes.

To help distinguish the effects of linguistic structures from that of culture (e.g., De Mooij & Hofstede, 2002), we next introduced two additional dishwashers, the Derin-300 and the Derin-900, which had identical numerical expressions in both languages (3×100 vs. 9×100). After viewing the control panels for the two products (see Appendix B), participants rated the quality of the Derin-900 relative to the Derin-300 (1-very bad, 20-very good), we did not expect to observe any differences across languages. Note that the scale to measure the relative quality of the dishwashers was non-numeric with bipolar end points.

4.2 | Results

Participants inferred a larger difference in suction power between the Derin-92 and the Derin-36 when they processed the information in Chinese ($M_{Chinese}$ = 11.71 vs. $M_{English}$ = 9.39, $F(1,224) = 18.1$, $p < .01$, see Table 3). As expected, however, the difference between the Derin-900 dishwasher and the Derin-300 was not significant across languages ($M_{Chinese}$ = 62.10 vs. $M_{English}$ = 65.50, $F(1,224) = 1.15$, $p > .28$).

4.3 | Discussion

Overall, in support of Hypothesis 1, when the information was processed in Chinese (vs. English), people perceived larger differences between 36 and 92, but not between 300 and 900, because the second pair has an identical linguistic numeral structure in both languages. Because the objective, mathematical differences are universal and identical (e.g., 92–36 = 56) regardless of language, examining the subjective, perceptual differences is challenging. Accordingly, instead of using direct measures (92–36 =?), we employed ABNs and measured the subjects' inferences about attributes and quality as proxies.

Our use of two different numerical pairs helped us rule out cultural differences as an alternative explanation. But null effects can be difficult to interpret, so it would be useful to show a reversal of the effect. Specifically, if the differences stem from numeral structures, then Chinese-speakers should not constantly perceive greater numerical differences than English speakers; perceptions should depend on the numeral structures at the specific number ranges as tested in the next study.

5 | STUDY 2

5.1 | Method

We employed a two language (English and Chinese) between-subjects × 2 number range (ten-thousands, ten-millions) within-subjects design to test the effects of linguistic structures we observed at different numerical ranges and with different types of numerical information. One hundred and four Chinese–English bilinguals at a Hong Kong University (Table 2) were randomly presented with either the English or Chinese version of an identical survey that introduced them to comparisons between two numerical pairs via various scenarios.

The first scenario asked participants to compare the prices of two cars, Model X for $50,000 and Model Y for $70,000. Because Chinese conceptualizes 50,000 and 70,000 as “5 × 10,000” and “7 × 10,000,” we expected the difference between the two numbers (2 units of 10,000) to be perceived as smaller than in English, which conceptualizes the same numbers as “50 × 1,000” and “70 × 1,000” (a difference of 20 units of 1,000). Because of “unit neglect,” 2 units of 10,000 in Chinese may be seen to be a smaller difference than 20 units of 1,000 in English.

Next, participants compared the populations of countries A and B at 60 million and 70 million. Because the difference corresponds to “6,000 × 10,000” versus “7,000 × 10,000” in Chinese as opposed to “60 × 1,000,000” versus “10 × 1,000,000” in English, this time we expected the difference to be perceived as greater in Chinese. Specifically, 1,000 units (of 10,000) in Chinese is more numerous than 10 units (of a million) in English. Participants rated the differences of both pairs on an unnumbered sliding scale going from extremely small to extremely large. To facilitate analysis, we used numerical coding to represent responses on the sliding scale.

5.2 | Results

To compare the perceived numerical differences depending on the numerical range, we ran a repeated measures MANOVA in which language (English vs. Chinese) served as the between subjects factor, and the two numerical pair comparisons (prices: $50,000 vs. $70,000; populations: 60 million vs. 70 million) served as the repeated measures factor. The results are summarized in Table 4.

Unsurprisingly, there was a significant main effect of the repeated measures factor (F(1,101)=6.10, p = .015) suggesting that there were differences in the comparisons of the two numerical pairs. More critical to our theorizing was the significant interaction of the repeated measures factor and language (F(1,102)=12.72, p = .001). As expected, contrast analysis showed that the perceived difference between $50,000 and $70,000 was greater in English than in Chinese ($M_{English}$ = 61.93 vs. $M_{Chinese}$ = 51.14, F(1,102) = 4.36, p = .039). Conversely, the difference between 60 and 70 million was perceived as greater in Chinese ($M_{Chinese}$ = 54.16 vs. $M_{English}$=.45.30, F(1,102) = 4.57, p = .035)

5.3 | Discussion

Our use of a two-level within-subjects factor provided a more conservative test than a between subjects design and strengthened support for Hypothesis 1. The fact that we observed greater differences between 50,000 and 70,000 in English and greater differences between 60 and 70 million in Chinese indicates that these discrepancies cannot be explained by a simple tendency to overestimate numbers in one language or culture or by the tendency of a specific individual over another.

Note that “numerosity” has never been studied as a mediator. Previous studies simply manipulate the numerosity of quantitative information and demonstrate its effects on various outcome variables (Pandelaere et al., 2011; Pelham et al., 1994). Diverging from the

TABLE 3 Results of study 1

		Design numbers		Mean values	
		Number comparison (within-subject)		Number comparison (within-subject)	
Study 1		Difference* (36–92)	Control (300–900)	Difference* (92–36)	Control (300–900)
Language (between-subject)	Chinese	(3 × 10 + 6)–(9 × 10 + 2)	(3 × 100)–(9 × 100)	11.71	62.10
	English	(30 + 6)–(90 + 2)	(3 × 100)–(9 × 100)	9.39	65.50

*The between-language difference is significant at p < .05 level.

TABLE 4 Results of Study 2

Study 2		Design-numbers Number range (within-subject) Ten-thousands* (50–70K)	Ten-millions* (60–70 million)	Mean values Number range (within-subject) Ten-thousands* (50–70K)	Ten-millions* (60–70 million)
Language (between-subject)	Chinese	(5 × 10,000)–(7 × 10,000)	(6,000 × 10,000)–(7,000 × 10,000)	51.14	54.16
	English	(50 × 1000)–(70 × 1000)	(60 × 1,000,000)–(70 × 1,000,000)	61.93	45.30

*The between-language difference is significant at $p < .05$ level.

extant literature, to test the mediating role of numerosity (Hypothesis 2) in the next study we asked participants in what format they perceived the numerical differences.

6 | STUDY 3

6.1 | Method

The purpose of this study was to test the mediating role of numerosity (H2), and replicate the previous results in a different language pair (English vs. French) (Hypothesis 1) while again ruling out the potential for sociocultural differences. We recruited participants who (a) shared the same culture (i.e., residents of Quebec), (b) were bilingual, and (c) were asked to comparatively evaluate two ABNs in either French or English. This enabled us to replicate our findings in the context of a vigesimal, high-numerosity context. Notably, we also used a real brand as the stimulus to increase the robustness of our findings regarding the effect of linguistic numeral systems on brand evaluations.

One hundred and ninety-two French-English bilingual Canadians (Table 2) participated in a two-condition (French vs. English) between-subjects design experiment to evaluate the Sony Cybershot-27 camera and its line extension, the Cybershot-87. In French, 27 is expressed as one unit of 20 plus 7 (similar to English) whereas 87 is expressed as four units of 20 plus 7 (4 × 20 + 7). Because of the greater numerosity in French than in English, we anticipated perceptions of a greater difference between the two products in the French condition (3 units of 20) than in the English condition (1 unit of 60).

We created print advertorials that narrate the existing brand and introduce the line extension (Appendix B), and identical stimuli were presented in either French or English.

Participants were introduced to the existing brand, the Cybershot-27, and the line extension, the Cybershot-87. Participants were informed that the memory capacity of the Cybershot-27 is one gigabyte (GB and were then asked to estimate memory capacity of the Cybershot-87 using a five-point scale (1GB-5GB).

To shed light on the underlying process and test Hypothesis 2, we next asked participants to evaluate the difference between 20 and 80 by choosing one of the two options (60 vs. 3 × 20) to reflect their numerosity perceptions. We expected a relatively higher choice ratio for "3 × 20" among those in the French condition. Because our participants were potentially from diverse backgrounds with varying levels of education, a potentially critical determinant in one's performance on numerical tasks, we specifically asked them about their level of education and controlled for it in subsequent analyses. Hence, we aimed to rule out differing levels of education as an alternative explanation.

6.2 | Results

The effect of language on comparative alphanumeric brand evaluations. Two participants failed the attention check (*where does the sun rise from?*) and were excluded from the data analysis. Participants in the French condition inferred a higher amount of memory for the new camera compared to those in the English condition (M_{French} = 3.66 vs. $M_{English}$ = 3.43; $F(1,187) = 4.76$, $p < .05$), and this result held even after controlling for level of education ($F(1,187) = 4.33$, $p < .05$, Table 5).

Numerosity Measure. Only 26% of participants in the English condition perceived the difference between the Cybershot-87 and the Cybershot-27 as "3 × 20," whereas 46% of participants in the French condition did so ($\chi^2 = 8.56$, $p < .01$, see Figure 2). Hence, in support of the numerosity argument, the linguistic numeral structure affected the evaluation of numerical differences across languages.

The Mediating Role of Numerosity. A mediation analysis with 5,000 bootstrapped samples was conducted in Mplus in which language (English = 0; French = 1) served as the independent variable, numerical difference as the mediator (*60* = 0; *3 × 20* = 1), and education as a covariate. As summarized in Figure 2, the differential effect of language on numerical difference was positive and significant ($b = .49$; $t_{188} = 2.43$, $p < .01$). After controlling for language and level of education, the differential effect of numerical difference on memory capacity was positive and marginally significant ($b = 0.17$; $t_{188} = 1.8$, $p = .07$). However, after controlling for the numerical difference, the direct effect of language on memory capacity was not significant ($b = 0.25$, $t_{188} = 1.59$, $p > .1$). in support of Hypothesis 1, the indirect path ($b = .08$) had a 95% confidence interval excluding zero (0.001–0.23), indicating a mediation effect.

TABLE 5 Results of Study 3

Study 3		Design-numbers (27–87)	Mean values (attribute inference*)
Language (between-subject)	French	(20 + 7)–(4 × 20 + 7)	3.66
	English	(20 + 7)–(80 + 7)	3.00

*The between-language difference is significant at $p < .05$ level.

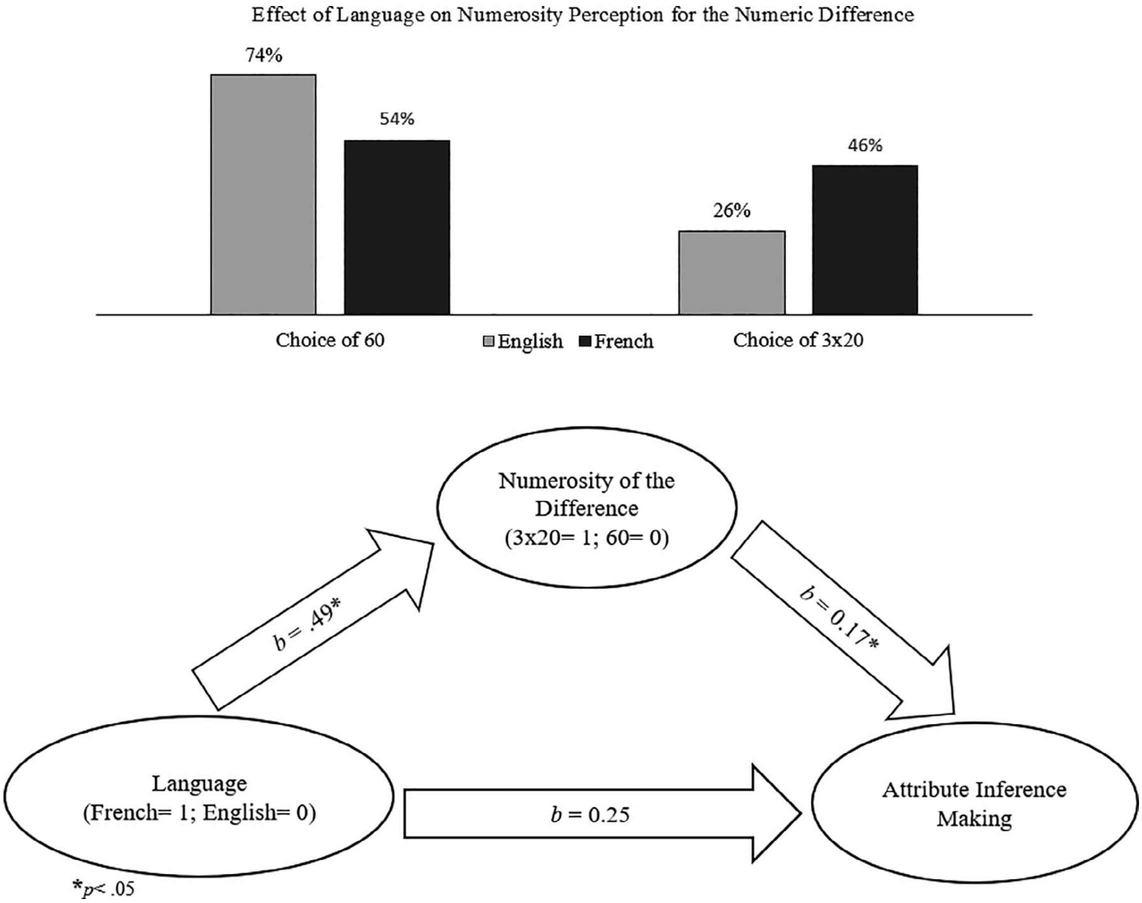

FIGURE 2 Results of mediation analysis—Study 3

6.3 | Discussion

The results of this study increased the robustness of our findings from previous studies by introducing the mediating role of numerosity and replicating the main effect in a different linguistic context. The results show that linguistic numeral structures, such as the vigesimal (French), affect how consumers perceive numerical differences (e.g., numerosity), which consequently affects their comparative evaluation of products. Our use of participants from Quebec, where people share similar geography, socioeconomic structures, and cultural values enabled us to show that the effect was not driven by these differences. The results provide further information about the numerosity-based mechanism associated with the effect of language on comparative evaluation of brands.

7 | STUDY 4

7.1 | Method

Fluency is commonly defined as the ease people experience when processing stimuli. When numerosity is higher due to linguistic structures, numerical differences might be more easily determined (Thomas & Morwitz, 2009). A potential alternative explanation would be that consumers vary in their ability to process numerical information, an individual difference termed *numeracy* (Weller et al., 2013). The use of a qualitative scale to capture perceived differences between brands can help prevent any potential confounds between the scale points and the specific numbers of the brand names that might have occurred in Study 3.

To rule out these alternative explanations, we recruited 210 French-English bilinguals from Canada (Table 2) and used Study 3's stimuli with critical additions. We captured the time it took to calculate the difference between 27 and 87 as a measure of processing fluency, and used subjective numeracy scale (SNS) to measure participants' numeracy (Fagerlin et al., 2007). To measure perceptions of the improvement in quality, we showed participants five photographs (Appendix B). The first photo was allegedly taken by the Sony Cyber-shot 27. The next four varied in resolution but all were of superior quality to that of the first picture. Participants were asked to guess the level of quality to be expected from the Cyber-shot 87. We also measured their willingness to purchase (WTP) the new versus existing product (1-Definitely Cybershot-27, 10-Definitely Cybershot-87).

7.2 | Results and discussion

Respondents in the French condition inferred greater quality improvement to the Cybershot-87 than their counterparts in the English condition (M_{FRC} = 3.68 vs. M_{FRC} = 3.37; $t(208) = -2.7$, $p < .01$, see Table 3) They and were more willing to purchase the new model (M_{FRC} = 8.25 vs. M_{ENG} = 7.33; $t_{208} = -3.51$, $p < .01$). Notably, the effect of language on WTP and perceived picture quality remained significant after controlling for SNS. Furthermore, the time spent on evaluating the difference between the two numbers did not differ significantly between the conditions (M_{ENG} = 2.72 vs. M_{FRC} = 2.58; t_{208} = 1.48, $p > .1$). Thus, processing fluency and numeracy were ruled out as alternative explanations for the observed linguistic effects (Table 6).

8 | GENERAL DISCUSSION

8.1 | Theoretical contributions

Our research is an initial effort to examine how linguistic differences in numeral structures affect the processing of numbers, prices, and ABNs. First, we demonstrated that when linguistic properties alter the numerosity of quantitative comparisons they affect consumers' ability to make comparative numerical evaluations. Second, by using bilingual participants randomly assigned to different languages, we showed that the differences in processing observed when linguistic numeral structures are the only difference across stimuli in two different languages are due to differences in linguistic numeral systems, not socio-cultural or individual differences. In these experiments, participants shared the same geographic location and culture; only the language in which they processed the numbers was different. Our use of ABNs that had more vague ties to actual quantities further helped to minimize cultural effects on numerical processing as well as individual differences such as processing fluency and numeracy.

This research contributes to the growing literatures on psycholinguistics, numerical processing, ABNs, and numerosity (Table 1) by providing a unique psycholinguistic angle that combines two research streams: the effect of language on consumer behavior (Alcántara-Pilar, Del Barrio-García, Crespo, & Porcu, 2017; Alcántara-Pilar, Del Barrio-García, Porcu, & Crespo-Almendros, 2017; Li & Kalyanaraman, 2012) and numerical processing (Colome et al., 2010; Pandelaere et al., 2011; Pica et al., 2004). We provide evidence for the effect of language on tasks related to making numerical comparisons and demonstrate an implication of this effect in the context of comparative ABN evaluations. We found that as the numeral system became more numerous due to these linguistic numeral properties, consumers evaluated greater amounts of difference between the numbers and thus between ABNs. Our research also contributes to the numerosity literature by showing that shifts in the numeral bases result in shifts in numerosity and affect the perceptions of quantitative differences.

8.2 | Managerial implications

Given the significance of brand names on consumers' brand/product evaluations (Gabrielsen & Zaichkowsky, 2012), our findings have important practical implications, especially in the global marketing domain. From a managerial point of view, numbers, including those in the ABNs of line extensions, may result in different consumer reactions in different languages. Indeed, there is ample research on foreign brand names and the potential effects of differences in the linguistic properties of verbal brand names (Klink, 2000; LeClerc et al., 1994). However, previous studies did not provide any guidance to marketers regarding the effect of linguistic differences on the processing of numbers. Because international consumers frequently compare alphanumeric brands or prices, practitioners can utilize the numbers included in global brands to either maximize or minimize the perceived differences of their product offerings in different countries.

Multinational firms are already known to use different verbal brand names to appeal to different cultures. For instance, the Good Humor ice cream brand in the United States is marketed under the brand names of Algida, TioRico, Frigo, Streets, etc., in different countries. Accordingly, marketers of alphanumeric brands can strategically

TABLE 6 Results of Study 4

Study 4		Design-numbers (27–87)	Mean values WTP*	Picture quality*	Time spent
Language (between-subject)	French	(20 + 7)–(4 × 20 + 7)	8.25	3.68	2.58
	English	(20 + 7)–(80 + 7)	7.33	3.37	2.72

*The between-language difference is significant at $p < .05$ level.

arrange the numbers in the brands to best fit the linguistic structure of the country in which they sell a product and can similarly arrange the prices. For example, an identical set of brands can be marketed as X30 and X90 in one market or as A20 and A80 in another market.

Our findings suggest that numbers in brand names can play a crucial role in consumer inferences about comparative prices and even their choice. For example, if the X20 is $1 and the X80 is $3, French (vs. English) customers might be more likely to pick the X80 because they implicitly think it should be four times better for only three times the price.

8.3 | Limitations and future research

Our research has some limitations that leave open avenues for future research. First, testing the effects of differences in linguistic numeral structures in additional languages with different numerical structures is an important future research avenue. Second, in this research, we focused on visual representation of the numbers in a digital (e.g., Arabic numerals) format to investigate the psycholinguistic effects of numeral systems on consumers' evaluations of numerical differences and brands. However, as extant research suggests (Athaide & Klink, 2012; Lowrey & Shrum, 2007, and others, Table 1), sound symbolism of the marketing stimuli, such as brand names in a verbal/audio representation, influences consumer evaluations, which can lead to sociolinguistic implications (Alcántara-Pilar et al., 2019). Hence, another future research opportunity lies in testing the effect of linguistic numeral systems in relation to varying representational formats such as audio and numerical words. Third, although the use of online panels is a widely practiced sample construction technique in empirical consumer behavior (Goodman et al., 2013; van Horen & Pieters, 2017), replication of the results with field experiments would increase the external validity and generalizability of our findings.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study can be available from the corresponding author upon reasonable request.

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REFERENCES

Ackerman, D., & Tellis, G. (2001). Can culture affect prices? A cross-cultural study of shopping and retail prices. *Journal of Retailing*, *77*(1), 57–82.

Alcántara-Pilar, J., Del Barrio-García, S., Crespo, E., & Porcu, L. (2017). A review of psycho- vs. socio-linguistics theories: An application to marketing research. In *Advertising and branding: Concepts, methodologies, tools, and applications* (pp. 1–30). Hershey, PA: IGI Global.

Alcántara-Pilar, J. M., Del Barrio-García, S., Porcu, L., & Crespo-Almendros, E. (2017). Language as a cultural vessel in online servicescapes: Its impact on consumers' perceived risk, attitudes, and behavioural intentions. *Journal of Consumer Behaviour*, *16*(6), e61–e75.

Alcántara-Pilar, J. M., Del Barrio-García, S., & Rodríguez-López, M. E. (2018). Does language matter? A cross-national comparison of the moderating effect of language on website information-processing. *Journal of Business Research*, *88*, 66–78.

Alcántara-Pilar, J. M., Sánchez-Duarte, I. M., Rodríguez-López, M. E., & Rojas-Lamorena, Á. J. (2019). The effect of sociolinguism on advertising slogans: Language as a conveyor of cultural characteristics. M. Epure & L. C. Mihăeş In *The role of language and symbols in promotional strategies and marketing schemes*, (pp. 126–143). Hershey, PA: IGI Global.

Athaide, G. A., & Klink, R. R. (2012). Creating global brand names: The use of sound symbolism. *Journal of Global Marketing*, *25*(4), 202–212.

Carnevale, M., Luna, D., & Lerman, D. (2017). Brand linguistics: A theory-driven framework for the study of language in branding. *International Journal of Research in Marketing*, *34*(2), 572–591.

Chen, H., & Rao, A. (2007). When two plus two is not equal to four: Errors in processing multiple percentage changes. *Journal of Consumer Research*, *34*(3), 327–340.

Colome, A., Laka, I., & Sebastian-Galles, N. (2010). Language effects in addition: How you say it counts. *The Quarterly Journal of Experimental Psychology*, *63*(5), 965–983.

Coulter, K. S., & Coulter, R. A. (2010). Small sounds, big deals: Phonetic symbolism effects in pricing. *Journal of Consumer Research*, *37*(2), 315–328.

De Cruz, H., & Pica, P. (2008). Knowledge of number and knowledge of language: Number as a test case for the role of language in cognition. *Philosophical Psychology*, *21*(4), 437–441.

De Mooij, M., & Hofstede, G. (2002). Convergence and divergence in consumer behavior: Implications for international retailing. *Journal of Retailing*, *78*(1), 61–69.

De Cruz, H. (2009). Is linguistic determinism an empirically testable hypothesis? *Logique et Analyse*, *52*(208), 327–341.

Downs, J. S., Holbrook, M. B., Sheng, S., & Cranor, L. F. (2010). Are your participants gaming the system? Screening Mechanical Turk workers. *In Proceedings of the SIGCHI conference on human factors in computing systems*, (2399–2402).

Fagerlin, A., Zikmund-Fisher, G., Ubel, P. A., Jankovic, A., Derry, H., & Smith, D. (2007). Measuring numeracy without a math test: Development of the subjective numeracy scale. *Medical Decision Making*, *27*(5), 672–680.

Gamble, A. (2006). Euro illusion or the reverse? Effects of currency and income on evaluations of prices of consumer products. *Journal of Economic Psychology*, *27*(4), 531542.

Gelman, R., & Gallistel, C. R. (2004). Language and the origin of numerical concepts. *Science*, *306*(5695), 441–443.

Goodman, J. K., Cryder, C. E., & Cheema, A. (2013). Data collection in a flat world: The strengths and weaknesses of mechanical Turk samples. *Journal of Behavioral Decision Making*, *26*(3), 213–224.

Gordon, P. (2004). Numerical cognition without words. *Science*, *306*(5695), 496–499.

Gunasti, K., & Devezer, B. (2016). How competitor brands affect within-brand choice. *Marketing Letters*, *27*(4), 715–727.

Gunasti, K., & Ozcan, T. (2016). Consumer reactions to round numbers in brand names. *Marketing Letters*, *27*, 309–311.

Gunasti, K., & Ross, W., Jr. (2010). How and when alphanumeric brand names affect consumer preferences. *Journal of Marketing Research*, *47*(6), 1177–1192.

Hardin, C., & Banaji, M. R. (1993). The influence of language on thought. *Social Cognition*, *11*(3), 277–308.

Hornikx, J., & O'Keefe, D. J. (2009). Adapting consumer advertising appeals to cultural values: A meta-analytic review of effects on persuasiveness and ad liking. *Communication Yearbook*, *33*, 38–71.

Hornikx, J., & van Meurs, F. (2015). Foreign language display in advertising from a psycholinguistic and sociolinguistic perspective: A review and research agenda. J. M. Alcántara-Pilar S. del Barrio-García E. Crespo-Almendros & L. Porcu In *Analyzing the cultural diversity of consumers in the global marketplace*, (pp. 299–319). Hershey, PA: IGI Global.

Hornikx, J., Van Meurs, F., & de Boer, A. (2010). English or a local language in advertising? The appreciation of easy and difficult English slogans in The Netherlands. *The Journal of Business Communication (1973)*, *47*(2), 169–188.

Hornikx, J., van Meurs, F., van den Heuvel, J., & Janssen, A. (2020). How brands highlight country of origin in magazine advertising: A content analysis. *Journal of Global Marketing*, *33*(1), 34–45.

Hunt, E., & Agnoli, F. (1991). The Whorfian hypothesis: A cognitive psychology perspective. *Psychological Review*, *98*(3), 377–389.

Justus, C. F. (2004). On language and the rise of a base for counting. *General Linguistics*, *42*(1–4), 17–43.

Kara, S., Gunasti, K., & Ross, W., Jr. (2015). Is it the 'alpha' or the 'numeric'?: Consumers' evaluation of letter versus number changes in alphanumeric brand names. *Journal of Brand Management*, *22*(6), 515–533.

Kara, S., Vredeveld, A. J., & Ross, J. . W. T. (2018). We share; we connect: How shared brand consumption influences relational brand connections. *Psychology & Marketing*, *35*(5), 325–340.

Keller, K. L., Heckler, S. E., & Houston, M. J. (1998). The effects of brand name suggestiveness on advertising recall. *Journal of Marketing*, *62*(1), 48–57.

Klink, R. R. (2000). Creating brand names with meaning: The use of sound symbolism. *Marketing Letters*, *11*(1), 5–20.

Klink, R. R., & Athaide, G. A. (2012). Creating brand personality with brand names. *Marketing Letters*, *23*(1), 109–117.

Koslow, S., Shamdasani, P. N., & Touchstone, E. E. (1994). Exploring language effects in ethnic advertising: A sociolinguistic perspective. *Journal of Consumer Research*, *20*(4), 575–585.

Kristensen, T., Gabrielsen, G., & Zaichkowsky, J. L. (2012). How valuable is a well-crafted design and name brand?: Recognition and willingness to pay. *Journal of Consumer Behaviour*, *11*(1), 44–55.

Lakoff, G., & Johnson, M. (2008). *Metaphors we live by*. Chicago, IL: University of Chicago Press.

LeClerc, F., Schmitt, B., & Dubé, L. (1994). Foreign branding and its effects on product perceptions and evaluations. *Journal of Marketing Research*, *23*(May), 263–270.

Li, C., & Kalyanaraman, S. (2012). What if web site editorial content and ads are in two different languages? A study of bilingual consumers' online information processing. *Journal of Consumer Behaviour*, *11*(3), 198–206.

Li, F., & Shooshtari, N. H. (2003). Brand naming in China: Sociolinguistic implications. *Multinational Business Review*, *11*(3), 3–21. http://dx.doi.org.ezproxy.lib.uconn.edu/10.1108/1525383X200300014.

Lowrey, T. M., & Shrum, L. J. (2007). Phonetic symbolism and brand name preference. *Journal of Consumer Research*, *34*(3), 406–414.

Lowrey, T. M., Shrum, L. J., & Dubitsky, T. M. (2003). The relation between brand-name linguistic characteristics and brand-name memory. *Journal of Advertising*, *32*(3), 7–17.

Luna, D., & Peracchio, L. A. (2005). Sociolinguistic effects on code-switched ads targeting bilingual consumers. *Journal of Advertising*, *34* (2), 43–56.

Luna, D., Peracchio, L. A., & de Juan, M. D. (2002). Cross-cultural and cognitive aspects of web site navigation. *Journal of the Academy of Marketing Science*, *30*(4), 397–410.

Marques, J. F. (1999). Changing "EUROpe"—The euro as a new subject for psychological research in numerical cognition. *European Psychologist*, *4* (3), 152–156.

Nejad, M. R., & Onay, S. (2014). Numerosity and cognitive complexity as moderators of the medium effect. *Procedia Economics and Finance*, *14*, 445–453.

Nikolinakou, A., & Phua, J. (2020). Do human values matter for promoting brands on social media? How social media users' values influence valuable brand-related activities such as sharing, content creation, and reviews. *Journal of Consumer Behaviour*, *19*(1), 13–23.

Ozcan, T., & Gunasti, K. (2019). How associations between products and numbers in brand names affect consumer attitudes. *Journal of Brand Management*, *26*, 176–194.

Pandelaere, M., Briers, B., & Lembregts, C. (2011). How to make a 29% increase look bigger: The unit effect in option comparisons. *Journal of Consumer Research*, *38*(2), 308–322.

Pelham, B. W., Sumarta, T., & Myaskovsky, L. (1994). The easy path from many to much: The Numerosity heuristic. *Cognitive Psychology*, *26* (April), 103–133.

Pica, P., Lemer, C., Izard, V., & Dehaene, S. (2004). Exact and approximate arithmetic in an Amazonian indigene group. *Science*, *306*(5695), 499–503.

Ramoniene, L., & Brazys, D. (2007). Euro introduction effects on individuals' economic decisions: Testing the presence of difference assessment account among Lithuanian and Latvian consumers. *Baltic Journal of Economics*, *6*(2), 29–55.

Schmitt, B. H., Pan, Y., & Tavassoli, N. T. (1994). Language and consumer memory: The impact of linguistic differences between Chinese and English. *Journal of Consumer Research*, *21*(3), 419–431.

Sen, S. (1999). The effects of brand name suggestiveness and decision goal on the development of brand knowledge. *Journal of Consumer Psychology*, *8*(4), 431–455.

Shrum, L. J., Lowrey, T. M., Luna, D., Lerman, D. B., & Liu, M. (2012). Sound symbolism effects across languages: Implications for global brand names. *International Journal of Research in Marketing*, *29*(3), 275–279.

Thomas, M., & Morwitz, V. G. (2009). The ease-of-computation effect: The interplay of metacognitive experiences and naive theories in judgments of price differences. *Journal of Marketing Research*, *46*(1), 81–91.

van Horen, F., & Pieters, R. (2017). Out-of-category brand imitation: Product categorization determines copycat evaluation. *Journal of Consumer Research*, *44*(4), 816–832.

Wertenbroch, K., Soman, D., & Chattopadhyay, A. (2007). On the perceived value of money: The reference dependence of currency Numerosity effects. *Journal of Consumer Research*, *34*(1), 1–10.

Weller, J. A., Dieckmann, N. F., Tusler, M., Mertz, C. K., Burns, W. J., & Peters, E. (2013). Development and testing of an abbreviated numeracy scale: A Rasch analysis approach. *Journal of Behavioral Decision Making*, *26*(2), 198–212.

Whorf, B. L. (1956). In J. B. C. Whorf (Ed.), *Language, thought, and reality: Selected writings of Benjamin Lee*. Cambridge, MA: Technology Press of MIT.

Wiese, H. (2003). *Numbers, language and the human mind*. Cambridge, England: Cambridge University Press.

Yorkston, E., & Menon, G. (2004). A sound idea: Phonetic effects of brand names on consumer judgments. *Journal of Consumer Research*, *31*(1), 43–51.

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APPENDIX A: Linguistic numeral structures

#	Chinese	English	French	Turkish	Danish
1	yi	one	un	bir	en
2	er	two	deux	iki	to
5	wu	five	cinq	bes	fem
7	qi	seven	sept	yedi	syv
8	ba	eight	huit	sekiz	otte
9	jiu	nine	neuf	dokuz	ni
10	shi	ten	dix	on	ti
11	shiyi (10+1)	eleven	onze	onbir (10+1)	elleve
20	**ershi (2x10)**	twenty	vingt	yirmi	tyve
21	ershiyi (2x10+1)	twenty-one	vingt et un	yirmibir	énogtyve
30	**sanshi (3x10)**	thirty	trente	otuz	tredive
31	sanshiyi (3x10+1)	thirty-one	trente et un	otuzbir	énogtredive
40	**sishi (4x10)**	forty	quarante	kirk	fyrre
41	sishiyi (4x10+1)	forty-one	quarante et un	kirkbir	énogfyrre
50	**wushi (5x10)**	fifty	cinquante	elli	halvtreds (2.5x20)
51	wushiyi (5x10+1)	fifty-one	cinquante et un	elli bir	énoghalvtreds
60	**liushi (6x10)**	sixty	soixante	altmis	tres
61	liushiyi (6x10+1)	sixty-one	soixante et un	altmisbir	énogtres
70	**qishi (7x10)**	seventy	**soixante-dix (60+10)**	yetmis	**halvfjerds (3.5x20)**
71	qishiyi (7x10+1)	seventy-one	soixante-et-onze (60+11)	yetmisbir	énoghalvfjerds
80	**bashi (8x10)**	**eighty**	**quatre-vingts (4x20)**	**seksen**	**firs**
81	bashiyi	eighty-one	quatre-vingt-un (4x20+1)	seksenbir	énogfirs
90	**jiushi (9x10)**	ninety	quatre-vingt-dix (4x20+10)	doksan	**halvfems (4.5x20)**
91	jiushiyi	ninety-one	quatre-vingt-onze (4x20+11)	doksanbir	énoghalvfems
100	yi bai	hundred	cent	yüz	hundrede
1,000	yi qian	thousand	mille	bin	tusind
10,000	wan (10,000)	ten-thousand	dix mille	on bin	titusinde
50,000	wu wan (5 x 10,000)	Fifty-thousand 50 x 1000	cinquante-mille 50 x 1000	elli bin 50 x 1000	halvtredstusinde 50 x 1000
500,000	Wu shi wan (50 x 10,000)	Five hundred thousand	cinq cent mile	bes yüz bin	fem hundrede
1,000,000	yi bai wan (100 x 10,000)	One million	un million	bir milyon	en million
50,000,000	wu bai wan (500 x 10,000)	Fifty million	cinquante- millions	bes milyon	halvtreds millioner
500,000,000	wu qian wan (5000 x 10,000)	Five hundred million	cinq cent millions	elli milyon	fem hundrede millioner

APPENDIX B: Stimuli of the studies

STUDY 1 - Advertising Messages and Visuals for Vacuum Cleaners and Dishwashers

Vacuum cleaners: There are too many ways dust and dirt can spread around. Engineered with high power, a long hose, and all surface suction, DERIN provides you with two new great products for your cleaning needs: Derin 36 and Derin 92. *(similar scenario for dish washers)*

VACUUM CLEANERS

DERIN 36

DERIN 92

DISHWASHERS

DERIN 300

DERIN 900

STUDY 2 - ENGLISH VS. CHINESE

	Numeral Structure in English	Numeral Structure in Chinese
60 million vs. 70 million	6 x 1,000,000 vs. 7 x 1,000,000 *(1 unit of difference)*	6000 x 1000 vs. 7000 x1000 *(1000 units of difference)*
50,000 vs. 70,000	50 x 1,000 vs. 60 x 1,000 *(10 unit of difference)*	5 x 10,000 vs. 6 x 10,000 *(1 unit of difference)*

STUDY 3 & 4 - ENGLISH VS. FRENCH

Conditions	Numeral Structure	Verbal in English
27 vs. 87 in English	20+7 vs. 80+7	twenty-seven vs. eighty-seven
27 vs. 87 in French	20+7 vs. 4x20+7	twenty-seven vs. four-twenties-seven

Sample Visuals

Advertising Message

Are you a fan of capturing fun and happy moments? Do you want your photographs to look live and fresh as the actual moment?

Sony has satisfied your need with **Sony CyberShot 27**. Now Sony is introducing a camera that is both convenient and of high quality.

Sony CyberShot 87 is on the stage enabling you to take great pictures while enjoying the moment. Capture life's moments with **Sony CyberShot 87** just like you have been doing with **Sony CyberShot 27**.

Sony, Make Believe!

Quality Question & Scale:

The photograph on the left panel depicts the 30x zoom version of the original image that was taken with ***Sony CyberShot** 27*. Accordingly, which one of the following do you expect to be the 30x zoom of the photo that was taken with ***Sony CyberShot** 87*?