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# Two Essays on the Effect of Alphanumeric Brand Names on Consumers' Brand Related Decisions

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Two Essays on the Effect of Alphanumeric Brand Names on  
Consumers' Brand Related Decisions

Selcan Kara, PhD

University of Connecticut, 2016

Abstract

Because consumers tend to rely on simplifying heuristics to reduce processing and judgmental operations (Bettman, Johnson, and Payne 2008; Tversky and Kahneman 1974), they use brand names as a judgmental heuristic, a phenomenon commonly referred to as the brand name heuristic (Maheswaran, Mackie and Chaiken 1992). From this perspective, in recent years, the use of alphanumeric brand names has emerged as an interesting test case for the role of cognition in consumers' brand evaluations in the Marketing field. Alphanumeric brand names consist of combinations of letters and numbers either in digit or word form (Pavia and Costa 1993), such as Coke Zero and Audi A4. Literature documents that consumers use alphanumeric brand names as cues for overall evaluation of brands and/or products (Gunasti and Ross 2010; King and Janiszewski 2011; Boyd 1985; Pavia and Costa 1993). I focus on how consumers' number cognition, which is also influenced by the language they speak, and letter cognition affects their evaluation of brands that use alphanumeric brand names. Hence, the current dissertation presents two essays. The first essay, in seven experiments, delineates the effects of alpha and numeric components of alphanumeric brand names (ANBs), by demonstrating the effects of disparities in processing between letter and number sequences on consumers' brand evaluations. The second essay, in seven studies across three languages, investigates the potential roles of two numeral system characteristics on consumers' evaluations of alphanumeric brand names (ANB):

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(i) base, defined as the number of unique digits, including zero, used to represent numbers in a positional numeral system, and (ii) non-transparency, defined as lack of smooth correspondence of the number words with the number values. Results of multiple international studies indicate that the aforementioned linguistic properties in the numeral parts of ABNs create different perceptions of numerosity in quantitative comparisons and lead to differences in comparative evaluations of ANBs.

Two Essays on the Effect of Alphanumeric Brand Names on  
Consumers' Brand Related Decisions

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at the

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2016

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2016

APPROVAL PAGE

Doctor of Philosophy Dissertation

Two Essays on the Effect of Alphanumeric Brand Names on  
Consumers' Brand Related Decisions

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## TABLE OF CONTENTS

1. CHAPTER 1: INTRODUCTION .....	1
1.1 References .....	8
2. CHAPTER 2: ESSAY 1.....	12
2.1 Introduction .....	12
2.2 Conceptual Background .....	14
2.3 Pretest .....	20
2.4 Study 1 .....	22
2.5 Study 2a .....	23
2.6 Study 2b .....	26
2.7 Study 2c .....	30
2.8 Study 3 .....	32
2.9 Study 4 .....	35
2.10 Study 5 .....	42
2.11 General Discussion .....	45
2.12 Conclusion .....	49
2.13 References .....	51
2.14 Tables .....	55
2.15 Figures .....	56
2.16 Appendices .....	57
3. CHAPTER 3: ESSAY 2.....	59
3.1 Introduction .....	59
3.2 Conceptual Background .....	63
3.3 Study 1 .....	72
3.4 Study 2 .....	74



3.5 Study 3 .....	76
3.6 Study 4 .....	78
3.7 Study 5 .....	83
3.8 Study 6 .....	87
3.9 Consumer Characteristics: Numeracy and Need for Cognition .....	90
3.10 Study 7 .....	93
3.11 General Discussion .....	100
3.12 References .....	105
3.13 Tables .....	112
3.14 Figures .....	116
3.15 Appendices .....	118

## **CHAPTER 1: INTRODUCTION**

“In general, people tend not to have clear and well-ordered preferences: Instead, preferences are actually constructed, not merely revealed, in the elicitation process, and the construction of preference is heavily influenced by the nature and the context of decision” (Shafir and LeBoeuf 2002, p. 496). Peoples’ decision making procedures are influenced by many internal factors, individual differences such as need for cognition, and external factors, characteristics of the decision problem such as the number of alternatives in a choice set (Bettman, Luce, and Payne 2008; Shafir and LeBoeuf 2002; Tversky and Kahneman 1974). Considering the effect of cognitive systems on consumer evaluations, prior literature documents that consumers are limited in terms of their capacity to process information. Instead, they tend to rely on simplifying heuristics to reduce processing and judgmental operations (Bettman, Luce, and Payne 2008; Tversky and Kahneman 1974). Maheswaran, Mackie and Chaiken (1992) extend this perspective to brand names, and demonstrate that “brand name information is considered as a knowledge structure that can operate as a judgmental heuristic” (p. 318). Specifically, consumers often base their product evaluations on brand names alone, a phenomenon commonly referred to as the brand name heuristic (Maheswaran, Mackie and Chaiken 1992). Given that brand names, like price and country of origin, are extrinsic product attributes, which play an important role in communicating information to consumers (Mazursky and Jacoby 1985; Zeithaml 1988), it is critical to understand the effect of cognitive structures in consumers’ assessment of brand names.

From this perspective, in recent years, the use of alphanumeric brand names has emerged as an interesting test case for the role of cognition in consumers’ brand evaluations in the

Marketing field. Alphanumeric brand names consist of combinations of letters and numbers either in digit or word form (Pavia and Costa 1993), such as Coke Zero and Audi A4. Both the letters and numbers may convey different meanings, either separately or together, evoking certain cues about the overall product or specific attributes (Gunasti and Ross 2010; King and Janiszewski 2011; Boyd 1985; Pavia and Costa 1993). Literature documents that consumers use numbers and/or letters in alphanumeric brand names to cue heuristics. For example, Gunasti and Ross (2010) find that consumers align their preferences for attributes and product models with larger numbers in ANBs because of their use of “the higher the better heuristic” (e.g., in terms of attribute superiority, BMW 3 35 is better than BMW 3 20, and in terms of overall product superiority, Audi A8 is superior to Audi A6, and Audi A6 is superior to Audi A4). As related to letters, research documents that consumers tend to match certain letters with certain product types (e.g., while the A2 brand was associated more with food products, the X2 was associated more with technical products). (Pavia and Costa 1993; Peterson and Ross 1972). Hence, consumers use alphanumeric brand names as cues for overall evaluation of brands and/or products.

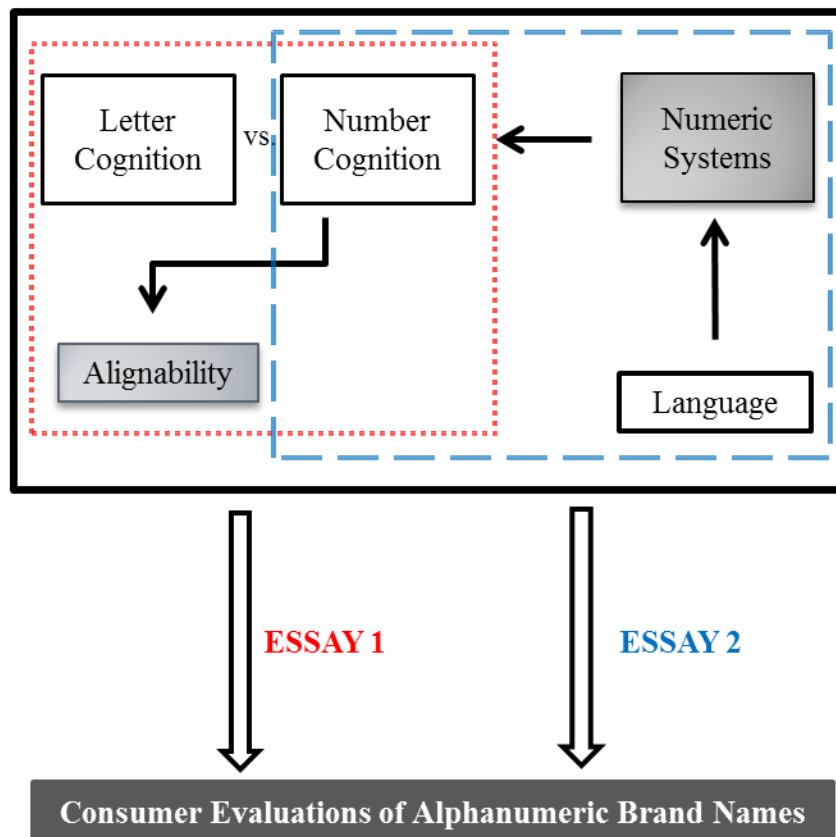
Figure 1 summarizes the conceptual framework and the purpose of my dissertation. Because “naming is one of the most important aspects of branding and essential for brand success” (Schmitt and Zhang 2012, p. 665), I focus my two dissertation essays on cognitive aspects of alphanumeric brand names. As described earlier, cognition and cognitive systems are highly influential in consumers’ preferences for products and brands. Accordingly, I focus on how consumers’ number cognition, which is also influenced by the language they speak, and letter cognition affect their evaluation of line extensions by means of alphanumeric brand names. Specifically, I focus on the effect of two cognitive domains; language comprehension and

number versus letter cognition on consumers' evaluations of brands. As shown in Figure 1, I propose that differences between letter and number cognition influence consumers' evaluations of alphanumeric brand names by means of numerical anchoring and alignability (Essay 1). Extending my research in Essay 1 on the effects of number cognition on consumers' decision making, in Essay 2 I postulate that consumers' language influences their evaluations of numbers in alphanumeric brand names; and therefore, their evaluations of these brands (Essay 2). I discuss each of my two essays in detail in the following section.

Figure 1

### The Conceptual Framework

#### COGNITIVE MECHANISMS AND ALPHANUMERIC BRAND NAMES



Essay 1 aims to disentangle the effects of alpha (i.e., letter) and numeric components of alphanumeric brand names on consumers' evaluations of product line extensions. The literature

on cognition suggests that there is dissociation between letter/word and digit/number recognition from a behavioral (Hamilton, Mirkin and Polk 2006) and a neuropsychological perspective (Park, Hebrank, and Polk 2012). Accordingly, I explore the effect of differences between number and letter cognition in consumers' assessment of line extensions introduced by changing the letter or the number components of the existing ANBs. Because of differences in serial order processing between numbers and letters (Damian 2004; Jou 2003), consumers perceive the line extension as a larger improvement of the existing product when the number component of the ANB increases than when the order of the letter component of the ANB increases. Moreover, based on recent theorization on Numerical Anchoring (Oppenheimer, LeBoeuf, and Brewer 2008; Russo 2010; Strack and Mussweiler 1997) and alignability, which refers to direct comparability of disparities in attributes or products through brand name (Gunasti and Ross 2010), I propose that consumers align their comparative evaluations of product attributes with the notion of an increase in ANBs of line extensions when the numeric component of the parent ANB increases to form the line-extension ANB. And, in the existence of numerical attribute evaluation, this alignability effect is anticipated to be one explanation for a more positive effect of number change in ANBs than letter change in ANBs on consumers' line extension evaluations.

Essay 2 focuses on another factor that influences how consumers process information conveyed by alphanumeric brand names: the consumers' language. Brand naming decisions are particularly important in the age of global marketing (Helm 2009; Schmitt and Zhang 2012). Literature documents the effect of language, specifically brand name translations, on consumers' preferences (Schmitt and Zhang 2012). However, language can also influence how consumers perceive brand names independent of how they are translated. For example, numbers in

alphanumeric brand names form a natural setting for exploring the effect of language on how consumers evaluate brands because of differences in numeral systems across languages. The Whorfian Hypothesis (Whorf 1956) indicates that language influences and shapes human thought. Taking this hypothesis further, scholars have demonstrated that language (e.g., numeral systems) influences numerical cognition (Colome, Laka, and Sebastian-Galles 2010; De Cruz and Pica 2008; Pixner, Zuber, Hermanova, Kaufmann, Nuerk, and Moeller 2011). Specifically, two aspects of numeral systems emerge as significant reasons for the effect of language on number cognition: base (i.e., decimal versus vigesimal), and transparency (i.e., regular or irregular digit structures), because these aspects lead to different levels of numerosity, which is “the number of units into which a stimulus is divided” (Pelham, Sumarta, and Myakovsky 1994, p. 103).

*Chinese* has a very systematized, “transparent” numeral system such that once a person knows the numbers 1 through 10 he or she can express any number up to 100 (e.g., 82 is eight-ten-two), however, *English* requires the knowledge of a new word for each decade (e.g., 82 is “eighty”-two) whereas *French* has a partial-vigesimal (20) system (e.g., 82 is four-twenty-two). Such variations in numeral structures across languages can make the numeral system more or less “numerous”, which in turn can influence consumers’ ability to compare numbers. Accordingly, the first purpose of essay 2 is to explore whether the numeric components of alphanumeric brand names create different perceptions of product features in the evaluation of line extensions because of the structure of the numeral system in the consumers’ language.

Moreover, I explore the degree to which the effect of language on consumers’ comparative ANB evaluations is influenced by differences in consumer characteristics and contexts. Specifically, the Triple Code Model proposes that numbers are presented and operated on in three different forms: visual, verbal, and analog (Dehaene 1992). Visual codes represent

numbers in digit forms based on Arabic numerals; verbal codes represent auditory sounds and the number words linked to the digits, and analog codes facilitate the representation of numeric magnitudes on a mental number line (Dehaene 1992; Dehaene, Bossini, and Giraux 1993; Dehaene and Cohen 1995). Thus, comparative evaluations of ANBs, which are inherently number comparison tasks, can be influenced by contextual factors, such as the exposure format to these numbers in ANBs (e.g., digital versus verbal, which entails both audio and number-word delivery). Consequently, the second purpose of essay 2 is to explore whether verbal versus digital exposure to numbers in ANBs is a critical factor to drive the effect of language on consumers' ANB evaluations. Finally, I incorporate the effect of differences in consumer characteristics, such as need for cognition (NFC), which refers to the amount of cognitive work an individual is willing to put in decision making (Cacioppo, and Petty 1982), and perceived numeracy, which is defined as one's ability to process numerical information (Fagerlin, Zikmund-Fisher, Ubel, Jankovic, Derry, and Smith 2007; Zikmund-Fisher, Smith, Uber, and Fagerlin 2007). Thus, the third and final purpose of essay 2 is to examine the moderating roles of NFC and perceived numeracy on the effect of language on consumers' comparative ANB evaluations.

In conclusion, as has been often stated in prior literature, a brand name as an extrinsic product attribute is highly influential on consumers' evaluations of products, such as quality judgments and attribute assessments (Gunasti and Ross 2010; Mazursky and Jacoby 1985; Zeithaml 1988). Specifically, alphanumeric brand names lead consumers to form associations between letter and/or number parts of the brand name and product features, series, or new product lines (Gunasti and Ross; King and Janiszewski 2011; Pavia and Costa 1993). My dissertation contributes to the prior literature on alphanumeric brand names by (1) delineating the

“alpha” and “numeric” components of ANBs and examining the underlying cognitive structures of consumers’ evaluation of ANBs, and (2) suggesting that consumer assessments of alphanumeric brand names may be highly language dependent, which may in turn be important for practitioners in the global marketing domain. Overall, my dissertation shows interesting differences in how consumers recognize the improvements between existing brands and new brand extensions based on how they process the numbers and letters in alphanumeric brand names.



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## CHAPTER 2: ESSAY 1

### The “Alpha” and the “Numeric” in Alphanumeric Brand Names<sup>1</sup>

The choice of what brand name to use is important to both firms and consumers, because brand names build and enhance brand equity (Aaker 1991; Keller 1993). Alphanumeric brand names (ANBs) consist of combinations of letters and numbers, either in digit or word form (Pavia and Costa 1993), such as Coke Zero or Audi A4. Letters and numbers in the brand names convey various meanings both separately and together, evoking cues concerning overall product or specific attributes (Gunasti and Ross 2010; Pavia and Costa 1993; Yan and Duclos 2013). Consumers often base product evaluations on brand names alone, a phenomenon called the brand-name heuristic (Maheswaran, Mackie, and Chaiken 1992), and research suggests ANBs lead to strong consumer reactions such as a preference for higher numbers (Gunasti and Ross 2010) and brand-name likeability (King and Janiszewski 2011).

Practitioners use ANBs in different ways, and change the letter or number components of existing ANBs to label product line extensions. Table 1 shows examples of how practitioners use ANB strategies such as changing letter and number parts to denote attribute enhancements in line extensions.

“Insert Table 1 about here”

For example, Mercedes increases the order of letters in its ANBs to denote improvement in the overall quality of its cars (e.g., S class cars are superior to E class cars; and E class cars are superior to C class cars). On the other hand, BMW, another major player in the automobile market, increases the numbers in its ANBs to designate the superiority of its classes (e.g., 7

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<sup>1</sup> A version of this dissertation essay got published at the Journal of Brand Management (Kara, Gunasti, and Ross 2015)

series cars are superior to 5 series cars; and 5 series cars are superior to 3 series cars). Hence, the purpose of the research herein is to explore which strategy is more effective in terms of creating favorable consumer evaluations for line extensions. Extant ANB literature suggests both number and letter effects. For example, consumers may match letters to product types (e.g., the letter A is associated with food, such as A1 steak sauce; the letter X is associated with technical products, such as BMW X5 SUVs) (Pavia and Costa 1993; Peterson and Ross 1972). Research also documents that consumers align their preferences for attributes and product models to larger numbers in ANBs due to the-higher-the-better heuristic (e.g., BMW 3 35 has better attributes than BMW 3 20; the Audi A8 is superior to the Audi A6) (Gunasti and Ross 2010).

Although extant research offers insights concerning perceptions of ANBs, disparities in consumers' processing of numbers versus letters in ANBs—and resulting effects on brand evaluations—remain uninvestigated. The purpose of this study is to examine the effects of alpha and numeric components of ANBs on consumer evaluations of product-line extensions. We explore disparities in consumer evaluations of letter and/or number variations in ANBs to uncover (i) how consumers react to letter changing strategies (e.g., ascending versus descending letters in ANBs), (ii) which brand-name strategies are more effective (e.g., letter change versus number change), and (iii) why consumers favor one strategy over the other. We examine how changes in letter versus number components of existing ANBs influence consumer evaluations of line extensions relative to an existing brand, and explore underlying mechanisms for the differential effect of alpha versus numeric. For example, given the existing product Panasonic C80, is it more beneficial for Panasonic to name an extension C90 or D80?, and how do these brand-name strategies influence consumer expectations, evaluations, and choices of a new product?

In seven experiments, we demonstrate first that ascending letters, compared to descending letters, in ANBs are better at evoking more favorable consumer evaluations for line extensions. We then show, however, that increasing numbers, compared to ascending letters, have a stronger effect on favorability of line extension evaluations. This effect holds for different letter-number pairs, numbers with more or less number of digits, letter-number pairs in reversed order, and with unknown brands. To explain these differences between letter and number sequences, we show that consumers align their expectations for increases in numeric attribute values with increases in the numbers in ANBs, and that this alignability drives the positive effect of number change over letter change on consumers' line extension evaluations, a finding which is consistent with the Selective Accessibility Model of Numerical Anchoring.

This research has important theoretical and managerial contributions. First, unlike extant research (e.g., Pavia and Costa 1993), we conceptualize the evaluative properties of letters as members of serial orders, over and above their categorization utility, such as the letter "A" being associated with foods. Second, we delineate the effects of alpha and numeric components of ANBs by demonstrating the effect of differences in processing between letter and number sequences on consumers' brand evaluations. Finally, from a managerial perspective, we suggest ways in which practitioners can enhance effectiveness of ANBs in line extensions.

## **Conceptual Background**

### ***Alpha Component of ANBs: Letters in Line Extensions***

Extant research suggests that alphabets, which are letters in a defined serial order, lack a rule-governing structure and are abstract (i.e., one needs to memorize the entire alphabet),

implicit (i.e., the primary purpose of the alphabet is not generating order, but producing words), and closed-ended (i.e., although the number of letters in an alphabet varies across languages, all alphabets have a set number of letters) (Jou 2003). Therefore, serial order memory processes are memorization-based for letters. Moreover, letters possess only ordinal representation (Jacob and Nieder 2008), which refers to the position of an object in a serial order, such as whether the letter X comes before Y (Fitousi 2010). Hence, letters in a serial order display a strong forward direction bias in that ordinal representation. However, subsequent letters do not always connote superiority. Specifically, the superiority of letters actually may decrease in ascending alphabetical order for some uses of letters (e.g., A is superior to B in grades and credit ratings) (Jou 2003). So ordinal superiority suggests that B is greater than A, but ascending letter superiority suggests that B is inferior to A.

In the ANB context, the forward-direction bias suggests that B10 is preferred to A10, whereas descending superiority in an alphabetical order suggests the opposite. We propose that, in the context of line extensions, because the name indicates a product or extension that comes after an original, the forward-direction bias will dominate, such that B10 will be evaluated more favorably than A10. We hypothesize that consumers evaluate line extensions with increasing order of the ANB's alpha components as superior to those with decreasing order of the alpha components. Therefore:

Hypothesis 1: Ascending letters in the ANBs of line extensions compared to the original ANB (e.g., from B to C) lead consumers to evaluate the line extension more favorably compared to descending letters compared to the original ANB (e.g., from B to A).

### ***The Alpha and the Numeric Effects in ANB Line Extensions***



Literature suggests dissociation between letter/word and digit/number recognition from both behavioral (Hamilton, Mirkin, and Polk 2006) and neuropsychological perspectives (Park, Hebrank, and Polk 2012). Specifically, serial-order processing is different for numbers and letters (Jou 2003). Unlike letter sequences, number series are rule-governed (i.e., once the order of numbers between 1 and 9 is learned, one can generate and form the entire series), explicit (i.e., the purpose of the number system is to code an order or denote a magnitude), and open-ended (i.e., number series go to infinity) (Jou 2003). Because number sequences are rule-governed, serial-order processing is less memorization-based for numbers than for letters (Jou 2003). Additionally, unlike letters, numbers possess both ordinal and cardinal meanings. As previously discussed, ordinality refers to the position of an object in serial order such as whether 30 comes before 40, whereas cardinality refers to the magnitude or value of an object, such as whether 40 is greater than 30 (Fitoussi 2010). Because numbers possess both cardinal and ordinal meaning, comparison of numbers, which have automatic access to their semantic meanings—the magnitude (Dehaene and Akhavein 1995), is more straightforward than comparison of letters.

Moreover, cardinality of numbers eliminates any ordinal meaning related ambiguities, such as the forward direction bias and descending superiority in letter series. Specifically, as previously discussed, in a line extension ANB context, on one hand, B10 may be evaluated to be superior to A10, because B comes after A. On the other hand, B10 may be evaluated to be inferior to A10, because B, compared to A, does not necessarily connote a superior meaning (e.g., grades). However, in number series, both the serial-order (ordinal) and semantic meanings (cardinal) of the numbers connote corresponding superiorities in a line extension context. Specifically, in a line extension ANB context, A20 is evaluated to be superior to A10, because 20 comes after 10 (i.e., the ordinal meaning), and 20 is superior to 10 (i.e., the cardinal meaning)

(e.g., 20 is greater than 10 in terms of the magnitude). Consequently, we suggest that disparities resulting from a number change, compared to a letter change, in ANBs lead to an advantage in consumers' evaluation of the "change".

Hypothesis 2: Consumers evaluate line extensions more favorably when the extension ANB is formed with increasing numbers rather than ascending letters.

### ***Mediating Role of Alignability***

In a recent taxonomy of ANBs, Gunasti and Ross (2010) specify two dimensions of ANBs, one of which is the alignability. Following Gunasti and Ross (2010), by alignability we mean the direct comparability of disparities in attributes or products through brand names. For example, most brands are aligned-ascending such that higher values correspond to better products. This alignability influences consumers' evaluations of ANBs especially when practitioners employ brand-attribute pairs whose correlations are obvious and easily detectable by decision makers (Gunasti and Ross 2010). Marketers often use aligned-ascending ANBs when introducing brand extensions linked to attributes (i.e., improved versions of existing products) or linked to products (i.e., new lines). While the brand-attribute correlations are not always so easily detectable (e.g., X10 with 8.3 MP vs. X25 with 9.7 MP), consumers may still align their preferences with increasing numbers in ANBs in aligned-ascending ANBs. Hence, consumers align their expectation of an increase in numeric attribute values with an increase in ANBs. Therefore, the notion of an increase in ANBs leads to an advantage for numbers over letters to induce more favorable line extension evaluations.

We argue that individuals align their comparative evaluations of product attributes with the notion of an increase in ANBs of line extensions when the numeric component of the existing ANB increases to form the line-extension ANB. In other words, we propose that, in the absence

of obvious correlation between numbers in ANBs and numeric attribute values, increasing numbers still have an advantage over ascending letters in terms of inducing more favorable line extension evaluations. Given that anchoring also influences consumer behaviors (Biswas and Burton 1993; McFerran et al. 2010), this conceptualization is also consistent with the Selective Accessibility Model (SAM), which posits that people generate estimates by using accessible anchor-consistent information, resulting in estimates close to anchor values (Strack and Mussweiler 1997). Specifically, recent literature on numeric anchoring rests on the theory that “‘selective accessibility’ or ‘activation’ of anchor-consistent knowledge leads to the anchoring effect” (Wegener et al. 2010 p. 6). For example, prior research suggests that numeric anchors prime related concepts (Jacowitz and Kahneman 1995; Wilson et al. 1996) such as a sense of semantic information about a magnitude (e.g., bigness or smallness) (Oppenheimer, LeBoeuf, and Brewer 2008; Sleeth-Keppler 2013). Oppenheimer et al. (2008) demonstrate that anchors bias judgments when they prime general notions of largeness or smallness by activating a general sense of magnitude instead of a numeric value. Correspondingly, a notion of an increase in ANBs can also act as an anchor by activating the general sense of increase in consumers’ line extension evaluations.

Consequently, based on the alignability and selective accessibility of “increase” in ANBs, we expect that increases in numeric components of ANBs will lead consumers to anticipate the line extension to possess increased numeric attribute values compared to the existing brand. When consumers are evaluating line extensions, the alignability of an increase in ANBs with the increase in numeric attribute values should lead to a more positive effect of the number change in ANBs compared to a letter change. Consequently, we propose:

Hypothesis 3: Consumers' more favorable brand evaluations for increasing numbers in ANBs, compared to ascending letters in ANBs, is mediated by their expectation of an increase in numeric attribute values (alignability)

We test the aforementioned hypotheses in seven experiments (Figure 1). Focusing first on the alpha component, we propose that ascending letters in ANBs results in more favorable evaluations of line extensions than descending letters (i.e., H1); in study 1, we test H1. In studies 2a, 2b, and 2c, we test H2; we address comparisons of alpha versus numeric components by examining whether changing the number parts of ANBs results in greater perceptions of improvement and more positive evaluations of line extensions in comparison to an existing product than changing the letter parts of ANBs (i.e., H2). Given that some firms employ a different ANB strategy, such as positioning the number before the letter (e.g, iPhone 5S), Study 3 increases the robustness and generalizability of our findings by demonstrating that the order of the ANB components (e.g., letter first – A70 versus number first – 70A) does not influence the more positive effect of the number change compared to the letter change on consumers' ANB evaluations. Study 4 replicates the results of studies 2a, 2b, and 2c, and tests H3, which posits mediation by alignability. Specifically, we test whether an increase in the numeric component of an ANB leads consumers to expect an increase in numeric attribute values of a line extension in comparison to those of a current product. This alignability mediates the differential effect of alpha versus numeric changes in ANBs on consumers' line extension evaluations. Study 5 rules out two alternative explanations (i) number processing fluency of numeric attribute values and numbers in ANBs driving the results, and (ii) consumer brand knowledge confounding the results. Specifically, in Study 5, we test H2 with unknown brands that have non-numeric attribute values in a non-extension context.

“Insert Figure 1 about here”

It is important to note that, in all the studies, letter change is expected to result in favorable consumer evaluations for the line extension compared to the existing brand. However, number change is expected to result in more favorable consumer evaluations than letter change for the line extension compared to the existing brand. Accordingly, we examine the difference in consumers' comparative evaluations of line extensions and existing brands between the number change and the letter change conditions. Because disparities between two numbers can range from minimal to infinity—in opposition to disparities between letters—we are forced to limit the scope of the numbers we use for the ANB's for this study. To effect a standard and fair comparison of number versus letter changes, we limit comparisons to numbers with the same number of digits, changing only left digits (e.g., A70 versus A80), and refrain from well-known effects (e.g., A7 versus A70, A90 versus A100, etc.) that boost numeric disparity perceptions. We increase the order of the letter by one step (e.g., A70 versus B70, M70 versus N70, etc.), and avoid alphabetic or phonetic issues that boost perceived disparity (e.g., A70 versus Z70 versus X70). Regarding H2, we compare the effects of increasing the left digit in the numeric component of ANBs by one unit (e.g., A70 to A80, A7 to A8, etc.), to a similar increase of the order of the alpha component in ANBs by one step (e.g., A70 to B70, A7 to B7, etc.).

### **Pretest: Letters**

As previously discussed, in the context of ANB line extensions, letters are positioned as elements of a serial order indicating improved versions of existing brands, or different classes of products (See Table 1). However, unlike numbers, it is difficult to ascertain a difference between

two successive letters, because letters lack cardinal meaning (i.e., magnitude). Although the difference between letter pairs is processed differently compared to evaluating the difference between two numbers, we aim to examine the differences between two successive letters before construction of stimuli for the studies. Despite the fact that one cannot ascertain a specific difference between two letters, to provide a fair comparison, we aim to ascertain that we use letter pairs that are not perceptually or aurally too similar. Hence, the purpose of the pretest is to select reasonably different letter pairs to be used in subsequent studies so that we do not favor number change.

One hundred and nine participants were recruited to make evaluations of differences between successive letter pairs such as A and B, and X and Y. Respondents were randomly assigned to five of 25 letter pairs in the English alphabet. Participants were asked to indicate how different the former letter is from the latter letter on an 11-point scale (0: Very Similar; 10: Very Different). For example, respondents were asked to indicate how different A is from B. The same question was repeated for the remaining 24 successive letter pairs (e.g., B, C; C, D etc.). It is important to note that participants were simply asked to evaluate the difference between two successive letters independent of any sequential order context.

The difference perceptions between two successive letter pairs were significantly different among letter pairs ( $F_{\text{difference}}(24, 491) = 3.59, p < .001$ ). Specifically, M and N were perceived to be the least different letter pair ( $M_{M-N} = 2.55$ ). The perceived difference between letters A and B ( $M_{A-B} = 5.21$ ) was significantly higher than the perceived difference between letters M and N ( $M_{M-N} = 2.55, t(491) = 3.24, p < .01$ ). Similarly, the perceived difference between letters D and E ( $M_{D-E} = 6.21$ ) was significantly higher than the perceived difference between letters M and N ( $M_{M-N} = 2.55, t(491) = 3.24, p < .01$ ). Consequently, M and N were not

used in stimuli in subsequent studies to prevent any unfair comparison of letter change with number change. In other words, despite the fact that we could not identify the exact difference between the two letters, we used at least relatively different letter pairs for a fair comparison of letter change and number change. The results of the pretest help us establish that the differences in physical properties of letters (e.g., shapes) will not account for the results in the subsequent experiments.

### **Study 1: Alpha Effects – Ascending versus Descending Order of Letters**

The purpose of study 1 was to test H1 by examining how changing letters in ANBs influences consumers' perceptions of line extensions. We tested whether using ascending letters in ANBs to form line extension ANBs (e.g., from D to E) leads consumers to evaluate line extensions more favorably in comparison to descending letters (e.g., from D to C).

Eighty-nine undergraduate students at a northeastern university participated in a between-subjects experiment for course credit. All respondents were initially exposed to specifications of a Dell D10 laptop (i.e., the existing brand), and were then exposed to a line extension either for a Dell C10 (ANB with a descending letter) or Dell E10 (ANB with an ascending letter), depending on the condition to which they had been assigned randomly. The brand Dell was selected for widespread use of numbers in its models. Stimuli consisted of a picture of the laptop and a table of specifications (Appendix A). The extension was identical in both conditions, except for the brand name. Participants reviewed the specifications of the Dell D10, and then the line extension on three dimensions: processor speed, RAM, and storage capacity. The line extension outperformed the existing brand on one dimension, storage capacity,

but was equal on the others. Because price is an extrinsic cue for perceived quality such that a higher price is perceived to imply higher quality (Riesz 1978; Zeithaml 1988), and perceived quality is a strong indicator of consumers' favorable brand evaluations, we used consumers' price expectations as a dependent variable in Study 1. Hence, after reviewing specifications of the Dell D10 and the extension (Dell C10 or Dell E10), participants provided their expectations for relative price of the line extension in comparison to the Dell D10 on a bipolar scale, with end points 1 (Price of the line extension is much cheaper than Dell D10) and 10 (Price of the line extension is much more expensive than Dell D10).

### ***Results and Discussion***

Supporting H1, participants expected the line extension to have a higher price in the ascending letters condition ( $M = 6.38$ ) than in the descending letters condition ( $M = 5.7$ ,  $t(87) = 2.73$ ,  $p < .01$ ). Results suggest that when they are evaluating line extension ANBs, consumers favor ascending alpha over descending alpha, despite the decreasing superiority of letters in ascending alphabetical order (e.g., A is perceived superior to B) (Jou 2003). Specifically, on one hand, compared to D10, C10 denotes a superior meaning, whereas E10 denotes an inferior meaning. On the other hand, C10 comes before D10, whereas, consistent with the line extension context denoting a product "coming after" a new one, E10 comes after D10. Therefore, participants expected the line extension to have a higher relative price than D10 when the line extension was named E10 versus C10. This finding suggests that participants evaluated line extension ANBs more favorably when the ANB was formed with an ascending order of letters in comparison to a descending order of letters.

### **Study 2a: Alpha versus Numeric Change Effect**



Study 2a tested H2 by examining how the introduction of changes using letter or number parts to existing ANBs (e.g., A70 versus A80, A70 versus B70, etc.) influences evaluations of line extensions relative to current offerings. Eighty-nine new undergraduate students at a northeastern university participated in a between-subjects experiment for course credit. The product was a digital camera, and Canon was used as an existing brand because of its prominence in the product category and widespread use of numbers in its model numbers. The existing brand was the Canon A70. Participants were assigned randomly to one of the two conditions: Canon A80 (i.e., ANB number-change) or Canon B70 (i.e., ANB letter-change condition). All participants were initially provided with attribute information for the Canon A70, and subsequently reviewed the identical information concerning the line extension except for the names, A80, B70. The line extension slightly outperformed the Canon A70 on one dimension, digital zoom. However, the Canon A70 was superior to the line extension on two other attributes, resolution and optical zoom. We designed the line extension not to be superior to the existing offering, A70, to focus on the effect of the names on brand evaluations. Thus, the existing brand was superior in terms of quantifiable attributes, but its brand name implied inferiority in comparison to the new brand (see Appendix A for a description of the stimuli).

Participants indicated their preferences between existing and line extension options on a bipolar scale, with end points 1 (I think the existing product A70 is definitely better) and 9 (I think the new product A80 (or B70) is definitely better). To understand expectations of attribute improvement as they relate to numerically calibrated attributes, respondents were told that existing product A70 had a screen size of 2.1 inches, and were asked to infer the screen size of the extension, A80/B70, using a range of 1.5 to 2.7 inches. Participants were asked to infer the

line extension's screen size by choosing from a 7-point scale ranging incrementally from 1.5 to 2.7 inches. The midpoint of the scale was 2.1 inches, the screen size of the A70.

## ***Results***

Although the A70 was a marginally superior product in comparison to the line extension in both conditions, the letter versus number change created a difference in consumer evaluations of line extensions. Preference for the A80 ( $M = 4.02$ ) over the A70 was higher than for the B70 ( $M = 3.05$ ,  $t(80.32) = 2.04$ ,  $p < .05$ ), supporting H2. Levene's test for equality of variances was significant ( $F = 17.52$ ,  $p < .01$ ); and the assumption of equal variances was rejected. Therefore, we report statistics for preferences using adapted degrees of freedom. This difference occurred in subsequent studies, which is why we have df values in decimals for some statistics. Respondents also inferred a larger screen size for the new camera when the brand name was A80 ( $M = 2.13$ ) (i.e., number change condition) versus B70 ( $M = 1.99$ ) (i.e., letter change condition) ( $t(87) = 2.23$ ,  $p < .05$ ). Only 24.4% of participants inferred a larger screen size for new product B70 in the letter-change condition. This ratio nearly doubled for A80; 45.8% of participants inferred a larger screen size for A80 in the number-change condition ( $\chi^2 = 4.42$ ,  $p < .05$ ).

## ***Discussion***

Supporting H2, the results of study 2a suggest a difference in evaluations of a line extension in comparison to an existing product, depending on whether the number or the letter changes in the ANB. Participants evaluated the same line extension differently solely because the brand name changed from A70 (i.e., existing product) to A80 (i.e., line extension, number-change condition) versus B70 (i.e., line extension, letter-change condition). Although the line extension was not superior to A70 in either of the two conditions, the preference for the line extension was higher in the number-change condition than in the letter-change condition. Thus,

participants evaluated the line extension in the number-change condition more favorably than in the letter-change condition, though the product was inferior in comparison to A70. We interpret this difference in favorability as the result of the change in the numeric component of the ANB. Similar results were observed for inferences. Participants inferred screen size of the line extension to be larger when the brand name was A80 (i.e., number-change condition) than when the brand name was B70 (i.e., letter-change condition). Hence, numbers—increasing the left digit by one unit—are better at inducing higher favorability and choice shares than letters—increasing the order of a letter by one step.

Relying on extant number-processing literature (Fitoussi 2010), one explanation for the more positive effect of number change over letter change is disparities in processing between numbers and letters. Because numbers have both ordinal and cardinal meanings, whereas letters have only ordinal meaning (Jou 2003), participants evaluated differences in ANBs as more significant when a number rather than a letter changed. They associated differences in ANBs more with change and improvement of the new line extension in comparison to the existing product in the number-change condition than in the letter-change condition, even if the product change was minimal. Numeric cognition of ANB exaggerated perceptions of differences between new and former brands.

### **Study 2b: Alpha versus Numeric Change Effect – Single Digit Numbers**

In study 2a, we demonstrate that increasing numbers in ANBs in comparison to an ascending order of letters in ANBs leads consumers to more favorable evaluations of line extensions. However, this effect might be attributed to the magnitude difference between the

numbers and the letters. We know that the difference between the two numbers was 10, but we do not know how big the perceived difference is between letters A and B. Thus, one might argue that the more positive effect of number change than letter change was observed simply because participants perceived the difference between A and B to be less than ten, the numeric difference between 70 and 80. Therefore, we replicated study 2a with the same letters (e.g., A and B) but with single-digit numbers (e.g., 7 and 8), again to test whether a number change (e.g., A7 versus A8) results in more favorable evaluations of line extensions than a letter change (e.g., A7 versus B7), despite a numeric difference of only one. The second purpose was to increase the robustness of the findings by replicating our results with an additional dependent variable, willingness to purchase.

Two-hundred four participants recruited from Amazon Mechanical Turk (mTurk.com) participated in a between-subjects online experiment. Except for the numbers in the ANBs, the stimulus and design of study 2b were identical to study 2a. The existing brand was a Canon A7 digital camera. Participants were assigned randomly to one of the two conditions: Canon A8 (i.e., number-change condition) or Canon B7 (i.e., letter-change condition). Like study 2a, participants were initially provided with attribute information for the A7, and subsequently with information about the line extension that was identical for A8 and B7. Specifications of the existing brand (i.e., A7) and line extensions (i.e., A8 and B7) were identical to those in study 2a.

Participants indicated their preferences between the existing brand and the line extension on a bipolar scale, with end points of 1 (I think the existing product A7 is definitely better) and 6 (I think the new product A8 (B7) is definitely better). In a departure from study 2a and to replicate findings with a new dependent variable, participants chose which product they would like to purchase using a bipolar scale, with end points of 1 (Definitely Canon A7) and 6

(Definitely Canon A8 (B7)). As in Study 2a, participants were informed that the existing product (i.e., A7) had a screen size of 2.1 inches, and inferred the screen size of the extension (i.e., A8 or B7) by choosing from a 6-point scale, corresponding to 1.7 to 2.7 inches, where 3 was equivalent to 2.1 inches (the size of the A7).

## ***Results***

“Some respondents may be participating in mTurk studies for quick cash rather than inherent interest, and may not be inclined conscientiously” (Downs et al. 2010, p. 2402). Before analysis, responses were screened, and seven participants were identified as answering unconscientiously. Six participants who selected the minimum scale points on all measures were excluded from the analysis. One participant, who selected the highest scale points on two of the measures and the lowest scale point on the other measure, was highly inconsistent, and was also excluded. Considering that a) the ratio of mTurk participants who do not answer conscientiously is reported as nearly 39% (Downs et al. 2010) and b) the ratio of participants excluded from mTurk studies ranges from 9% to 20% (Baskin et al. 2014), excluding 3.4% (7 of 204 participants) of participants appears reasonable.

Like study 2a, preferences for the A8 (i.e., number change) ( $M = 2.14$ ) over the A7 were higher than preferences for the B7 (i.e., letter change) ( $M = 1.72$ ,  $t(175.58) = -2.62$ ,  $p < .01$ ) over the A7. As described previously, Levene’s test for equality of variances was again significant ( $F = 7.52$ ,  $p < .01$ ). Regarding willingness to purchase, participants were more willing to purchase the line extension in comparison to the existing brand (A7) when the extension was named A8 (i.e., number change) ( $M = 2.11$ ) than when the extension was named B7 (i.e., letter change) ( $M = 1.79$ ,  $t(173.6) = -1.91$ ,  $p = .058$ ). Levene’s test was again significant ( $F = 6.27$ ,  $p < .05$ ). Moreover, the mean screen size inferred in the letter change condition ( $M = 3.13$ ) was not

significantly larger than the screen size of the existing brand ( $t(97) = 1.15, p > .1$ ); whereas in the number change condition ( $M = 3.41$ ) it was significantly larger than the screen size of the existing brand ( $t(97) = 3.45, p < .01$ ). This result also suggests that number change, compared to letter change, led to an improvement over the existing brand demonstrating an inference of better product attributes. Finally, respondents inferred a larger screen size for the new camera when the brand name was A8 ( $M = 3.41$ ) (i.e., number change) than when the brand name was B7 ( $M = 3.13$ ) (i.e., letter change) ( $t(195) = -1.69, p < .1$ ). Only 32.7% of participants in the letter-change condition inferred a larger screen for B70, but more than half (53.5%) inferred a larger screen for A80 in the number-change condition ( $\chi^2 = 8.76, p < .01$ ).

## ***Discussion***

In study 2b, we replicated results from study 2a with single-digit numbers and an additional dependent variable. In further support of H2, participants evaluated the line extension more favorably, chose the line extension over A7, and inferred higher screen sizes when the extension ANB was formed by increasing numbers than by an ascending order of letters. Results from study 2b suggest that the stronger effect of numbers is not due to differences in numeric magnitude. Study 2b also shows that the results extend to consumption behavior, measured as willingness to purchase, which was also influenced by a change in numeric versus alpha components of ANBs. In particular, consumers choose a line extension over an existing brand (A7) more often when the line extension ANB is formed with an increasing numeric component than with an ascending alpha component. From a methodological viewpoint, the marginal significance of willingness to purchase might be attributed to mTurk carelessness (Downs et al. 2010), but from a conceptual viewpoint, willingness to purchase, a behavioral intention, might also be influenced by external factors such as need for a camera. Psychology literature suggests a

discrepancy between attitudes and behaviors, and the effect of external factors on the relationship between attitudes and behaviors (Ajzen 1985; Sheppard, Hartwick, and Warshaw 1988). Because changes to the numeric component result in more favorable attitudes toward the line extension than changes to the alpha component, the marginal significance of willingness to purchase supports a more positive effect of number change in comparison to letter change on extension ANB evaluations.

Despite the marginal significance of the numeric attribute inferred, there was a more positive effect of increasing numbers in comparison to ascending order of letters on participants' evaluations of extension ANBs. Study 2b's results increase the robustness of findings by replicating results that changing numeric components of ANBs induces more favorable evaluations of line extensions than changing alpha components.

### **Study 2c: Alpha versus Numeric Change Effect – Different Letter and Number Pairs**

The purpose of study 2c was to replicate the results of study 2a with different letter and number pairs to exclude another alternative explanation that the findings may be specific to the letters A and B. Increasing numbers in comparison to an ascending order of letters in ANBs could have led participants to perceive more favorable evaluations of line extensions because the letters used were A and B. Therefore, the letter pair D and E and the number pair 40 and 50 were used as components of ANBs in the stimulus of study 2c to replace A/B and 70/80.

Four-hundred sixteen mTurk workers participated in a between-subjects, online experiment. Because study 2c was a replication (except for the numbers and letters in the ANBs), its stimulus and design were identical to study 2a. The existing brand was Canon D40.

Participants were assigned randomly to one of two conditions: Canon D50 (i.e., ANB number change) or Canon E40 (i.e., ANB letter change). Like studies 2a and 2b, respondents compared evaluations of a line extension and an existing offering. Respondents were initially exposed to the specifications of the D40, and then those of the line extension, identical except for the name D50 or E40. Specifications of the existing offering (i.e., D40) and line extensions (i.e., D50 and E40) were identical to those in studies 2a and 2b. The same procedure for study 2b was applied to study 2c. The dependent variables were relative preference, willingness to purchase between the existing brand and line extension, the line extension's inferred attribute.

## ***Results***

Following prior research on mTurk (Downs et al. 2010), responses were screened and nine participants (2%) were identified as answering unconscientiously; they selected the minimum scale points on all measures, and were excluded from the analysis.

Results of study 2c support H2. Preferences for the line extension over the existing brand (D40) were higher when the brand name was D50 (i.e., number change) ( $M = 1.99$ ) than when the brand name was E40 (i.e., letter change) ( $M = 1.77$ ,  $t(405) = -2.31$ ,  $p < .05$ ). Participants were more willing to purchase the D50 (i.e., number change) ( $M = 1.99$ ) in comparison to the D40 than the E40 (i.e., letter change) ( $M = 1.76$ ) in comparison to the D40 ( $t(405) = -2.25$ ,  $p < .05$ ). Similarly, respondents inferred a larger screen size for the new camera when the brand name was D50 ( $M = 3.5$ ) (i.e., number change) than E40 ( $M = 3.15$ ) (i.e., letter change) ( $t(405) = -2.87$ ,  $p < .05$ ). Moreover, the mean screen size inferred in the letter change condition ( $M = 3.15$ ) was not significantly larger than the screen size of the existing brand ( $t(194) = 1.7$ ,  $p > .05$ ); whereas in the number change condition ( $M = 3.5$ ) it was significantly larger than the screen size of the existing brand ( $t(194) = 6.2$ ,  $p < .01$ ). This result also suggests that number change,



compared to letter change led to an improvement over the existing brand demonstrating an inference of better product attributes. Only 37.4% of participants inferred a larger screen size for new product E40 in the letter-change condition, whereas 54.2% inferred a larger screen size for the D50 in the number-change condition ( $\chi^2 = 11.55, p < .05$ ).

### ***Discussion***

Study 2c's results also replicate the positive effect of a change in the numeric component of ANBs in comparison to a change in the alpha component. The numeric component was better at prompting higher favorability and choice share than the alpha component. The primary contribution of Study 2c is replication of this finding with different letter (e.g., D and E) and number (e.g., 40 and 50) pairs. Thus, the finding does not appear to be specific to A and B.

### **Study 3: Does The Order of ANB Components Matter?**

As previously discussed, we focus on evaluative differences between letter pairs and number pairs. Specifically, to strengthen our proposition of evaluative differences between letter and number pairs, and to rule out the possibility that the results can be attributed to attention or perception related ideas, such as the greater noticeability of change in number versus letter components, we conducted Study 3. Additionally, practitioners can also use ANBs with components in reversed order, such as positioning numbers before letters (e.g., iPhone 5S). To increase the generalizability of our conceptualization in terms of managerial implications, we tested whether the order of ANB components (e.g., letter first – A70 versus number first – 70A) will influence the positive effect of number change over letter change. Based on our theorization of processing differences in numbers versus letters, our anticipation was that the order of ANB

components will not affect our findings regarding number versus letter changes in ANBs.

Another purpose was to examine how number versus letter changes in ANBs influence price perceptions. Brand names and prices are extrinsic product attributes, which communicate information to consumers (Mazursky and Jacoby 1985; Zeithaml 1988). Because price is also a numeric attribute, and differs from the perspectives of practitioners and consumers, we explore whether number versus letter changes in ANBs lead to variations in how consumers evaluate the price of line extensions. Therefore, a new dependent variable in study 3 was the price expectation for a line extension given the price of an existing brand.

Four-hundred and sixty eight mTurk workers participated in a 2 (change: number versus letter) x 2 (order: letter first versus number first) between-subjects, online experiment. The brand names used in Study 3 were identical to those in Study 2a. In a minor departure from previous studies, participants were not instructed that there was an original brand and an extension. Instead, participants were instructed that Canon, a well-known electronics brand, has two brands that they need to evaluate based on brand names. This minor departure from previous studies enabled us to demonstrate that the findings supporting H2 are not specific to a line extension context. Participants were randomly assigned to one of the four conditions: Canon A70 and Canon A80 (number change – letter first condition), Canon A70 and Canon B70 (letter change – letter first condition), Canon 70A and Canon 80A (number change – number first condition), or Canon 70A and Canon 70B (letter change – number first condition). Next, participants were asked to indicate their preferences between the two brands on a 6-point bipolar scale, with end-points 1 (Canon A70 is certainly more favorable) and 6 (Canon A80 is certainly more favorable) for the letter first – number change condition. Finally, participants were told that the price of A70

(for the letter first conditions) was \$109, and were asked to what they thought the price of the A80 (for the number change – letter first condition) would be.

## ***Results***

One participant who did not pass the attention check (Baskin et al. 2014) was excluded. Supporting our theorization of differences in evaluations, the type of change in the ANB had a highly significant effect on relative preference for the two brands ( $F(1, 463) = 85.36, p < .01$ ), whereas the order of the ANB components was barely marginally significant ( $F(1, 463) = 2.82, p > .09$ ). The interaction of Order and Change was non-significant ( $F(1, 463) = 1.5, p = .22$ ). Specifically, preferences for A80 ( $M = 5.52$ ) in comparison to A70 were higher than preferences for B70 ( $M = 3.39$ ) in comparison to A70 ( $F(1, 463) = 54.42, p < .01$ ). Similarly, preferences for 80A ( $M = 5.61$ ) in comparison to 70A were also higher than preferences for 70B ( $M = 3.98$ ) in comparison to 70A ( $F(1, 463) = 32.3, p < .01$ ). Hence, independent of the order of ANB components, the number change ( $M = 5.57$ ) resulted in higher comparative evaluations than the letter change did ( $M = 3.69, F(1, 463) = 85.36, p < .01$ ). It is important to note that the marginal significance of the effect of the order ( $F(1, 463) = 2.82, p = .09$ ) does not conflict with the results discussed above, because the only significant effect of the order of ANB components on preferences for the line extension was within the letter change condition. Specifically, preferences for 70B ( $M = 3.98$ ) in comparison to the 70A were higher than preferences for B70 ( $M = 3.39$ ) in comparison to A70 ( $F(1, 463) = 4.178, p < .05$ ).

Similarly, for the price expectation, the effect of the type of change in the ANB was significant ( $F(1, 463) = 41.47, p < .01$ ); whereas the effect of order of ANB components was non-significant ( $F(1, 463) = .474, p > .05$ ). And, the interaction of Order and Change was also non-significant ( $F(1, 463) = .1, p > .05$ ). Particularly, participants inferred higher prices for A80

( $M = \$151.76$ ) in comparison to A70 than for B70 ( $M = \$129.52$ ) in comparison to A70 ( $F(1, 463) = 18.65; p < .01$ ). A similar pattern was also observed, when the order of ANB components was reversed. Participants inferred higher prices for the 80A ( $M = \$150.4$ ), in comparison to the 70A than for the 70B ( $M = \$125.88$ ) in comparison to 70A ( $F(1, 463) = 22.97, p < .01$ ). Overall, the number change ( $M = 151.08$ ) in the ANB led to higher comparative price inferences than the letter change ( $M = 127.7, F(1, 463) = 41.49, p < .01$ ) in ANBs, independent of the order of ANB components.

### ***Discussion***

In addition to replicating the findings of the previous studies, results of Study 3 revealed that changing the order of the components (alpha and numeric) in ANBs does not reduce the stronger effect of number change compared to letter change on consumers' brand evaluations. This finding also supports our theorization based on different evaluative properties of number versus letter series, by ruling out attention related alternative explanations, such as position of numbers in ANBs (e.g., always after letters) enhancing the noticeability of disparities between numbers compared to those between letters. Specifically, we demonstrated that the positive effect of number change compared to letter change cannot be attributed to the fact that numbers are usually presented after letters in ANBs. Additionally, replication of findings in a non-extension context enables us to generalize our findings. Specifically, despite the fact that we did not anchor participants as one product being an improved version of the other, we provided support for H2. Thus, we can conclude that the more positive effect number change over letter change is not limited to the line extension context.

### **Study 4: Alignability of Numeric Increase in ANBs and Numeric Attribute Improvement**

The purpose of study 4 was to test H3 by examining whether a) increasing numbers in ANBs lead consumers to evaluate a line extension as having increased numeric attributes (alignability), and b) this numeric alignability mediates consumers' more-favorable evaluations of ANBs with increased numeric components in comparison to increased alpha components.

### ***Stimuli***

The product category and letter-number combinations were identical to those of Study 2a. The existing brand name was changed to the Sony CyberShot, another major player in the market, to replicate results using a different brand. The existing brand was Sony CyberShot A70. The line extension was Sony CyberShot A80 for the number change condition and Sony CyberShot B70 for the letter change condition. We included two dependent variables. First, to test how the extension names affected inferences about product attributes, we created four product specifications from which participants chose the one that best characterized the line extension. As shown in Appendix B (for the letter change condition), the four options were created by adding attributes to and/or improving attributes of the A70. We increased the numeric values of attributes and added attributes to calibrate the numeric attribute advancements.

The first option was identical to the A70 on all but one attribute, which was superior in terms of one increased numeric attribute. The second option had identical specifications to A70, but it also had one additional feature. The third option was superior to the A70 on all dimensions. The fourth option had all of its attributes improved and an additional feature added in comparison to the A70. Because the purpose was to test whether increasing the number in the ANB (e.g., from A70 to A80), in comparison to increasing the order of the letter in the ANB (e.g., from A to B) leads participants to perceive the line extension as having increased numeric

attributes in comparison to an existing product (i.e., A70), we created two sets of options. The first two options had one numeric attribute change in comparison to A70, and the second two had multiple numeric attribute changes in comparison to A70. The first two product alternatives that had one improved attribute or one extra specification added with respect to A70 were classified as *one numeric attribute change* options, and the two alternatives, with all superior attributes or all features improved plus an extra specification, were classified as *multiple numeric attribute change* options. The same set of options was provided to participants for the number-change condition. The only difference was the line extension brand name, A80.

Second, to test consumers' assessments of line extension quality, the dependent variable was a measure of picture quality. As shown in Appendix B for the letter-change condition, 4 photographs with varying levels of quality were used to test evaluations of extension quality. The photographs were created by altering the pixels, and ordered in quality levels of better, equal, worse, and much worse in comparison to the quality of the photograph supposedly taken with the A70. This allowed us to measure quality perceptions created by changes in numeric versus alpha components.

### ***Procedure***

One-hundred seventy-eight undergraduate students at a northeastern university participated in the study for course credit. Participants were assigned randomly to one of two conditions, letter change (A70/B70) versus number change (A70/A80). Initially, participants were instructed that Sony, a popular digital and electronics brand, had two digital camera products that were the Sony CyberShot A70 and Sony CyberShot A80 (for the number-change condition) or Sony CyberShot B70 (for the letter-change condition). Before providing participants with product information, they identified which brand was for the newer product,

A70 or A80 in the number-change condition, and A70 or B70 in the letter-change condition based solely on ANBs. This helped us understand perceptions regarding which product was newer based on the brand names.

Participants were then shown specifications (i.e., numeric attributes) of the A70 and specifications for four additional product options, with comparable feature sets to A70 (see Appendix B for the letter-change condition). Described previously, these options were created to examine the effect of letter versus number change on participants' anticipations of numeric attribute improvements. The same set of options was provided to participants in the letter-change condition. The only difference in the number-change condition was the line extension brand name being A80. Participants chose the option they perceived was A80 (for the number-change condition) or B70 (for the letter-change condition). Participants were then shown a photograph supposedly taken with the A70, and shown a set of 4 photographs with varying levels of quality (Appendix B). They identified the one they believed was taken by the line extension, A80 or B70. The photographs were ordered by quality, but no labels indicated the quality of the photographs. Finally, participants were told that the price of A70 was \$199, and were asked to write what they thought the price of the A80 (for the number-change condition) or the B70 (for the letter-change condition) would be.

## ***Results***

Two participants whose attention or involvement was low were identified. These participants provided answers that were highly inconsistent on price and attributes. Consequently, these participants were excluded.

We ran a logistic regression with the two conditions (i.e., number and letter change) as the independent variable and perceptions of product newness (i.e., A70 versus A80 or B70) as

the dependent variable. The regression coefficient was significant ( $b = -1.75$ , Wald  $\chi^2 = 13.06$ ,  $p < .01$ ). 70.5% of participants in the letter-change condition identified B70 as the new product, whereas 93.2% in the number-change condition recognized A80 ( $\chi^2 = 15.28$ ,  $p < .01$ ), showing that more participants associated the change in numeric (versus alpha) component with the introduction of a new product.

To evaluate participants' quality expectations for A80 and B70, the photographs were coded in ascending order of quality from 1 to 4, where higher values corresponded to higher perceived image quality. Respondents expected a higher image quality in the number change condition (i.e., A80) ( $M = 3.82$ ) in comparison to the letter-change condition (i.e., B70) ( $M = 3.67$ ,  $t(166.19) = -2.08$ ,  $p < .05$ ). Levene's test was significant ( $F = 15.171$ ,  $p < .01$ ). 69.3% of participants rated the quality of the photograph produced by B70 as better than that produced by A70, whereas the percentage increased to 83% for A80 ( $\chi^2 = 4.5$ ,  $p < .05$ ). Participants also expected the line extension to have a higher price in the number-change condition ( $M = \$256.6$ ) than in the letter-change condition ( $M = \$243.55$ ,  $t(174) = -2.1$ ,  $p < .05$ ).

*Mediation of product quality judgments by attribute improvements (alignability).* As described earlier, participants were shown two sets of two options to identify as A80 or B70 given the characteristics of A70. Analysis revealed that changes in the number ( $M = 84.1\%$ ) versus the letter ( $M = 68.2\%$ ) were more likely to increase inferences that line extension involved *multiple numeric attributes changes* ( $\chi^2 = 6.13$ ,  $p < .05$ ). Mediation analysis, with 5000 bootstrapped samples, was run on M-Plus because, we had a dichotomous independent variable (e.g., letter versus number change) and a dichotomous mediator (e.g., attribute improvements as *multiple numeric attribute change* versus *single numeric attribute change*). Mediation analysis revealed indirect-only mediation (Zhao, Lynch, and Chen 2010); controlling for letter/number



change, the differential effect of attribute improvement (*single numeric attribute change* = 0; *multiple numeric attribute change* = 1) was positive on product quality judgments ( $\beta = .19$ ;  $t(174) = 4.35, p < .01$ ). Controlling for attribute improvement, the direct effect of letter/number change (letter change = 0; number change = 1) on product quality judgments was not significant ( $\beta = .05, t(174) = .69, p = .49$ ). The indirect path ( $\beta = .1$ ) had a 95% confidence interval that did not include zero (0.03 to 0.19).

*Mediation of price expectation by attribute improvements (alignability).* Attribute improvement was perceived to be *multiple numeric attribute change* more in the number-change condition ( $M = 84.1\%$ ) than in the letter-change condition ( $M = 68.2\%, \chi^2 = 6.13, p < .05$ ). Similarly, mediation analysis with 5000 bootstrapped samples, was run on M-Plus because we had a dichotomous, independent variable (e.g., letter versus number change) and a dichotomous mediator (e.g., attribute improvements as *multiple numeric attribute change* versus *single numeric attribute change*). Mediation analysis revealed indirect-only mediation (Zhao et al. 2010); controlling for letter/number change, attribute improvement (*single numeric attribute change* = 0; *multiple numeric attribute change* = 1) associated positively with price expectation ( $\beta = 14.06, t(174) = 3.41, p < .01$ ). Controlling for attribute improvement, the direct effect of letter/number change (letter change = 0; number change = 1) on price expectation was not significant ( $\beta = 5.65, t(174) = .88, p = .38$ ). The indirect path ( $\beta = 7.34$ ) had a 95% confidence interval that did not include zero (2.5 to 15.13).

It is possible that the four options created for the specifications of the line extension fall into two categories as numeric attributes improved versus added instead of *multiple numeric attribute change* and *single numeric attribute change*. To exclude this alternative, we ran the mediation analysis suggested by it, resulting in no significant differences between the number-

and letter-change conditions concerning how consumers perceive the numeric attributes of the line extension ( $\chi^2 = .82, p = .37$ ). Thus, this alternative explanation appears implausible.

### ***Discussion***

Participants' product assessments were measured with different dependent variables: perceptions of newness of the line extension, expectations of improvement dimensions and quality, and price expectation for the line extension. Results suggest increases in brand evaluations between extensions when the numeric component of the ANB increased versus when the order of the letter component of the ANB increased. Study 4 replicates results of studies 2a, 2b, and 2c, and provides details regarding perceptions of improvement for the new product solely based on letter or number changes. Thus, the results also suggest participants evaluated a number change in the ANB as an indication of a higher quality line extension with improved specifications in comparison to a letter change in the brand name.

The most noteworthy result of study 4 was the mediating role of alignability of increases in numeric components with evaluations of numeric attributes. Increasing the numeric component in the existing ANB to form the line extension ANB led consumers to anticipate increases in numeric attribute values of the line extension in comparison to the current product. This alignability mediated the differential effect of alpha versus numeric changes in ANBs on evaluations of line extensions, as higher quality. In support of H2, participants expected the Sony CyberShot A80 to be more expensive in comparison to the existing brand A70 than the Sony CyberShot B70. Participants discerned a number change in ANBs as an indication of a higher-priced product in comparison to a letter change. Similar to quality judgments, alignability mediated the differential effect of alpha versus numeric changes on expectations of price of line extensions.

### **Study 5: Alignability or Fluency?**

Results of Study 4 revealed that increasing numbers, compared to ascending letters, lead consumers to expect increased numeric attribute values, and that this alignability in terms of consumers' expectation of an equivalent increase numbers in ANBs and attribute values drives a more positive effect of the number change, compared to the letter change, on consumers' ANB evaluations. The basic premise of the hypothesized effects lies in the proposition that numbers are better at inducing an expectation of increase than letters, because they have cardinal meaning, specifically magnitude. However, one can argue that the results of Study 4 could have been driven by the fluency of number processing. Particularly, increasing numbers in ANBs and numeric attribute values may lead to a fluency in number processing, and this fluency might be driving the more positive effect of the number change over the letter change in ANBs on consumers' ANB evaluations. Hence, the question of whether number change, compared to letter change, results in more favorable ANB evaluations in existence of non-numeric attribute values arises. Thus, the purpose of Study 5 was to test H2, which posits that consumers evaluate line extensions more favorably when the extension ANB is formed with increasing numbers rather than ascending letters, with non-numeric attribute values that should favor letter change over number change based on a fluency argument. However, because we suggest that number change is better than letter change in terms of inducing the notion of increase, we continued to expect observe more favorable consumer reactions to the number change in ANBs than the letter change in ANBs. Hence, we aimed to increase the robustness of our findings.

Another purpose of Study 5 was to replicate our previous results in a non-extension context, in which participants do not anchor on one of the brands as a new version of the other. As in Study 3, this context enables us to increase the generalizability of the findings, by demonstrating that the more favorable effect of number change over letter change in ANBs is not specific to the line extension context. The final purpose of Study 5 was to replicate our results with unknown brands so that we could rule out another possible alternative explanation, that the more positive effect of number change, over letter change, in ANBs is affected by consumers' knowledge about the brand.

A total of 181 undergraduate students at a Northeastern university participated in a 2 (change: number versus letter) condition between-subjects experiment in exchange of course credit. The product category was again a digital camera. However, diverging from previous studies the cameras were non branded ANBs, such as A70 and A80 or B70. As in Study 3, participants were not instructed that there was an original brand and an extension. Instead, participants were provided with a table that displays non-numeric consumer ratings on three dimensions, which are image quality, ease of use and LCD panel quality, for the two camera brands, A70-A80 in the number change condition and A70-B70 in the letter change condition. Participants saw the reviews for both camera brands in the same table. The reviews ranged from “fair” to “excellent” for each of the cameras. The reviews were designed to be balanced so that neither of the camera brands was superior to the other. Next, participants were asked to indicate their preferences between the two brands on a 6-point bipolar scale, with end-points 1 (A70 is certainly more favorable) and 6 (A80 is certainly more favorable) for the number change condition. Finally, participants chose which product they would like to purchase using a bipolar scale, with end points of 1 (Definitely A70) and 6 (Definitely A80).

## ***Results and Discussion***

As with previous studies, the results of study 5 support H2. In the number change condition preferences for the A80 over the A70 ( $M = 4.76$ ) were greater than preferences for the B70 over the A70 in the letter change condition ( $M = 4.23$ ,  $t(175.82) = -2.21$ ,  $p < .05$ ). Similarly, participants were more willing to purchase the A80 (i.e., number change) ( $M = 4.63$ ) in comparison to the A70 than the B70 (i.e., letter change) ( $M = 4.15$ ) in comparison to the A70 ( $t(175.14) = -2.13$ ,  $p < .05$ ). As previously discussed, Levene's test for equality of variances was significant both for relative preference ( $F = 5.99$ ,  $p < .05$ ) and for the willingness to purchase ( $F = 7.34$ ,  $p < .05$ ); and the assumption of equal variances was rejected. Therefore, we report statistics for the aforementioned measures using adapted degrees of freedom.

Results of Study 5 revealed that the more positive effect of increasing numbers over ascending letters in ANBs on consumers' ANB evaluations is robust with non-numeric attribute values. Specifically, as previously discussed, in line with processing fluency, an alternative explanation for this effect could have been the consistency between numbers in ANBs and numeric attribute values of the product, which could have driven more positive effect of the number change, over the letter change in ANBs on consumers' brand evaluations. Thus, we aimed to replicate the results with a non-numeric attribute set, which is consistent with ascending letters in ANBs. According to the consistency argument, ascending letters, compared to increasing letters in ANBs should have led to more favorable ANB evaluations. However, we showed that increasing numbers, compared to ascending letters, still lead to more favorable consumer evaluations for ANBs even when attribute values are non-numeric. Thus, in support of our alignability theorization, increasing numbers, compared to ascending letters in ANBs induce expectation of an improved new product to consumers. Another important contribution of Study

5 was demonstrating that this effect is robust with unknown brands and in a non-extension context.

## **General Discussion**

As extant literature indicates often, brand name, as an extrinsic product attribute, is highly influential on consumer evaluations of products, including quality judgments and attribute assessments (Gunasti and Ross 2010; Mazursky and Jacoby 1985; Zeithaml 1988). ANBs lead consumers to associate letter and/or number parts of a brand name and product features, series, or new product lines (Gunasti and Ross 2010; King and Janiszewski 2011; Pavia and Costa 1993). This study contributes to extant literature by delineating alpha and numeric components of ANBs and examining the effect of each component on consumers' ANB evaluations. We address the alpha component of ANBs, and despite the descending superiority in the ordinality of the alphabet (Jou 2003), we demonstrate that consumers evaluate a line extension formed with an ascending order of the letter in ANBs in comparison to a descending order more favorably because of strong forward-direction bias in the alphabet (Jou 2003), resulting in strong associations of the latter letter (e.g., B versus A) with introduction of line extensions.

We illustrate the effect of disparities between number and letter cognition in assessments of line extensions introduced by changing the letter or number components of existing ANBs. Due to differences in serial order processing between numbers and letters (Damian 2004; Jou 2003), consumers perceive line extensions as a larger improvement of an existing product when the number component of an ANB increases than when the order of the letter component of the

ANB increases. This effect was observed with various dependent variables such as overall favorability, quality judgment, price expectation, and novelty of the product.

We report variations in how consumers evaluate attribute improvements and dimensions of improvement resulting from the effect of alignability of numeric components (i.e., increases in numeric components of ANBs) with numeric attribute values (i.e., increases in numeric attribute values) on subsequent judgments. As extant research suggests, we find that consumers are influenced by increases in the numeric components of ANBs and align their anticipation of numeric attributes with this notion of increase. The alignability mediates the differential effect of alpha versus numeric changes in ANBs on consumer evaluations of line extensions, as higher quality and more expensive.

Finally we increase the robustness and generalizability of our findings by replicating the effect with different stimuli, such as different number-letter pairs, numbers with more or less number of digits, and letter-number pairs in reversed order, and in various contexts, such as non-extension contexts, unknown brands, and with non-numeric attribute values. From a theoretical perspective, by showing that the more positive effect of the number change, over the letter change, in ANBs is also observed with a non-numeric attribute set, which should have favored ascending letters in ANBs according a fluency (e.g., consistency) argument, we ruled out the effect of fluency (e.g., consistency) as an alternative conceptualization. And, we strengthened support for our conceptualization involving alignability as a mediator, which suggests that increasing numbers, compared to ascending letters in ANBs, induces expectation of an improved new product to consumers, as the mechanism that drives the more positive effect of increasing numbers, over descending letters in ANBs on consumers' ANB evaluations.

It is important to note that we specifically focus on disparities in numeric and alpha components of ANBs in brand evaluations, which are inherently processing tasks. One might argue that the proposed hypotheses can also be driven by perception instead of cognition or information processing. Specifically, it may be argued that the difference between two letters can also be a perceptual difference (e.g., visual similarity of the letters M and N), or a phonological difference (e.g., sound similarity of the letters M and N), whereas the difference between two numbers is definitely the magnitude difference. Such a disparity could be an issue if the difference between letter pairs and number pairs were compared in a context that lacks serial order. The ANB line extension context, where numbers and letters are used as elements of serial orders obviates this alternative theorization. Particularly, the literature documents that “the discrimination of both number sequences and letters of the alphabet is characterized by the distance effect; that is, the ability to discriminate between two numbers or letters improves (with regard to reaction time and precision) as the (numerical or alphabetical) distance between the items increases” (Jacob and Nieder 2008 p. 41). This explanation implies that letters and numbers can display similar characteristics when they are represented as elements of a serial order just like in line extension ANBs. However, as previously indicated, letters only have ordinal meaning, whereas numbers have both ordinal and cardinal meanings (e.g., the magnitude). In an evaluation task, we believe this distinction drives the proposed more positive number change effect over letter change effect on consumers’ line extension evaluations.

Our perspective indicates that the serial order processing of numeric versus alpha changes in ANBs leads to a variation in perceived differences between line extensions and existing products. From a managerial viewpoint, our findings provide insights into a common practice by practitioners. As previously discussed, firms change the letter or number components of existing



ANBs to label line extensions. This research suggests that practitioners' current naming strategies may not be optimal. Specifically, Panasonic changes letters to imply attribute advancement (e.g., the Panasonic HDC-HS80 and the HDC-TM80, refer to the same product with different data-storage attributes), whereas Mercedes changes letters to differentiate product lines (e.g., Mercedes C350, S350, and E350 define different classes of cars). However, consumers might not perceive common use of letter-changing strategies to reflect new product lines and number-changing strategies to indicate attribute improvements as effective. This research suggests that it might be better for practitioners to use number-changing strategies to denote improved line extensions than to use letter-changing strategies.

Another managerial implication is that our findings are robust when alphanumeric components occur in reversed order, such as Apple iPhone 4, 4S, 5, and 5S. Increasing numbers, over ascending letters, still result in more favorable line extension evaluations, when the order of ANB components is reversed (e.g., iPhone 4S versus iPhone 5S). Furthermore, as previously discussed, our findings are also robust when ANBs are unknown brands in a non-extension context. Thus, the more positive effect of increasing numbers, over ascending letters in ANBs, is not specific to line extension contexts, and can be equally important for less known or completely unknown new brands. These findings increase the generalizability of our conceptualization in terms of managerial implications.

### ***Limitations and Future Research***

This study offers new insights into ANBs, and opportunities for future research. We focus on two electronics product categories, cameras and laptops, two categories in which ANBs are predominant and successful. Extant literature suggests that widespread use of ANBs is especially prevalent in technical product categories (Gunasti and Ross 2010; Pavia and Costa

1993). Use of cameras as stimuli serves as a baseline to understanding strong consumer reactions toward number and letter changes in ANBs. Replication with various product categories represents a research opportunity, and changing the product category might alter how consumers evaluate letter and the number changes.

Another future research opportunity lies in testing the aforementioned hypotheses with varying number and/or letter combinations. This research is limited to increasing the left digit of numbers in ANBs by one unit, and increasing the order of letters by one step. One or more numeric effects such as the distance effect, defined as “the closer the perceived distance between the two analog magnitudes, the greater the difficulty in discriminating them on this scale” (Thomas and Morwitz 2005, p. 55), might influence results. Such number-related effects might represent boundary conditions for the more positive effect of numeric changes in ANBs in comparison to alpha changes we find.

## **Conclusion**

This research delineates the effect of alpha and numeric components of ANBs, and demonstrates the effect of differences between number and letter cognition on consumers’ evaluation of these brand names. Based on six experiments, we show that processing of number versus letter changes in ANBs results in differences in consumers’ evaluations of how different the line extensions and existing brands were. Specifically, we find that consumers evaluate a line extension more favorably, when the line extension ANB is formed with (i) an ascending order of letters, compared to a descending order of letters, and (ii) an increasing number, compared to an ascending order of letters. Additionally, we demonstrate that the more positive effect of number

change, over letter change, on consumers' evaluations of line extensions is mediated by the alignability of the "increase" in numeric attribute values with the "increase" in numeric components on ANBs.

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TABLE 1

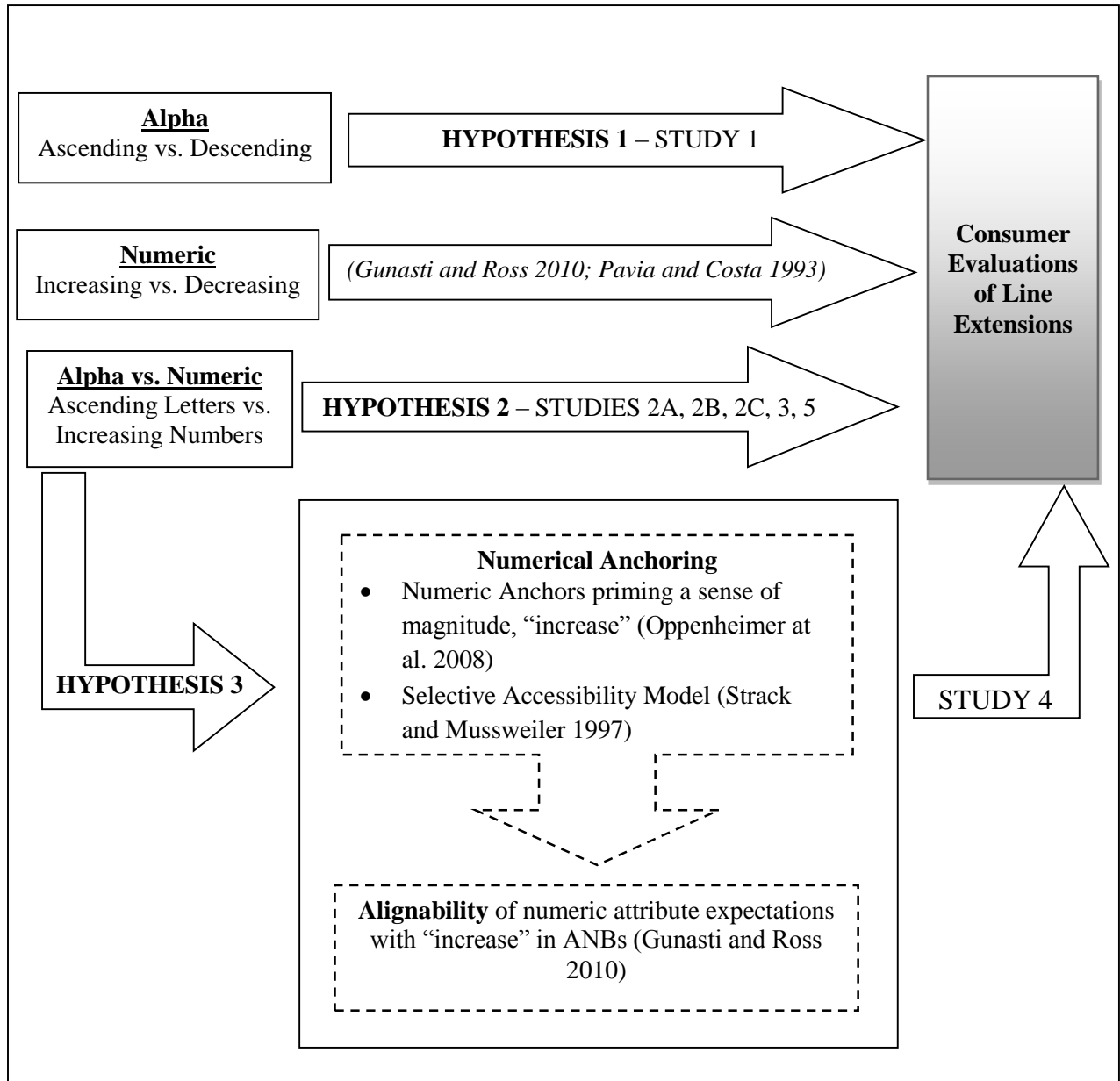
## SUMMARY OF ANB STRATEGIES IN LINE EXTENSIONS

Brand	Line extensions			
	Use of numbers	Dimension of improvement	Use of letters	Dimension of improvement
Audi	A4 vs. A6	Engine size	A4 vs. S4	Engine type
BMW	3 20 vs. 3 50 5 20 vs. 5 50	Engine size	M5 xDrive vs. M5 iDrive	Drive terrain
Mercedes	E350 vs. E550	Engine size	C vs. E vs. S	Classes of cars
Panasonic Camera	V550 vs. V250	Image Stabilizer	TM90 vs. SD90	Memory capacity
Samsung Camera	H300 vs. H304	Memory Capacity	WB200 vs. NX200	Types of cameras
HP Laptop	Pavilion dv4t vs. Pavilion dv6t	Screen size	Pavilion m6 vs. Pavilion g6	Classes of laptops
Apple	iPhone 3 vs. 4 vs. 5	Extension	iPhone 4 vs. 4S iPhone 5 vs. 5S	Extension



FIGURE 1

CONCEPTUAL MODEL OF RESEARCH ON DELINEATING ALPHA AND NUMERIC IN ANBS



## APPENDIX A

### STIMULUS FOR STUDIES 1 AND 2A

#### Stimulus for Study 1 – Ascending Letters Condition

Dell, an electronics brand has the Dell D10 laptop model with the following key features



<i>Existing Dell Product Specs</i>	<i>Brand: <b>Dell D10</b></i>
Processor Speed (GHz)	1.8
RAM (GB)	4
Storage Capacity (GB)	320

Dell is planning to introduce a new laptop, Dell E10, in the market with the following specifications

<i>Existing Dell Product Specs</i>	<i>Brand: <b>Dell E10</b></i>
Processor Speed (GHz)	1.8
RAM (GB)	4
Storage Capacity (GB)	500

#### Stimulus for Study 2A

		Number Change	Letter Change
Canon	Canon A70	Canon A80	Canon B70
Digital Zoom	5x	6x	6x
Resolution (Mega Pixels)	4.0 MP	3.2 MP	3.2 MP
Optical Zoom	3.6x	3x	3x
Dependent Variables	Mean Values		
Relative Preference	N/A	4.02	3.05
Inference Making	N/A	2.13	1.99

## APPENDIX B

### STIMULUS FOR STUDY 4

#### Letter Change Condition – Attribute Improvement

Sony has *Sony CyberShot A70* digital camera product with following features:

<i>Sony CyberShot A70</i>	
Resolution	8.2 MP
Optical Zoom	3.6x
Digital Zoom	11x

Which of the following offerings do you think stand for *Sony CyberShot B70*?

<b>Single Numeric Attribute Change</b>		<i>Sony CyberShot B70</i>		<i>Sony CyberShot B70</i>	
		Resolution	8.2 MP	Resolution	8.2 MP
		Optical Zoom	5.6x	Optical Zoom	3.6x
		Digital Zoom	11x	Digital Zoom	11x
<b>Multiple Numeric Attribute Change</b>		<i>Sony CyberShot B70</i>		<i>Sony CyberShot B70</i>	
		Resolution	12.2 MP	Resolution	12.2 MP
		Optical Zoom	5.6x	Optical Zoom	5.6x
		Digital Zoom	13x	Digital Zoom	13x
				Extra Memory Card	4 GB

#### Letter Change Condition – Perceived Output Quality



This photograph depicts the 30x zoom version of the original image below that was taken with *Sony CyberShot A70*. Accordingly, which one of the following do you expect to be the 30x zoom of the photo that was taken with *Sony CyberShot B70*?



## **CHAPTER 3: ESSAY 2**

### **What Does Your Brand “State” to You?: An Exploratory Examination of How Language Affects Comparison of Alphanumeric Brand Names**

Alphanumeric brand names (ANBs) include combinations of letters and numbers, either in digital or word form, such as Saks Fifth Avenue or BMW 335xi (Pavia and Costa 1993). There is a growing stream of literature on the effect of ANBs on consumer evaluations of brands. King and Janiszewski (2011) investigated the effect of fluency in number processing; Yan and Duclos (2013) demonstrated the anchored meanings in numbers on consumers’ reactions to ANBs. Past research documents that the inclusion of numbers in ANBs affects consumers’ evaluation of attribute inferences and price perceptions (Pavia and Costa 1993; Gunasti and Ozcan 2016). Specifically, consumers generally evaluate an A20 brand product as superior to an A10 brand because 20 is greater than 10 - known as “the higher the better” heuristic (Gunasti and Ross 2010).

Because consumer decisions frequently deal with ANB comparisons, such as whether to upgrade from Sony Cybershot WX60 to the WX80, differences in numeral systems across languages have a significant potential to influence consumer judgments especially in the global marketing domain. For example, Sony Cybershot digital camera models WX60 and WX80 are merchandised both in the United States and in France. How consumers process numbers in ANBs may be strongly related to the language structure of the numeral system, because the linguistic structure can make the numeral system more or less “numerous”. Numerosity is briefly described as “the number of units into which a stimulus is divided” (Pelham, Sumarta, and

Myakovsky 1994, p. 103). Let us consider the number 82. In English it is verbalized in forward order by using a new word for the decade (e.g., eighty) as 80-2 (eighty-two). In French, 82 is expressed in a different structure as 4-20-2 (quatre-vingt-deux). On the other hand, Chinese has a highly structured and regular counting system in which 82 is pronounced simply as 8-10-2 (ba-shi-er). The preceding example illustrates that the exact same number (e.g., eighty) can be verbalized in a more (e.g., 8 units of 10 in Chinese) versus a less (e.g., 4 units of 20 in French) numerous structure. As various studies have documented the effect of numerosity on consumer decision making and evaluation of quantitative information in various contexts (Gamble 2006; Marques 1999; Pandelaere, Briers, and Lembregts 2011; Wertenbroch, Soman, and Chattopadhyay 2007), we expect that linguistic numeral properties that lead to variations in numerosity of numeral systems can influence consumers' ANB evaluations. Hence, the question of whether consumers' ability to compare Sony Cybershot WX60 and Sony Cybershot digital camera models WX60 and WX80 is influenced by the language that they speak (English or French) arises. Accordingly, the first aim of the research herein is to explore whether and how differences in numeral structures across languages influence consumers' comparative ANB evaluations in a line extension context. Additionally, we argue that these structural differences across languages make numeral systems more or less numerous influencing consumers' comparative evaluations of ANBs, which are inherently number comparison tasks.

Moreover, the research herein explores the degree to which the effect of language on consumers' comparative ANB evaluations is influenced by differences in contexts and consumer characteristics. Specifically, another important effect of language on number cognition lies in how different ways to encode numbers such as verbal and digital affects processing (Campbell 1994; Colome, Laka, and Sebastian-Galles 2010; Dehaene 1992). On one hand, the Triple Code

Model proposes that numbers are presented and operated on on three different forms: visual, verbal, and analog (Dehaene 1992), and language influences numeric tasks that are performed in verbal forms such as counting and simple one digit calculations (Colome, Laka, and Sebastian-Galles 2010). On the other hand, the Multiple Encoding Hypothesis proposes that number processing is performed on four major forms: Arabic, magnitude, visuo-spatial and verbal (Campbell 1994; Campbell and Clark 1992; Campbell and Epp 2004) and these codes are highly interactive so that language can affect any numeric task. Hence, comparative evaluations of ANBs, which are inherently number comparison tasks, can be influenced by contextual factors, such as the format in which individuals are exposed to these numbers in ANBs (e.g., digital versus verbal, which entails both audio and number-word delivery). Consequently, the second aim of the research herein is to explore whether verbal versus digital exposure to numbers in ANBs is a critical factor to drive the effect of language on consumers' ANB evaluations.

Finally, we recognize that some individuals are better at understanding numeric information and at systematic processing, whereas others may not be and they rely more on heuristic based analysis (Gunasti and Ross 2010; Peters, Dieckmann, Dixon, Hibbard, and Mertz 2007). We test for the effects of difference in perceived numeracy, defined as one's ability to process numerical information (Fagerlin, Zikmund-Fisher, Ubel, Jankovic, Derry, and Smith 2007; Zikmund-Fisher, Smith, Uber, and Fagerlin 2007), and need for cognition, defined as the amount of cognitive work an individual is willing to put into decision making (Cacioppo, and Petty 1982), on how language influences consumers' comparative ANB evaluations. Thus, the third aim of the research herein is to explore whether individual difference variables such as perceived numeracy and need for cognition influence the effect of language on consumers' comparative ANB evaluations.

In summary, this research provides important theoretical and managerial contributions to the growing literature on alphanumeric brand names (Ang 1997; Boyd 1985; Gunasti and Ross 2010; Gunasti and Ozcan 2016; Gunasti and Devezer 2015; Kara, Gunasti and Ross 2015; King and Janiszewski 2011; Pavia and Costa 1993; Yan and Duclos 2013;), linguistics in brand names (Klink 2000; Lowrey and Shrum 2007) and effect of number processing and numerosity on consumer behavior (Bagchi and Davis 2012; Thomas and Morwitz 2009; Gamble 2006; Marques 1999; Pandelaere, Briers, and Lembregts 2011; Wertenbroch, Soman, and Chattopadhyay 2007).

We make five contributions. Our investigation, involving seven studies across three languages first documents that language influences consumers' comparative ANB evaluations. Specifically, we examine the two characteristics of linguistic numeral properties: Number base and non-transparency and we show how they affect consumers' number comparisons (Study 1), and comparative ANB evaluations for line extensions (Studies 2, 3, 4, and 7). Second, we demonstrate that these two linguistic properties of numeral systems change the numerosity of number comparisons (Studies 5, and 7). Furthermore, to rule out alternative explanations regarding the mechanism, we show that the effect of differences across linguistic numeral systems on number comparison tasks is not driven by number processing fluency, but by numerosity (Study 6, Study 7). Third, we demonstrate that the effect of language on ANB evaluations occurs in both verbal and visual exposure to numbers in ANBs (Studies 2, 3, 4 and 7). Fourth, this research enriches the theoretical understanding of the effect of language on number processing by providing evidence that linguistic characteristics are prominent factors driving between-language differences in the evaluation of ANBs over and above socio-cultural differences (Studies 4 and 7). Finally, from a managerial perspective, we show that use of the

same numbers in ANBs in global brands may result in differing consumer reactions across languages.

## **Conceptual Background**

### ***Effect of Language on Number Comparisons and Linguistic Numeral Systems***

The Whorfian Hypothesis (Whorf 1956) proposes that language influences and shapes human thought. Deviating from Whorf's initial strong linguistic determinism, so called because it suggests that "language determines thought entirely" (De Cruz 2009, p. 327), other scholars have argued that the scope of the Whorfian Hypotheses is too broad (Hardin and Banaji 1993), and instead proposed that language affects cognition in more limited ways (Hunt and Agnoli 1991) one of which is number cognition (Pica, Lemer, Izard, and Dehaene 2004; Colome, Laka, and Sebastian-Galles 2010). The effect of language on number cognition has received attention in various disciplines, such as cognitive science, linguistics, and behavioral studies (De Cruz and Pica 2008; Gelman and Gallistel 2004; Gordon 2004; Pica et al. 2004; Wiese 2003).

Although the literature documents the effect of language on number processing, the question of what kind of number processing task is influenced by language remains unanswered. Specifically, the Triple Code Model suggests that numbers are presented and operated on in three different forms: visual, verbal, and analog (Dehaene 1992). Visual codes represent numbers in digit forms based on Arabic numerals; verbal codes represent auditory sounds and the number words linked to the digits, and the analog code facilitates the representation of numeric magnitudes on a mental number line. According to Dehaene's Triple Code Model (Dehaene 1992; Dehaene and Cohen 1995), language influences numeric tasks that are performed in verbal forms such as counting and simple one digit calculations (Colome, Laka, and Sebastian-Galles



2010). Hence, language should not influence comparative evaluation of ANBs, because number comparison is performed in analogue magnitude representation. However, Campbell and colleagues introduce the Encoding-Complex Hypothesis for number processing. In this model, number processing is performed by “task-specific activation of information in one or more representational codes” (Campbell and Epp 2004) such as Arabic, visuo-spatial and verbal, and these codes are highly interactive so that language can affect any numeric task. They suggest that the effect of language might be especially strong in verbal format (Campbell 1994; Campbell and Clark 1992; Campbell and Epp 2004; Colome, Laka, and Sebastian-Galles 2010). This model suggests that evaluation of ANBs (i.e., comparison of numeric components in ANBs) will be influenced by the language. Thus, as supported by the Encoding-Complex Hypothesis, we expect linguistic numeral systems to influence consumers’ ability to compare numbers in ANBs of extensions.

Hypothesis 1: Linguistic properties of numeral systems lead to differences in consumers’ comparative number evaluations.

Linguistic numeral systems display significant differences in various aspects, each of which constitutes a characteristic of number processing system. Figure 1 summarizes the linguistic differences in numeral systems of some widely used languages. We present three properties: Base, Non-transparency, and Inversion.

“Insert Figure 1 here”

Base refers to the number of unique digits, including zero, used to represent numbers in a positional numeral system (Justus 2004). For example, Chinese, which belongs to the Sino-Tibetan language family, uses a clear decimal system so that the number 80 is verbalized as eight-ten (ba-shi), whereas French uses a vigesimal (base 20) system for the number 80 so that it

is verbalized as four-twenty (*quatre-vingt*). Transparency refers to whether or not there is smooth correspondence of the number words with the number values (Pixner, Zuber, Hermanova, Kaufmann, Nuerk, and Moeller 2011). For example, the Chinese numeral system is more transparent than English numeral system, because the number 60 is literally expressed as six-ten in Chinese (*liu shi*) (Pixner et al. 2011), whereas it requires a new word for the tens digit (e.g., sixty instead of six-tens) in English. Thus, knowing the number words for the first nine digits and the number 10 would be enough to generate all numbers up to one hundred in Chinese. Turkish, which belongs to the Altaic-Turkic language family, is also highly transparent but one needs to know a specific number word for each new decimal as well as one through nine in Turkish. Consequently, Turkish is positioned slightly above Chinese on the axis of “non-transparency” of numeral systems (Figure 1). In this sense Turkish and English display similar characteristics. Additionally, English has some specific number words that do not follow any rule or standard, such as eleven and twelve. These linguistic numeral properties make English more non-transparent than Chinese and Turkish in Figure 1. Similarly, German, another Indo-European language, also has some irregular number words such as *elf* (11) and *zwölf* (12), which increase the level of “non-transparency” for the German numeral system.

The inversion property refers to the backward system of forming the number words in German, whereby the order of the digits in number words is inverted compared to that in digital forms (Zuber, Pixner, Moeller, and Nuerk 2009). For example, the number 27 is expressed as “seven and twenty” (*sieben und zwanzig*) in German. This inversion property leads German to be positioned as higher than Chinese, Turkish, and English on the “inversion” axis of Figure 1. Moreover, as in most other Indo-European languages, in English, the order of digits is reversed in number words between 10 and 20 (e.g., 16 is read as “sixteen” in which six is verbalized

before ten, whereas in Turkish 16 is read as “on-altı”, which expresses ten before six). Therefore, as shown in Figure 1, the English numeral system has some level of “inversion”. Finally, because of its unique linguistic properties such as the use of different bases (e.g., the vigesimal system in Quatre (4) -vingt (20) for 80; the sexagesimal system in soixante for 60, and soixante (60)-dix (10) for 70; the decimal system in trente for 30), and number words that do not follow any rules (e.g., onze for 11, douze for 12, treize for 13, quatorze for 14, quinze for 15, seize for 16), the other Indo-European language we study, French, is positioned as high on both “non-transparency” and “base” axes.

We specifically focus on the two properties of linguistic numeral systems (base and non-transparency), because these two properties lead to variations in numerosity of numeral systems across languages, and consequently, exert an influence on number comparisons by means of the same mechanism.

### ***Numerosity and the Linguistic Numeral Properties: Base and Non-transparency***

While most modern languages are based on the decimal system (10) that makes up the backbone of the Hindu-Arabic numerals, various languages including French, Danish, Welsh, Irish retain certain reflections from the vigesimal (20) system used in Mayan numerals and sexagesimal (60) system, which originated from the Sumerians and was widely used in Babylonian numerals (Barton 1908; Ifrah 2000). Specifically, although languages like Chinese, English, Spanish and Turkish use the decimal, base ten (10), system (Bender and Beller 2006), among these four languages, Chinese follows a stricter (transparent) decimal numeral system (MacLean and Whitburn 1996) (e.g., 80 is ba-shi, 8-10). However, French uses a partly vigesimal system that is based on expressing some numbers as products of twenty such as quatre-vingt (80) (four-twenty). While the vigesimal system is dominant in Welsh (e.g., 30 is

referred to as 10 on 20) and Danish (e.g., 60 is three twenties), in French some numbers are expressed in base sixty (sexagesimal), such as the sum of 60 and 17 as in *soixante-dix-sept* (sixty-seven-teen) for 77 (See Figure 1).

We suggest that use of different bases to express numbers, such as eight-ten (*ba-shi*) in Chinese versus four-twenty (*quatre-vingt*) in French, changes the numerosity of how these numbers are processed and evaluated. As previously described, “numerosity is the number of units into which a stimulus is divided” (Pelham et al. 1994, p. 103). For example, we can express one year as 365 days or 52 weeks or 12 months. These three measures differ in numerosity so that 365 days, compared to 12 months, is a more numerous way of expressing a year. Literature suggests that “people are especially sensitive to numerosity as a cue for judging quantity” (Pelham et al. 1994, p. 103), so that they may focus on the number of units to evaluate a difference or to judge a quantity, and ignore the size of the unit in which quantitative information is specified (Pandelaere, Briers, and Lembregts 2011; Pelham et al. 1994). This phenomenon is known as the numerosity heuristic (Pelham et al. 1994). Specifically, when a quantity is expressed in more, compared to less, numerous units, individuals are inclined to overestimate the quantity (Pandelaere Briers, and Lembregts 2011; Pelham et al. 1994; Ramonienė and Brazys 2007).

Previous research documents the effect of numerosity in various contexts such as spending in currency exchange situations (Wertenbroch, Soman, and Chattopadhyay 2007), the compression effect, which refers to perception of larger price differences in smaller currencies (Gamble 2006; Marques 1999), and more effort put on achieving the loyalty programs or reward points by consumers, when the medium (e.g., reward points) is more numerous (Nejad and Onay 2014). Despite the fact that all the aforementioned effects include translation of one unit or

quantitative information to another, the effect of numerosity is also observed in evaluations of quantitative information that do not include a preferential target for translation, such as comparative attribute evaluations (Pandelaere et al. 2011). Thus, the effect of numerosity is present in any situation that includes quantitative information relevant to consumer decision making and entails comparison of quantitative options or information (Pandelaere et al. 2011), such as ANB evaluations. Knowing that a higher number of units suggests larger quantities when the size of units is ignored, we expect to see more numerous expression of numbers (e.g., smaller bases such as 10) to lead consumers to evaluate larger differences between the two ANBs. In other words, we expect to observe more numerous systems to lead to increased differences between two numbers, thus the ANBs that contain them. Hence, we propose that linguistic numeral properties (base and non-transparency) influence the numerosity of number comparisons.

Hypothesis 2: Linguistic numeral properties, such as transparent decimal (base 10), compared to non-transparent and vigesimal (base 20), lead consumers to evaluate number (thus ANB) comparisons as being more numerous

Specifically, as previously discussed, use of different bases to express numbers, such as eight-ten (ba-shi) in Chinese (decimal) versus four-twenty (quatre-vingt) in French (vigesimal), makes numbers more or less numerous. For example, let us consider the comparison of the two numbers 20 and 80. In Chinese, which uses a transparent decimal (base 10) system, the quantitative comparison is between two-ten (er-shi) and eight-ten (ba-shi). Hence, from the numerosity perspective, the two numbers differ “six” units of “ten”, which is the base (i.e., the size of the unit). On the other hand, the exact same comparison is between twenty (vingt) and four-twenty (quatre-vingt) in French, which uses a partial-vigesimal system. Thus, from the

numerosity perspective, the two numbers differ “three” units of “twenty”, which is the base (i.e., the size of the unit). That is, the exact same numeric difference of 60 represents a more numerous quantitative information in a decimal system like Chinese (6 units of 10), than in a vigesimal system like French (3 units of 20). Because consumers focus on the number of units instead of the size of units (numerosity heuristic), we expect transparent decimal, compared to vigesimal, system to lead consumers to evaluate larger differences between two numbers, thus ANBs.

Hypothesis 3a: Expression of two ANBs in vigesimal vs. transparent decimal base decreases consumers’ perceived differences between them.

A similar numerosity rationale applies to the effect of non-transparency on consumers’ comparative ANB evaluations. The level of transparency refers to smoothness in correspondence of the number words with the number values (Pixner et al. 2011). For example, “most Asian languages are characterized by a very transparent number word system” such that the number 66 is literally expressed as six-ten-six in Chinese (lio-shi-lio) (Pixner et al. 2011, p. 372). However, most European languages have some irregularities (e.g., 11 is eleven in English, and elf in German) and a new word for each tens digit (e.g., zwanzig in German and twenty in English, instead of two-ten), which make the numeral systems less transparent (Pixner et al. 2011). Chinese has a highly transparent and regular numeral system so that knowing the number words for the first nine digits and the number 10 would be enough to generate all numbers up to one hundred, whereas Turkish and English have a new word for each tens digit (e.g., 20 is “twenty” in English, and “yirmi” in Turkish). English has additional irregularities such as some specific number words that do not follow any rule or standard (e.g., eleven and twelve).

Within the scope of this research, we focus on the existence of a new word for each tens digit, and refer to it as non-transparency, because this type of non-transparency alters the numerosity of numeral systems. Specifically, use of a new word for each tens digit (non-transparency), like base, changes the numerosity of how these numbers are processed and evaluated. For example, let us consider the comparison of the two numbers 20 and 80. As previously described, in Chinese, which uses a transparent decimal (base 10) system, the two numbers differ “six” units of “ten”, because the quantitative comparison is between two-ten (er-shi) and eight-ten (ba-shi). On the other hand, the exact same comparison is between twenty and sixty in English, which uses a non-transparent decimal system. We propose that, this non-transparency decreases the numerosity of the quantitative comparison, because the comparison is “one” unit of “sixty” in English, as opposed to “six” units of “ten” in transparent decimal systems like Chinese. Thus, the exact same numeric difference of 60 represents a more numerous quantitative information in a transparent decimal system like Chinese (6 units of 10), than in a non-transparent decimal system like English (1 unit of 60). Similarly, as opposed to a quantitative comparison in a vigesimal system like French (e.g., twenty vs. four-twenty), a quantitative comparison in a non-transparent decimal system like English (e.g., twenty vs. eighty) is less numerous. Specifically, in a vigesimal system the numbers 20 and 80 differ by “three” units of “twenty”, whereas in a non-transparent decimal system the exact same numeric difference is “one” unit of “sixty”. Because more numerous expression of numbers leads consumers to evaluate larger numeric differences, we propose that non-transparency decreases perceived numeric differences. Formally, we hypothesize:

Hypothesis 3b: Expression of two ANBs in a non-transparent vs. transparent decimal numeral systems decreases the consumers’ perceived differences between them

Hypothesis 3c: Expression of two ANBs in a non-transparent decimal vs. vigesimal numeral systems decreases the consumers' perceived differences between them

“Insert Table 1”

Table 1 summarize how linguistic numeral properties, base and non-transparency, influence numerosity of quantitative comparisons. Because a higher number of units suggests larger quantities when the size of units is ignored, we expect to see an increased perception of quantitative difference in transparent decimal (H3b) and vigesimal numeral systems compared to non-transparent decimal systems (H3c). Additionally, as previously discussed, because quantitative comparisons in transparent decimal systems are more numerous than those in vigesimal systems, we expect to observe an increased perception of quantitative difference in transparent decimal systems compared to vigesimal decimal systems (H3a).

It is important to note that some scholars argue that number words (language) do not affect number processing or underlying representations of numbers, because number words are cultural inventions (Frank, Everett, Fedorenko, and Gibson 2008). However, Pixner and colleagues (2011) focus on the Czech language which has two different number-word systems: non-inverted order (i.e., 25 coded as twenty-five), and inverted order (i.e., 25 coded as five-twenty), to partial out the effect of culture on the comparison of number cognition across languages. They find that, despite the fact that all participants are native Czech speakers and grew up in the same culture; inversion related errors are observed more in transcoding inverted number-words compared to non-inverted number-words (Pixner et al. 2011). This suggests that culture is not the only factor in differences in linguistic number comprehension. Based on this discussion in the literature, we also aim to demonstrate that between-language differences in evaluation of ANBs are not driven by culture but linguistic properties of number words.



We also control for context effects, because the Encoding-Complex Hypothesis suggests that the effect of language on evaluation of ANBs (i.e., comparison of numeric components in ANBs) is stronger in verbal format (Campbell 1994; Campbell and Clark 1992; Campbell and Epp 2004; Colome, Laka, and Sebastian-Galles 2010). It is not known if the format by which consumers are exposed to numbers (e.g., verbal vs. digital) would affect consumers' number cognition in ANBs nor is it known whether any such effects cross language boundaries. Hence, we explore whether verbal versus digital exposure to numbers in ANBs is a prominent context to drive between language differences.

### **Study 1: The Effect of Language (Base) on Number Comparisons**

In support of the Encoding-Complex Hypothesis, but in contrast to Dehaene's Triple Code Model, we aimed to test the effect of language on number comparisons (H1). Specifically, we examined the effect of vigesimal, compared to transparent decimal, numeral systems on consumers' number comparisons. Hence, we tested H1 and H3a, by comparing French, which has a partial vigesimal numeral system, and Chinese, which has a highly regular (transparent) decimal numeral system. Furthermore, we aimed to examine the effect of linguistic numeral systems on consumers' number comparisons in a verbal exposure format: Number words.

The numbers included in our stimulus were 20 and 80. In Chinese both the numbers 20 and 80 are verbalized on base ten as 2 (er) x 10 (shi) , and 8 (ba) x 10 (shi). In French, the number 20 is also verbalized on base ten, but in a non-transparent structure like 20 (vingt). However, diverging from Chinese, in French, 80 is verbalized on base twenty as 4 (quatre) x 20 (vingt), because of the vigesimal system. Hence, from the numerosity perspective the two

numbers differ by 6 units of 10 in Chinese, whereas they differ by 3 units of 20 in French. Consequently, because of an increase in numerosity of the quantitative comparison from 3 units of 20 (French) to 6 units of 10 (Chinese), we anticipate increased evaluations of the numeric difference between the numbers 20 and 80 for Chinese speaking participants compared to French speaking participants.

Because our purpose was to test the effect of linguistic numeral properties on consumers' number comparisons, we conducted an international experiment. A total of 156 undergraduate students participated in a 2 condition (Language: French vs. Chinese) between-subject design experiment to assess the numeric difference between the numbers 20 and 80. Specifically, to examine whether differences in linguistic numeral systems (e.g., difference in numerosity of the quantitative comparison) influences evaluation of numeric differences, we asked participants to evaluate the difference between the numbers “twenty” and “eighty” on a 7-point bipolar scale (1= The difference is very small, 10= The difference is very large). The identical stimulus was presented in two different languages.

### ***Results and Discussion***

Analysis revealed that, in support of H1, language influenced participants' number comparisons. Specifically, participants evaluated a higher numeric difference between the numbers 20 and 80 in Chinese ( $M_{Chinese} = 7.77$ ) than in French ( $M_{French} = 6.17$ ;  $t(154) = 4.40$ ,  $p < .01$ ). In support of the Encoding-Complex Hypothesis, language influences number comparisons. Additionally, this finding also supports H3a, which posits an increasing effect of decimal over vigesimal system on number comparisons. Because the comparison of 20 to 80 is more numerous in a transparent decimal system like Chinese (e.g., 6 units of 10) than in a vigesimal system like French (3 units of 20), participants' evaluation for this numeric difference is higher

in Chinese than in English. However, we do not know how the effect of language on number comparisons manifests itself in a product context when line extensions are labeled with ANBs that include digital numbers. In the next set of studies, we addressed this issue.

## **Study 2: Transparent Decimal versus Vigesimal Systems in Audio Exposure**

The purpose of Study 2 was to test the effect of vigesimal, compared to transparent decimal, numeral systems on consumers' comparative ANB evaluations. Hence, we tested H3a, by comparing French, which has a partial vigesimal numeral system, and Chinese, which has a highly regular (transparent) decimal numeral system. Furthermore, we aimed to examine the effect of linguistic numeral systems on consumers' ANB evaluations in an audio exposure format to the numbers in ANBs.

### ***Study Design***

Appendix A summarizes the linguistic structures of the numbers included in our stimulus. The parent brand was a Dyson EasyDust 22 and the line extension was a Dyson EasyDust 88 vacuum cleaner. As illustrated in Appendix A, in Chinese both the numbers 22 and 88 are verbalized on base ten as  $2 \times 10 + 2$ , and  $8 \times 10 + 8$ . Hence, as previously discussed, from the numerosity perspective the two numbers differ by 6 units of 10. In French, the number 22 is also verbalized on base ten, but in a non-transparent structure like  $20 + 2$ . However, diverging from Chinese, in French, 88 is verbalized on base twenty as  $4 \times 20 + 8$ , because of the vigesimal system. Hence, from the numerosity perspective the numbers differ by 3 units of 20. Consequently, because of a decrease in numerosity of the quantitative comparison from 6 units of 10 (Chinese) to 3 units of 20 (French), we anticipate that this vigesimal system in French will

result in a reduced difference perception between the numbers 22 and 88 for French speaking participants compared to Chinese speaking participants.

An audio advertorial that narrates the existing brand and introduces the line extension was created to provide consumers with the ANBs. The ad did not include any product attribute information but instead emphasized the ANBs. The ad script, shown in Appendix B, was read out loud by a native speaker of each of the two languages. Hence, participants listened to the audio ad. While listening to the ad, participants were exposed to the picture of the vacuum cleaner.

### ***Procedure***

We conducted an international experiment to test consumer reactions to numbers in ANBs in a line extension context. Ninety-three undergraduate students participated in a 2 condition (Language: French vs. Chinese) between-subject design experiment to evaluate a hypothetical new product offering of the Dyson EasyDust Vacuum Cleaner. The identical stimuli were presented in two different languages. Participants were not provided with product specifications or attributes for the products but were initially exposed to audio advertorials that introduced the existing brand and the extension ANBs. The existing brand was Dyson EasyDust 22, and the line extension was Dyson EasyDust 88. Immediately after exposure to the ad, participants were asked to evaluate whether the new product has a higher price on a 201-point sliding scale (-100=The new product is cheaper, +100=The new product is more expensive).

### ***Results and Discussion***

Analysis revealed that, in support of H3a, participants expected a greater price difference between the old and the new Dyson in Chinese ( $M_{Chinese} = 44.67$ ) than in French ( $M_{French} = 33.05$ ;  $t(91) = 2.17, p < .05$ ). Because the quantitative comparison of Dyson 22 to Dyson 88 is more

numerous in a transparent decimal system like Chinese (e.g., 6 units of 10) than in a vigesimal system like French (3 units of 20), participants' comparative number, thus ANB evaluations are higher in a transparent decimal, compared to a vigesimal, system. Furthermore, in support of the Encoding-Complex Hypothesis, this effect of linguistic numeral systems was observed in a line extension ANB context. However, we do not know whether the effect of language on comparative ANB evaluations pertains in digital exposure to numbers. In the next set of studies, we addressed this issue and we also examined the effect of another linguistic property (non-transparency) on consumers' evaluations of ANBs.

### **Study 3: Transparent versus Non-Transparent Decimal Bases in Digital Exposure**

The first purpose of Study 3 was to demonstrate that the effect of linguistic numeral systems, non-transparency, on consumers' ANB evaluations is also observed in digital exposure to numbers in ANBs. The second purpose of Study 3 was to test the effect of non-transparency on consumers' comparative ANB evaluations by comparing a more numerous (Chinese) decimal system and a less numerous (English) decimal numeral system. Hence, we tested H3b, by comparing English, which has a non-transparent decimal numeral system, and Chinese, which has a transparent decimal numeral system.

#### ***Study Design***

The design of Study 3 was similar to that of Study 2, except for the product category, the numbers used in ANBs, and the exposure format to the numbers in ANBs. As illustrated in Appendix A, the existing brand was the TomTom T28 GPS Navigation System and the new line

extension was the TomTom T82 GPS Navigation System. In Chinese, both the numbers 28 and 82 are verbalized in a highly transparent structure so that the number word for 28 is formed as  $2 \times 10 + 8$ , and the number word 82 is formed as  $8 \times 10 + 2$ . However, diverging from Chinese, both the numbers 28 and 82 are verbalized in a non-transparent decimal system in English. In English, as previously described, a new word for each tens digit is required (non-transparency). Therefore, both the numbers 28 and 82 are verbalized in a non-transparent decimal structure so that the number word for 28 is formed as  $20 + 8$ , and the number word for 82 is formed as  $80 + 2$ . Consequently, from the numerosity perspective, a quantitative comparison in a transparent decimal system like Chinese is more numerous (e.g., the difference is 6 units of 10), than in a non-transparent decimal system like English (e.g., the difference is 1 unit of 60). We anticipate higher numerosity of the comparison between the numbers 28 and 82 in Chinese to result in an increased difference perception between the numbers 28 and 82 for Chinese speaking participants compared to English speaking participants. Following Study 2, advertorials that describe the existing brand and introduce the line extension were created to provide consumers with the ANBs. As in Study 2, the ads did not include any product attribute information but instead emphasized the ANBs (See Appendix B for details). Diverging from Study 2, participants read the print ads as displayed in Appendix B. Thus, participants were exposed to the numbers in the ANBs in a digital format.

### ***Procedure***

Seventy-seven undergraduate students participated in an international experiment to evaluate a hypothetical new product offering of the TomTom GPS Navigation System. Similar to Study 2, Study 3 was also in a line extension context, but the print ads included digital numbers in ANBs so that participants were exposed to the numbers in digital formats. Study 3 was a 2

condition (Language: English vs. Chinese) between-subject design experiment, and the same design and stimuli (in the appropriate language) was used in each of the two languages. As in Study 2, participants were not provided with product specifications or attributes for the products but were initially exposed to the print ads as shown in Appendix B. Next, as in Study 2, participants were asked to indicate their comparative price expectation for the line extension as opposed to the parent brand on a 201-point sliding scale (-100= The new product is cheaper, +100= The new product is more expensive).

### ***Results and Discussion***

Non-transparency in decimal systems had an effect on comparative price expectations for the line extension as opposed to the parent brand. Specifically, in support of H3b, the comparative price expectation for TomTom T82, compared to TomTom T28, was higher in Chinese ( $M_{\text{Chinese}} = 51.47$ ) than in English ( $M_{\text{English}} = 39.78$ ;  $t(75) = 1.62$ ,  $p = .055$ ). Specifically, because of the non-transparency in English, using a new word for the tens digit such as twenty and eighty, the numerosity of the quantitative comparison in the ANBs decreased to “one unit” of 60 as opposed to “six units” of 10 in Chinese. Because a higher number of units suggests larger quantities when the size of units is ignored, Chinese speaking participants evaluated an increased difference between the two ANBs compared to English speaking participants. Furthermore, in support of the Encoding-Complex Hypothesis, and in contrast to the Triple Code Model, this effect of linguistic numeral systems was observed despite the fact that participants were exposed to numbers in ANBs in digital formats.

### **Study 4: Vigesimal versus Non-Transparent Decimal Numeral Systems in Number Words**

The purpose of Study 4 was threefold. First, we aimed to test H3c, by comparing French, which has a partial vigesimal numeral system, and English, which has a non-transparent decimal numeral system. Specifically, in Study 4, we examined whether a vigesimal, compared to a non-transparent decimal, numeral system leads to an elevated evaluation of differences between the two ANBs. Second, we addressed whether culture intervenes in the effect of linguistics, and aimed to show that differences in evaluation of ANBs will be observed only for numbers that are structurally different across languages (French and English). Third, in the first set of studies we used price as our main dependent variables because it is a highly quantifiable proxy for product quality (Riesz 1978; Zeithaml 1988), and it provides the most important implications for brand extensions context. However, one might argue that perceptions of differences in prices might have socio-cultural underpinnings. To further rule out this possibility we used a more objective product quality outcome as the dependent variable to measure the difference in consumers' product perceptions. Finally, we aimed to examine the effect of language on consumers' ANB evaluations in another verbal exposure format: Number words.

As previously discussed, Dehaene's Triple Code Model suggests that ANB comparisons should not be influenced by the language, because number comparisons are performed in analog magnitude representation (e.g., representation of numbers on mental number line) (Dehaene 1992; Dehaene and Cohen 1995; Colome, Laka, and Sebastian-Galles 2010). However, we do not know whether ANB comparisons in number-word format (i.e., verbal) are influenced by language. Consequently, we test the effect of the vigesimal versus non-transparent numeral system on consumers' ANB evaluations in a print ad setting so that participants are exposed to the numbers as number words. In other words, we used number words as a proxy for verbal representation of number processing in comparative ANB evaluations.



## *Study Design*

Appendix A summarizes the linguistic structures of the numbers included in our stimulus. The parent brand was Sony CyberShot twenty-seven (27) and the line extension was Sony CyberShot eighty-seven (87) in the difference condition; whereas the parent brand was Sony CyberShot thirty-eight (38), and the line extension was Sony CyberShot sixty-eight (68) in the no difference condition. The numbers in ANBs were provided to participants in number-word formats. As illustrated in Appendix A, in English both the numbers 27 and 87 are verbalized on a non-transparent base ten structure such as  $20 + 7$ , and  $80 + 7$ . Hence, as previously described, the numerosity of this quantitative comparison is 1 unit of 60. Similar to English, in French the number 27 is also verbalized on base ten as  $20 + 7$ . However, diverging from English, in French 87 is verbalized on base twenty as  $4 \times 20 + 7$ , because of the vigesimal system. Thus, the numerosity of this quantitative comparison is 3 units of 20. Consequently, because of an increase in numerosity of the comparison between the numbers 27 and 87 in French (e.g., 3 units of 20), compared to English (e.g., 1 unit of 60), we anticipate an elevated difference perception between the numbers 27 and 87 for French speaking participants compared to English speaking participants. On the other hand, in terms of the number word structures, neither of the numbers 38 or 68 is different in English and in French. Specifically, the number 38 is verbalized on a non-transparent decimal system both in English and in French (i.e.,  $30 + 8$ ). Similarly, the number 68 is also verbalized on a non-transparent decimal system both in English and in French (i.e.,  $60 + 8$ ). Accordingly, we do not anticipate any between language differences for the number pair of 38 and 68; whereas we anticipate between language differences for the number pair 27 and 87. Therefore, the number pair 27 – 87 is referred as “difference condition” whereas the number pair 38 – 68 is referred as the “no difference condition”.

As in Study 3, print advertorials that narrate the existing brand and introduce the line extension were created to provide consumers with the ANBs. The ads did not include any product attribute information but instead emphasized the ANBs, which were formed with number words. (See Appendix B for details).

### ***Procedure***

We conducted an international experiment to test consumer reactions to numbers in ANBs in a line extension context. Two hundred and three undergraduate students participated in a 2 (Number pair: difference vs. no difference) x 2 (Language: French vs. English) between-subject design experiment to evaluate hypothetical new product offerings of the Sony CyberShot Camera. The identical stimuli were presented in two different languages. Participants were not provided with product specifications or attributes for the products but were initially exposed to print advertorials that introduced the existing brand and the extension ANBs that were formed with number words. The existing brand was Sony CyberShot twenty-seven, and the line extension was Sony CyberShot eighty-seven in the difference condition, whereas the existing brand was Sony CyberShot thirty-eight, and the line extension was Sony CyberShot sixty-eight in the no difference condition. Immediately after exposure to the ads, participants were exposed to a picture that was supposedly taken with the existing Sony camera, and shown a set of 4 photographs with varying levels of quality. These 4 photographs with varying levels of quality were used to examine evaluations of extension quality compared to the existing brand. The photographs were created by altering the pixels, and ordered in quality levels of better, equal, worse, and much worse in comparison to the quality of the photograph supposedly taken with the existing Sony. Participants were asked to select the picture that they believed was taken by the

line extension. Hence, the dependent variable was the reflection of numeric differences in ANBs to non-numeric differences in quality perceptions of photographs.

## ***Results***

Initially, to evaluate participants' quality perceptions for the line extension, compared to the parent brand, the photographs were coded in ascending order of quality from 1 to 4, where higher values corresponded to higher perceived image quality. Although the main effect of language on quality perceptions was not significant ( $F(1, 199) = 1.79, p = .18$ ), the interaction effect of language and number pair was significant on participants' comparative quality judgments ( $F(1, 199) = 4.58, p < .05$ ). In support of H3c, French-speaking participants expected a higher quality ( $M_{French} = 3.78$ ) for the new Sony camera than did English-speaking participants ( $M_{English} = 3.49$ ) in the difference condition (27-87 number pair) ( $t(199) = 2.58, p < .05$ ). However, in the no difference condition (38-68 number pair), the perceived quality for the new Sony was not significantly different between French- and English-speaking participants ( $M_{French} = 3.81, M_{English} = 3.88; t(199) = -.54, p = .59$ ).

## ***Discussion***

The results of Study 4, like the previous studies, suggest that, in support of H1, linguistic numeral systems lead to variations in perceived differences between ANBs. Specifically, in support of H3c, a vigesimal digit structure (i.e., French), compared to a non-transparent decimal digit structure (i.e., English) induces French-speaking participants to perceive the new product as higher quality, compared to the existing brand, than English-speaking participants do. Verbalization of the number word “eighty” as “four-twenty” in the partial vigesimal numeral system of French, compared to the non-transparent decimal numeral structure in English (eighty), leads consumers to perceive an increased difference between the two ANBs (Sony

CyberShot 27 versus Sony CyberShot 87). Because the comparison of the two ANBs is more numerous in a vigesimal system like French (“three units” of 20) compared to a non-transparent decimal system like English (“one unit” of 60), consumers perceive a larger quality difference between the two ANBs. More importantly, these between-language differences were not observed when the numbers in ANBs are not linguistically different between French and English. Specifically, because the numbers 38 and 68 are not different in terms of linguistic numeral properties in English and in French, the non-numeric quality perception was not significantly different between these two languages when the ANBs were formed with the numbers 38 and 68. This result suggests between-language differences are not simply driven by socio-cultural differences but linguistic differences of numeral systems. Finally, the results of Study 4 suggest that language influences consumers’ comparative ANB evaluations, when they are exposed to numbers in number-word (verbal) form. Thus, the results of the aforementioned studies suggest that the effect of language on comparative number, consequently ANB, evaluations is robust across exposure formats such as audio, digital and number words.

### **Study 5: Numerosity within English**

Studies 1, 2, 3 and 4 provided evidence for H1, and H3 (H3a, H3b and H3c), which are based on the numerosity of the numeral systems, by demonstrating the effect of linguistic numeral properties on consumers’ comparative ANB evaluations. Thus, our next step was to test H2, by exploring whether linguistic numeral properties influence consumers’ evaluation of numerosity for quantitative comparisons. Specifically, as previously discussed, we propose that when quantitative comparisons get more numerous as a result of the linguistic numeral properties (e.g., base and non-transparency) consumers evaluate larger differences in quantitative

comparisons, thus in comparative ANB evaluations. Hence, the purpose of Study 5 was to explore the effect of variations in numeral structures on consumers' evaluation of quantitative comparisons.

### ***Study Design and Procedure***

In Study 5, we tested the effect of numerosity in a within language (English) quantitative comparison context. Hence, in Study 5 we presented participants two digital numbers in the mathematical structure that reflects the verbalization of these numbers in English or in French or in Chinese numeral system depending on their condition; and asked them to evaluate the difference between the two numbers, 20 and 80. Appendix B illustrates how participants were exposed to these numbers depending on their condition. For example, in the French structure condition, participants were exposed to the numbers 20 and 80 as 20 and 4x20, because the numbers 20 and 80 are verbalized as “vingt” (twenty) and “quatre-vingt” (four-twenty) in French (vigesimal base). Similarly, in the Chinese structure condition, participants were exposed to the two numbers as 2x10 and 6x10, because the numbers 20 and 80 are verbalized as “er-shi” (two-ten) and “ba-shi” (eight-ten) in Chinese (transparent decimal base). Finally, in the English structure condition participants were simply exposed to the numbers as 20 and 80, because these numbers require a new word for the tens digit such as “twenty” and “eighty” (non-transparent decimal base). To measure how numerous participants perceive this quantitative comparison across different conditions, we created three options of answers, one of which participants were asked to select. The exact same numeric difference of sixty was displayed as 6x10 (Chinese structure) and 3x20 (French structure) and 60 (English structure), ranging from the most numerous to the least numerous in the three options. (See Appendix B for the details of the stimulus)

One hundred and fifty-five undergraduate students at a Northeastern University participated in a 3 condition (Linguistic numeral structure: English vs. French vs. Chinese) between-subject experiment. As previously discussed, participants were exposed to the number pair of 20 and 80 in the mathematical structure that reflects the linguistic numeral property depending on their condition, and were asked to select the option that best describes the difference between the two numbers. We expected participants in the Chinese structure condition to mostly select the option 6x10; participants in the French structure condition to mostly select the option 3x20; and the participants in the English structure condition to mostly select the option 60. Study 5 was a within language (English) study.

### ***Results and Discussion***

Because the dependent variable was a choice among three options (A= 6x10, B= 3x20, and C= 60) and the independent variable, which was the experimental condition (English structure, French structure, Chinese structure), was also discrete, we initially ran Multinomial Logit Analysis to understand relative choice shares of the options (A, B, and C) across conditions (Chinese, French, and English). Analysis revealed that, the relative choice share of 3x20 over 60 was significantly higher in the French condition than in the English condition (Wald  $\chi^2 = 10.86$ ,  $p < .01$ ); and the relative choice share of 3x20 over 6x10 was significantly higher in the French condition than in the Chinese condition (Wald  $\chi^2 = 13.56$ ,  $p < .01$ ). Finally, the relative choice share of 60 over 6x10 was significantly higher in the English condition than in the Chinese condition (Wald  $\chi^2 = 7.43$ ,  $p < .01$ ). As illustrated on Table 2, 42.2% of the participants who chose 60 over 3x20 and 6x10 were in the English condition; 62.9% of the participants who chose 3x20 over 60 and 6x10 were in the French condition; and 77.8% of the

participants who chose 6x10 over 3x20 and 60 were in the Chinese condition ( $\chi^2 = 33.98, p < .01$ ).

The results of Study 5 provide preliminary evidence for the numerosity argument by showing that how consumers are exposed to quantitative comparisons (e.g., numeral structures) influences how they perceive the numeric difference (e.g., numerosity). Specifically, these results suggest that, when consumers are exposed to the numbers 20 and 80 in a vigesimal numeral structure (20 vs. 4x20), they evaluate the numeric difference to be 3 units of 20. Similarly, when consumers are exposed to this number pair in a transparent decimal system (2x10 vs. 8x10), they perceive the numeric difference to be 6 units of 10. Finally, when consumers are presented these numbers in a non-transparent decimal structure they evaluate the numeric difference to be 60. Hence, how numbers in a quantitative comparison task are structured influences consumers' evaluation of how numerous the difference between the two numbers is. To increase the generalizability and robustness of our findings, our next step is to show a similar influence of how numeric comparisons are structured on consumers' evaluation of numeric differences in a between language context.

The findings of Study 5 provided preliminary evidence on the effect of numeral structures on consumers' evaluation of numerosity in quantitative comparisons. Specifically, in Study 5, we used a proxy for linguistic numeral systems by creating three conditions that mimic the numeral structures in the three languages, which are English, Chinese and French. This issue is addressed in Study 7. Particularly, instead of mimicking the linguistic structures like 20 vs. 4x20 for French, and 2x10 vs. 6x10 for Chinese, In Study 7 we ask French or English speaking participants to evaluate the difference between the numbers 20 and 80 by choosing one of the three options: A) 60, B) 3x20, C) 6x10.

## **Study 6: Number Processing Fluency?**

We showed the effect of linguistic numeral systems such as differences in bases (vigesimal system) (H3a), and effects of non-transparency (H3b and H3c) on consumers' ANB evaluations in studies 2, 3, and 4. We based our hypotheses on the numerosity argument, which suggest that when quantitative comparisons get more numerous, consumers evaluate larger differences. Specifically, we proposed that linguistic numeral properties make numeral systems, thus numeric comparisons, more or less numerous (H2), which results in variations in comparative ANB evaluations. We tested this assumption in a within language context in Study 5. However, one can argue that number processing fluency drives the results. Specifically, these linguistic numeral properties such as vigesimal (four-twenty) and transparent decimal (eight-ten) might complicate or ease number processing, as opposed to non-transparent decimal systems (eighty). For example, considering the results of Study 4, one might argue that the comparison of the numbers 27 and 87 might be easier in French (twenty-seven vs. four-twenty-seven) than in English (twenty-seven vs. eighty-seven). Specifically, extant literature suggests that larger bases, such as vigesimal, can facilitate number processing, because they are efficient for constructing big numbers (Zhang and Norman 1995). Hence, especially when forming the number words as products or sums of twenties, vigesimal compared to decimal, numeral systems can influence consumers' ability to compare ANBs formed with the numbers 20 and 80 (e.g., mathematically  $4 \times 20$ ). Consequently, this expression of "four-twenty" (quatre-vingt) in French might result in an ease of number processing when comparing the two ANBs formed with these numbers. According to the ease-of-computation effect, which suggests that when it is easier to evaluate if



the two numbers are apart, they are evaluated as being further apart (Thomas and Morwitz 2009), this increase in number processing fluency might lead to increased perceptions of differences between the two ANBs formed with these numbers. Hence, the purpose of Study 6 was to test this theorization to rule out an alternative explanation, number processing fluency.

### ***Study Design and Procedure***

Appendix B summarizes the details of the stimuli. Similar to Study 1, we did not use any brand names and ask for participants' brand evaluations. Instead we explored participants' number processing and quantitative comparisons. Similar to Study 5, Study 6 was also a within language study, and we mimicked the numeral structures of the languages. Specifically, to explore participants' quantitative comparisons, we presented participants two digital number pairs in the mathematical structure that reflects the verbalization of these numbers in either English or French numeral system; and asked them to evaluate the difference between the two numbers for both of the number pairs. The number pairs were  $27 - 87$  and  $26 - 83$ . In the English numeral structure condition, participants were exposed to the numbers in the mathematical notation that reflects the non-transparent decimal numeral structure, such as  $20 + 7$  vs.  $80 + 7$ ; and  $20 + 6$  vs.  $80 + 3$ . In the French numeral structure, which uses a vigesimal base for these number pairs, condition, participants were exposed to the numbers in the mathematical notation that reflects the vigesimal numeral structure, such as  $20 + 7$  vs.  $4 \times 20 + 7$ ; and  $20 + 6$  vs.  $4 \times 20 + 3$  (See Appendix B for details).

We conducted a within language (English) experiment to test the effect of linguistic numeral properties on number processing fluency and quantitative comparisons. Sixty-nine undergraduate participants at a Northeastern University participated in a 2 condition (Linguistic numeral structure: English vs. French) between-subject experiment to evaluate the aforementioned number pairs. In the English (French) structure condition, participants were

initially exposed to the number pair  $20 + 7$  vs.  $80 + 7$  ( $20 + 7$  vs.  $4 \times 20 + 7$ ), and were asked to indicate their evaluation for the difference between the two numbers on a 10-point bipolar scale (1= The difference is very small, 10= The difference is very large). Participants followed the same procedure for the number pair  $26 - 83$ . To understand the effect of linguistic numeral structures on participants' number processing fluency, we measured the time (in seconds) that they spent on evaluation of the difference between the two numbers for both of the number pairs.

### ***Results and Discussion***

Analysis revealed that participants evaluated a larger difference between the two numbers for both of the number pairs ( $27 - 87$ , and  $26 - 83$ ) in the French structure condition ( $M_{French\_27-87} = 8.09$ ,  $M_{French\_26-83} = 7.8$ ) than in the English structure condition ( $M_{English\_27-87} = 6.56$ ;  $t_{27-87} (67) = -3.34$ ,  $p < .01$ ;  $M_{English\_26-83} = 6.44$ ;  $t_{26-83} (67) = -2.91$ ,  $p < .01$ ). These results support the findings of the previous studies. Specifically, a vigesimal (e.g., French structure) compared to a non-transparent decimal (e.g., English structure) numeral system resulted in elevated quantitative comparisons. Besides, unlike previous studies, in Study 6 the effect of numeral properties on quantitative comparisons was observed in a within-language context (English), which also suggests that the aforementioned results cannot be attributed to sociocultural differences. To test the effect of linguistic numeral structure on number processing fluency, we did natural log transformation on the time spent on participants' evaluation of difference between the two numbers, because the distribution of the time measure was right skewed (Howell 2007; Tabachnick and Fidell 2007). For the number pair  $26 - 83$ , time spent for the evaluation of the difference between the two numbers was not statistically different ( $M_{French\_26-83} = 2.21$ ,  $M_{English\_26-83} = 2.06$ ;  $t_{26-83} (67) = -1.02$ ,  $p > .1$ ). More interestingly, participants spent more time in evaluation of the difference between the two numbers for the number pair  $27 - 87$  in the

French structure condition ( $M_{French\_27-87} = 2.96$ ) than in the English structure condition ( $M_{English\_27-87} = 2.53$ ;  $t_{27-87} (67) = -3.16, p < .01$ ). This result suggests that participants processed the number comparison more fluently in the English structure than in the French structure. According to the ease-of-computation effect, when it is easier to evaluate if the two numbers are apart, they are evaluated as being further apart (Thomas and Morwitz 2009). Hence when processing fluency in number comparisons is high (e.g., time spent to evaluate numeric differences is low), participants are expected to evaluate larger differences. However, the results of Study 6 display a different pattern. Specifically, although time spent to evaluate the numeric difference for the number pair 27 – 87 in the English condition was lower than that in the French condition, in contrast to the ease-of-computation effect, participants perceived smaller numeric differences in the English structure condition compared to the French structure condition. In other words, despite the fact that number processing fluency for quantitative comparisons was higher in the English structure than in the French structure, participants did not evaluate larger, but a smaller numeric difference in the English structure compared to the French structure.

Results of Study 6 not only increase the robustness of our findings by showing the effect of linguistic numeral structures on quantitative comparisons in a within language design and in a general number comparison context, but also shed light onto the mechanism. Specifically, we rule out the alternative explanation that suggests number processing fluency as the underlying mechanism for the effect of linguistic numeral properties on consumers' comparative number, thus ANB evaluations.

### ***Consumer Characteristics: Numeracy and Need for Cognition***

Individuals are different in terms of how they understand and evaluate numeric information (Peters et al. 2007; Weller, Dieckmann, Tusler, Mertz, Burns, and Peters 2013), and

how they approach and execute cognitive information, which we argue includes comparison of numbers in ANBs, (Cacioppo and Petty 1982). The former of these individual differences, which will be reflected as consumer characteristics in ANB evaluations, is numeracy, whereas the latter one is need for cognition. Although, making a decision generally involves evaluation of numeric information, and therefore some level of mathematical skills, consumers' ability to perform these tasks vary (Peters et al. 2007; Weller et al. 2013). The effect of individual differences in numeracy has been an extensively researched area in medical and health related decision making in terms of understanding the risks and benefits of medical treatments (Fagerlin et al. 2007; Lipkus, Samsa, and Rimer 2001; Lipkus and Peters 2009). To measure numeracy, researchers have developed and used various scales, such as objective scales that require individuals to perform mathematical tasks and probabilistic assessments (Schwartz, Woloshin, Black, and Welch 1997; Lipkus Samsa, and Rimer 2001; Weller et al. 2013), and subjective scales that measure one's evaluation of his or her own perceived mathematical skills (Fagerlin et al. 2007).

We utilize the Subjective Numeracy Scale (See Appendix A) to measure consumers' perceived numeracy. We do this for three conceptually and empirically grounded reasons. First, because individuals perform mathematical computations and risk or probability related percentage analysis in objective numeracy measures, the effect of national education system can interfere with the effect of linguistic irregularities of numeral systems. Specifically, literature suggests an effect of national education system on acquisition of certain mathematical skills (Vasilyeva, Laski, Ermakova, Lai, Jeong, and Hachigian 2015). For example, it is known that Asian and European school students generally outperform American school students in mathematics (Mullis, Martin, Foy and Arora 2012; Stevenson, Chen, Lee 1993; Vasilyeva et al. 2015). Second, the literature documents a high correlation between objective numeracy measures

and the Subjective Numeracy Scale (SNS) (Fagerlin et al. 2007; Zickmund-Fisher et al. 2007). This finding implies that the SNS sufficiently represents both subjective and objective numeracy. Third, prior research suggests that mathematical computations can be very intimidating for a non-negligible number of participants so that individuals are unwilling to complete the objective scales and/or desire to use calculators which can confound the results (Fagerlin et al 2007). Consequently, to minimize the effects of nationality and/or culture that may confound the effect of language on consumers' ANB evaluations; we use perceived numeracy (SNS), and propose that it moderates the relationship between linguistics irregularities of numeral systems and consumers' ANB evaluations. Specifically, because consumers who are high in perceived numeracy are better at numeric tasks such as comparing the numbers in ANBs than are consumers who are low in perceived numeracy, these consumers' ability to make number comparisons should be influenced by the linguistic irregularities of numeral systems less than those who are low in perceived numeracy. Formally, we posit:

Hypothesis 4: The effect of linguistic properties of numeral systems on consumers' ANB evaluations is weaker for consumers with high subjective numeracy than for consumers with low subjective numeracy

Despite the fact that perceived numeracy is based on individuals' perception of their own numerical skills, one might still argue that any form of numeracy may be influenced by the national education system which might confound the effect of language on consumers' ANB evaluations. Therefore, we incorporate need for cognition (NFC), which is "a stable and chronic individual difference" (Olsen, Samuelsen, and Gaustad 2014, p. 1066) as a moderator into the conceptual framework. "NFC captures the fact that some people engage in and enjoy thinking more than others do" (Olsen, Samuelsen, and Gaustad 2014, p. 1066). Specifically, individuals

with high NFC, compared to those with low NFC, are more willing to engage in effortful cognitive processing, an example of which can be comparison of the numbers in ANBs (Cacioppo and Petty 1982). Because consumers with high NFC will invest more effort in processing numeric differences in line extension ANBs than consumers with low NFC will, we expect high NFC to be a boundary condition to the effect of linguistic irregularities on consumers' ANB evaluations. Formally, we propose that:

Hypothesis 5: The effect of linguistic properties of numeral systems on consumers' ANB evaluations is weaker for consumers with high NFC than for consumers with low NFC.

### **Study 7: The Same Culture with Two Different Languages and Consumer Characteristics**

Studies 2, 3 and 4 demonstrated the effect of linguistic numeral systems on consumers' quantitative comparisons in the context of comparative ANB evaluations. Studies 5 and 6 shed light on the process. Specifically, the results of Study 5 showed that the linguistic numeral structures influence how numerous consumers evaluate quantitative comparisons. Moreover, Study 6 ruled out the alternative explanation of number processing fluency, which could be argued to drive the effect of linguistic numeral structures on consumers' quantitative comparisons, thus comparative ANB evaluations. The purpose of Study 7 was threefold. First, we aimed to test the effect of consumer characteristics on the influence of language on consumers' comparative ANB evaluations (H4 and H5). Additionally, in the aforementioned international studies we did not collect any demographic information that could help us understand differences, if any, in consumer profile. Hence, in Study 7, we controlled for consumer demographics. Second, we aimed to formally test H2, which posits the effect of

linguistic numeral systems on numerosity of comparative number, thus ANB evaluations, in a between-language context. Finally, although in Study 4 we demonstrated that the between language differences are not observed when the numerals are not structurally different between the two languages, we aimed to further rule out the potential effect of socio-cultural differences on quantitative comparisons in a more theoretically sound design. Specifically, we ran Study 7 with Canadian (Quebec) participants who share the same culture, but are asked to comparatively evaluate two ANBs in two different languages, French and English. Hence, another purpose of Study 7 was to test H3c (vigesimal vs. non-transparent decimal numeral structures) with bilingual Canadian participants.

### ***Study Design***

The stimulus of Study 7 was almost identical to that in the difference condition of Study 4 (See Appendix A for details). Specifically, the parent brand was Sony CyberShot 27 (twenty-seven) and the line extension was Sony CyberShot 87 (eighty-seven). Diverging from Study 4, participants were exposed to the numbers in the ANBs in digital format. As previously described, the numerosity of the quantitative comparison of  $20 + 7$  to  $80 + 7$  is 1 unit of 60. On the other hand, the numerosity of the quantitative comparison of  $20 + 7$  and  $4 \times 20 + 7$  is 3 units of 20. Because of this increase in numerosity of the comparison between the numbers 27 and 87 in French (e.g., 3 units of 20), compared to English (e.g., 1 unit of 60), we anticipate an elevated difference perception between the numbers 27 and 87 for French speaking participants compared to English speaking participants. As in previous studies, print advertorials that narrate the existing brand and introduce the line extension were created to provide consumers with the ANBs. The ads did not include any product attribute information but instead emphasized the ANBs, which were formed with digital numbers. (See Appendix B for details).

### ***Procedure***

A total of 210 Canadian Qualtrics panel workers participated in a 2 condition (Language: French vs. English) between-subjects design experiment to evaluate hypothetical new product offerings of the Sony CyberShot Camera. The identical stimuli were presented in two different languages. Diverging from the previous studies, initially participants were asked to confirm that they were from Quebec, where most of the residents speak English and French fluently. Participants confirming that they were from Quebec were asked to select the language (English or French) that they spoke most fluently. Participants were exposed to these two questions both in English and in French. Next, depending on their selection of language, participants were assigned one of the two conditions: English or French. In other words, participants who selected English (French) as their most fluent language took the questionnaire in English (French). As in the previous studies, participants were initially exposed to print advertorials that introduced the existing brand and the extension ANB that were formed with digital numbers. The existing brand was Sony CyberShot 27, and the line extension was Sony CyberShot 87. After exposure to the ad, participants were asked to evaluate the new versus the old brands on multiple dimensions. Specifically, participants were asked to assess whether the new product has higher quality on a 10-point sliding scale (1= CyberShot 27 has lower quality, 10= CyberShot 87 has higher quality). Next, diverging from the previous studies, we measured participants' behavioral intentions (willingness to purchase) resulting from linguistic numeral structures. Particularly, participants were asked to indicate which brand they would buy on a 10-point bipolar scale (1= Definitely CyberShot 27, 10= Definitely CyberShot 87). Then, as in Study 4, participants were exposed to a picture that was supposedly taken with the existing Sony camera, and shown a set of 4 photographs with varying levels of quality. Participants were asked to select the picture that they believed was taken by the line extension.



Next, as in Study 5, we asked participants to evaluate the difference between the numbers 20 and 80 by choosing one of the three options: A) 60, B) 3x20, C) 6x10. We expected a maximum choice ratio of (i) 60 for English speaking participants, and (ii) 3x20 for French speaking participants. As in Study 6, to rule out the alternative explanation of number processing fluency, we asked participants to calculate the numeric difference between the numbers 27 and 87, and measured the time participants spent on this question. Finally, participants were asked to answer questions on individual differences and demographics. Specifically, in a departure from previous studies, to test the effects of differences in individual characteristics (H4 and H5), we measured participants' numeracy using Fagerlin et al.'s SNS (Subjective Numeracy Scale) (See Appendix C for the scale items) (2007), and NFC using Cacioppo and Petty's 18 item Need for Cognition Scale (1982). Participants were also asked to answer a series of demographic questions such as age, gender, and their native language.

## ***Results***

*Sample characteristics.* 51.4% of the sample consisted of females, and the average age of the sample was 46 ( $M_{\text{Age\_French}} = 48.77$ ,  $M_{\text{Age\_English}} = 43.50$ ;  $t_{\text{age}}(208) = -2.5$ ,  $p < .05$ ). Average subjective numeracy ( $M_{\text{Numeracy}} = 4.18$ ; Cronbach's Alpha = .85) and average need for cognition (NFC) ( $M_{\text{NFC}} = 4.98$ ; Cronbach's Alpha = .78) for the sample were above the median.

*Effect of language on numerosity and comparative ANB evaluations.* As in Study 4, the photographs were coded in ascending order of quality from 1 to 4, where higher values corresponded to higher perceived image quality. In support of H3c, as in Study 4, French-speaking participants expected a higher quality ( $M_{\text{French}} = 3.68$ ) for the new Sony camera than did English-speaking participants ( $M_{\text{English}} = 3.37$ ;  $t(208) = -2.7$ ,  $p < .01$ ). A similar pattern was also observed in comparative quality judgments. Specifically, participants in the French

condition ( $M_{French} = 8.11$ ) evaluated a higher quality for the Sony CyberShot 87 as opposed the Sony CyberShot 27 than participants in the English condition ( $M_{English} = 7.50$ ;  $t(208) = -2.56, p < .05$ ). Regarding willingness to purchase, which is a behavioral intention unlike previous measures, participants were more willing to purchase the line extension in comparison to the parent brand in the French condition ( $M_{French} = 8.25$ ) than in the English condition ( $M_{English} = 7.33$ ;  $t(208) = -3.51, p < .01$ ). Finally, to demonstrate the effect of linguistic numeral systems on how numerous number comparisons are evaluated, as in Study 5, we ran a multinomial logit by including Numeracy and NFC as covariates. Diverging from Study 5, we tested the effect of language on numerosity in a between-language context. Analysis revealed that, after controlling for Numeracy and NFC, the relative choice share of 3x20 over 60 was significantly higher in the French condition than in the English condition (Wald  $\chi^2 = 5.03, p < .05$ ); and the effects of Numeracy and NFC were also significant (Wald\_Numeracy  $\chi^2 = 4.98, p < .05$ ; Wald\_NFC  $\chi^2 = 5.75, p < .05$ ). Interestingly, the effects of Numeracy and NFC on the relative choice of 3x20 over 60 were in the opposite direction. On one hand, with one unit of increase in Numeracy, the multinomial log-odds of choosing 3x20 over 60 decreased by .38 unit after controlling for the language (Wald\_Numeracy  $\chi^2 = 4.98, p < .05$ ). On the other hand, with one unit of increase in NFC, the multinomial log-odds of choosing 3x20 over 60 increased by .47 unit after controlling for the language (Wald\_NFC  $\chi^2 = 5.75, p < .05$ ). As illustrated on Figure 2, analysis revealed that 57.8% of the participants who chose 60 over 3x20 and 6x10 were in the English condition; and 56.7% of the participants who chose 3x20 over 60 and 6x10 were in the French condition ( $\chi^2 = 10.74, p < .01$ ).

*Number processing fluency as the process.* As in Study 6, we did a natural log transformation on the time spent on participants' evaluation of numeric difference between the

two numbers, because the distribution of the time measure was right skewed (Howell 2007; Tabachnick and Fidell 2007). Similar to Study 6, analysis revealed that number processing fluency is not the underlying mechanism for the effect of language comparative number evaluations. Specifically, time spent for the evaluation of the difference between the two numbers was not statistically different between the English ( $M_{English} = 2.72$ ) and the French conditions ( $M_{French} = 2.58$ ;  $t(208) = 1.48, p > .1$ ). Hence, we replicated the result of Study 6 in a between-language experiment.

*Moderating role of numeracy and NFC.* To test the moderating role of Numeracy and NFC, we used 5,000 bootstrap samples with bias-corrected 95% confidence estimates (i) for each moderator separately (PROCESS-Model 1, Hayes 2013); and (ii) for both of the moderators simultaneously (PROCESS-Model 2, Hayes 2013). Willingness to purchase, picture quality, and quality judgments served as the dependent variables, NFC and numeracy as the moderators and the linguistic numeral properties (language) as the predictor variable. Table 3 and Table 4 summarize the results. Specifically, neither NFC nor Numeracy moderated the relationship between linguistic numeral systems (Language: English vs. French) on comparative ANB evaluations such as willingness to purchase, picture quality and quality judgments. Specifically, the bootstrap confidence intervals for the moderating effects of NFC and Numeracy included zero in Model 1 (See Table 3). Similarly, the bootstrap confidence intervals for the moderating effect of NFC and Numeracy (simultaneously) included zero in Model 2 (See Table 4). Hence, we provided statistical support for neither H4 nor H5.

### *Discussion*

The results of Study 7, in addition to providing statistical support for the effect of linguistic numeral properties on comparative ANB evaluations (H1) like the previous studies,

demonstrated that this effect is not driven by socio-cultural in a very sound setting. Specifically, we replicated the effect of language on comparative number evaluations with participants from Quebec, where they share the same socio-cultural values but speak two different languages, English and French. The findings of Study 7 rule out the potential effect of socio-cultural differences on quantitative comparisons. Additionally, the results of Study 7 provide further information regarding the mechanism for the effect of language on consumers' comparative ANB evaluations. Specifically, as in Study 5, consumers perceive the numeric comparison (20 vs. 80) to be more numerous when they are exposed to these numbers in French (3x20) than in English (60). Hence linguistic numeral systems influence how numerous consumers perceive quantitative comparisons. Knowing that when a quantity is expressed in more, compared to less, numerous units, individuals are inclined to overestimate the quantity (Pandelaere et al. 2011; Pelham et al. 1994; Ramonienė and Brazys 2007), we suggest that variations resulting from base and non-transparency in numerosity influence consumers' comparative number, thus ANB evaluations. This suggestion is also supported by the results; because the comparison of the two ANBs is more numerous in a vigesimal system like French (3x20) compared to a non-transparent decimal system like English (1x60) (H3c), consumers perceive larger differences between the two ANBs on multiple dimensions, such as picture quality, willingness to purchase and quality judgments.

Another interesting finding in Study 7 is the opposing effects of Numeracy and NFC on how numerous number comparisons are evaluated. On one hand, increases in Numeracy, which refers to one's perceived efficacy in numerical tasks, lead to a decrease in how numerous quantitative comparisons are evaluated. On the other hand, increases in NFC, which refers to how much an individual prefers to put cognitive effort in decision making, lead to an increase in

how numerous quantitative comparisons are evaluated. Hence two consumer characteristics that capture how consumers cognitively evaluate numeric information influence how numerous consumers evaluate quantitative comparisons. This finding could be an interesting future research avenue to further explore.

Moreover, as in Study 6, the results show that number processing fluency is not the underlying mechanism for the effect of language comparative number evaluations, because the time spent on evaluation of the numeric difference between 27 and 87 is not different between English and French. Hence, the results of Study 7 strengthen our numerosity approach by replicating the findings in Study 5 and Study 6 in a between-language design.

We do not find that Numeracy and NFC moderate the effect of language on comparative ANB evaluations. This result implies that the effect of language on number processing is so strong that it is not influenced by consumer characteristics, such as Numeracy and NFC, which can potentially influence number processing. Although the results do not provide statistical support for H4 and H5, they still increase the robustness of our findings. Specifically, the effect of language on comparative ANB evaluations is replicated with multiple dependent measures one of which is willingness to purchase. This result suggests that the effect of language on numerosity influences behavioral intentions as well as consumer evaluations.

## **General Discussion**

This research contributes to the growing literature on ANBs, numerical cognition, and numerosity by providing a unique psycholinguistic angle that may have strong managerial implications especially in the global marketing domain. First, we demonstrate that differences in

linguistic numeral properties that alter the numerosity of quantitative comparisons, such as different bases (e.g., vigesimal vs. decimal), and non-transparency (e.g., a new word for each tens digit), influence consumers' ability to make comparative ANB evaluations. Second, we controlled for the role of a contextual factor (e.g., exposure format to the numbers in ANBs) in the effect of language on consumers' ANB evaluations, and found that between language differences are prominent both in verbal (e.g., audio and number words) and digital (e.g., Arabic) exposure to the numbers in ANBs. Finally, by showing that the between-language differences are observed only when linguistic numeral structures are different between the languages, and by replicating between-language results with Canadian participants, who share the same culture yet speak two different languages (English and French), we provide evidence that our findings are due to differences in linguistic numeral systems as opposed to socio-cultural differences. Specifically, some scholars argue that number words (language) do not affect number processing or underlying representations of numbers, because number words are cultural inventions (Frank et al. 2008). However, Pixner and colleagues (2011) focus on the Czech language, which has two different number-word systems: non-inverted order (i.e., 25 coded as twenty-five), and inverted order (i.e., 25 coded as five-twenty), to partial out the effect of culture on the comparison of number cognition across languages. They find that, despite the fact that all participants are native Czech speakers and grew up in the same culture; inversion related errors are observed more in transcoding-inverted number-words compared to non-inverted number-words (Pixner et al. 2011). This discussion in the literature suggests, and our findings support that culture is not a significant factor in linguistic number comprehension.

This research has significant theoretical contributions and important managerial implications. From, a theoretical perspective, in support of the Encoding-Complex Hypothesis

(Campbell 1994; Campbell and Clark 1992; Campbell and Epp 2004), and in contrast to the Triple Code Model (Dehaene 1992; Dehaene and Cohen 1995), our findings provide evidence for the effect of language on number comparison tasks (Study 1), and implication of this effect in the context of comparative ANB evaluations (Studies 2, 3, 4, and 7).

Specifically, our findings uncover the dimensions of the effects of linguistic properties on number comparisons. First, we showed that in support of the Encoding Complex Hypothesis, language influences number comparison tasks. Second, we demonstrated the effect of language on number comparisons in line extension ANB context that require comparative ANB evaluations. Specifically, we focused on the two properties of linguistic numeral systems, base and non-transparency, which lead to variations in numerosity of numeral systems across languages. We found that as the numeral system gets more numerous because of these linguistic numeral properties, consumers evaluate increased differences between the two numbers, thus ANBs. As illustrated in Table 1 base and non-transparency influence numerosity of quantitative comparisons. Because a higher number of units suggests larger quantities when the size of units is ignored (the numerosity heuristic), a decreased perception of quantitative differences was observed moving from transparent decimal numeral systems to non-transparent decimal numeral systems (Table 1). Third, we provided evidence for the effect of base and non-transparency on how numerous number comparisons are perceived. We showed the effect of numerosity on quantitative comparisons in a different context such as linguistic numeral properties. Finally, we replicated the effect of language on consumers' ANB evaluations in various exposure formats audio, number words, and digital. As such our findings suggest that the effect of language on number comparisons is strong enough to be observed both in digital and verbal (audio and number-words) formats. Specifically, unlike the extant literature suggesting (i) no effect of

language (Dehaene 1992; Dehaene and Cohen 1995), or (ii) a stronger effect of language in verbal exposure to numbers (Campbell 1994; Campbell and Clark 1992; Campbell and Epp 2004) on number comparisons, our findings demonstrate that language influences number comparisons in any exposure format.

From a managerial point of view, we show that use of the same numbers in ANBs of global brands may result in differing consumer reactions across languages. While there is ample amount of research on foreign brand names and the potential effects of differences in linguistic properties of verbal brand names (Klink 2000; Lowrey and Shrum 2007; LeClerc, Schmitt, and Dubé 1994), past literature does not provide any guidance to marketers on the linguistic differences in processing numbers included in brand names (ANBs). As consumers frequently deal with comparative ANB evaluations, which are inherently number comparison tasks, the language that they speak can influence their evaluations of line extension ANBs that are globally merchandised. Thus, marketers can utilize the numbers included in ANBs to either maximize or minimize the perceived differences among their product offerings in different countries.

### ***Limitations and Future Research Directions***

The research herein offers new insights into ANBs, and avenues for future research. In this research we purposefully focused on ANBs as an implication for the effect of language on number comparisons, because processing of numbers in brand names is less susceptible to any cultural differences in number perceptions compared to say processing of price or other quantitative attributes. For example, one might argue that Chinese are more sensitive to price differences. However, comparison of differences in brand name numbers as a proxy for product improvement perceptions decreases the likelihood that such arguments are valid, and it provides both theoretically and managerially interesting implications. Future research can examine the



effect of language on consumers' ability to make number comparisons in various other contexts such as pricing, and attribute information. Specifically, if the effect of language on comparative price and numeric attribute evaluations can be demonstrated, linguistic numeral systems can be influential factors that alter general consumer behavior.

Another future research opportunity lies in the effect of inversion, which is the reversed digit order in the number-word system (e.g., *ein (1)-und-zwanzig (20)* in German as opposed to *twenty (20)-one (1)* in English), on consumers' quantitative comparisons. Knowing that consumers who have an inverted linguistic numeral system, such as German, may pay more attention to the units digit (Macizo and Herrera 2011), one could argue that the inversion has a decreasing effect on consumers' comparative ANB evaluations, when the unit digit of the larger number is smaller than the unit digit of the smaller number. Because inversion operates on a different processing mechanism that is related to the attention to order of digits, it is not within the scope of this paper.

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TABLE 1  
LINGUISTIC NUMERAL PROPERTIES AND NUMEROSITY

	Comparison	Size of the Unit	Number of Units	Sample Language
<b>Transparent Decimal</b>	2x10 vs. 8x10	10	<b>6</b>	Chinese
<b>Vigesimal</b>	20 vs. 4x20	20	<b>3</b>	French
<b>Non-transparent Decimal</b>	20 vs. 80	60	<b>1</b>	English

↓  
Numerosity

TABLE 2  
RESULTS OF STUDY 5

Choice	Language (Condition)		
	English Condition 20 vs 80	French Condition 20 vs 4x20	Chinese Condition 2x10 vs 8x10
<b>60 (E)</b>	42.2%	26.5%	31.4%
<b>3x20 (F)</b>	20%	62.9%	17.1%
<b>6x10 (C)</b>	5.6%	16.7%	77.8%

TABLE 3  
RESULTS OF MODERATION (SEPARATE MODERATORS) IN STUDY 7

<i>IV: Language (French vs. English)</i>	<b><i>PROCESS Model 1 Moderator: NFC</i></b>			<b><i>PROCESS Model 1 Moderator: Numeracy</i></b>		
	Interaction Effect	CI: 95% Lower	CI: 95% Upper	Interaction Effect	CI: 95% Lower	CI: 95% Upper
<b>DV: Willingness to purchase</b>	-.21	-.69	.49	-.31	-.82	.20
<b>DV: Picture Quality</b>	.001	-.26	.26	.02	-.21	.24
<b>DV: Quality Judgments</b>	-.22	-.76	.34	-.09	-.56	.38

TABLE 4  
RESULTS OF MODERATION (TWO MODERATORS) IN STUDY 7

<i>IV: Language (French vs. English)</i>	<b><i>PROCESS Model 2 Moderator: NFC</i></b>			<b><i>PROCESS Model 2 Moderator: Numeracy</i></b>		
	Interaction Effect	CI: 95% Lower	CI: 95% Upper	Interaction Effect	CI: 95% Lower	CI: 95% Upper
<b>DV: Willingness to purchase</b>	-.04	-.68	.59	-.29	-.83	.26
<b>DV: Picture Quality</b>	-.04	-.31	.23	.03	-.21	.27
<b>DV: Quality Judgments</b>	-.13	-.71	.45	-.05	-.55	.45

FIGURE 1  
LINGUISTIC PROPERTIES OF NUMERAL SYSTEMS

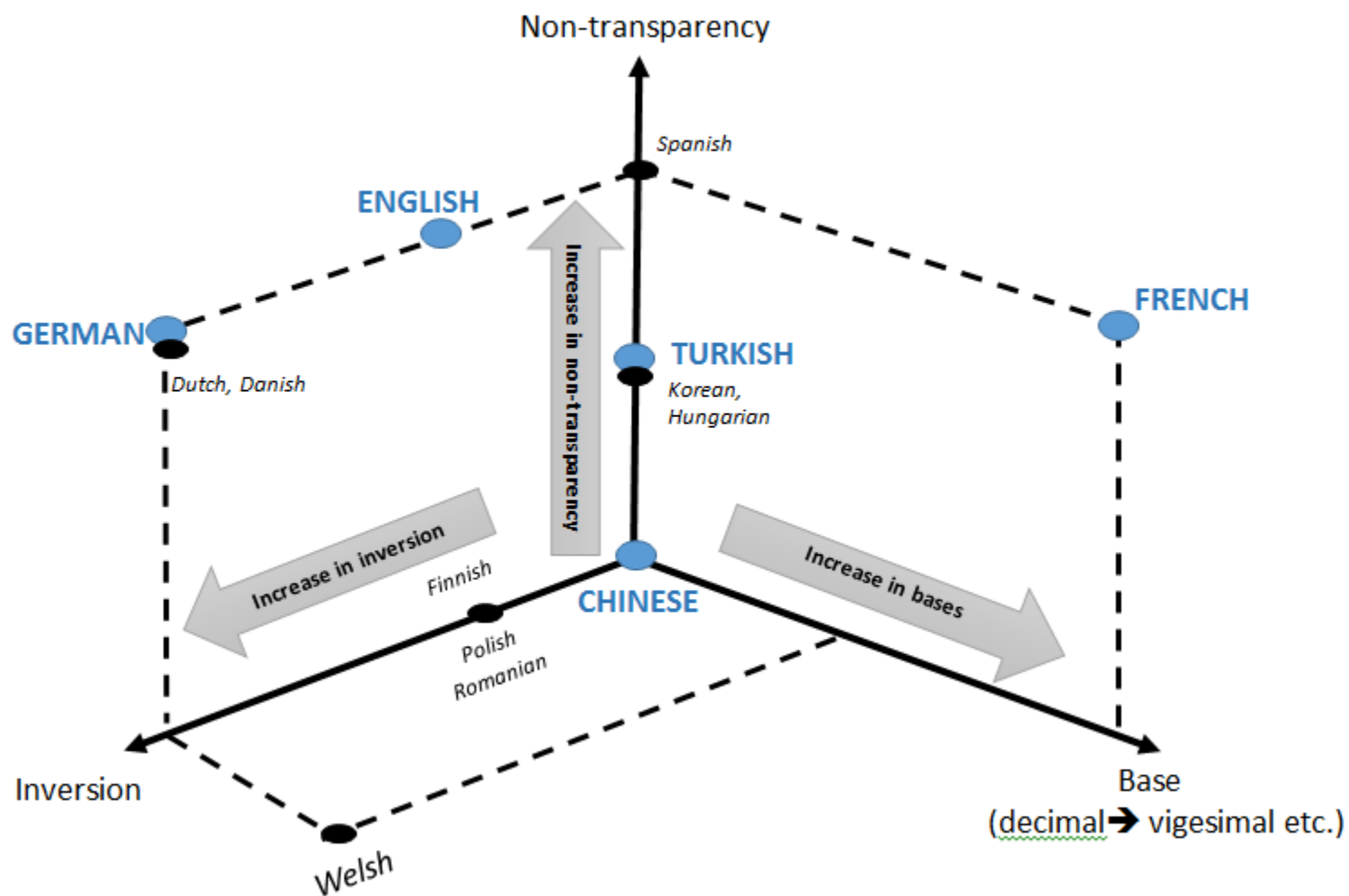
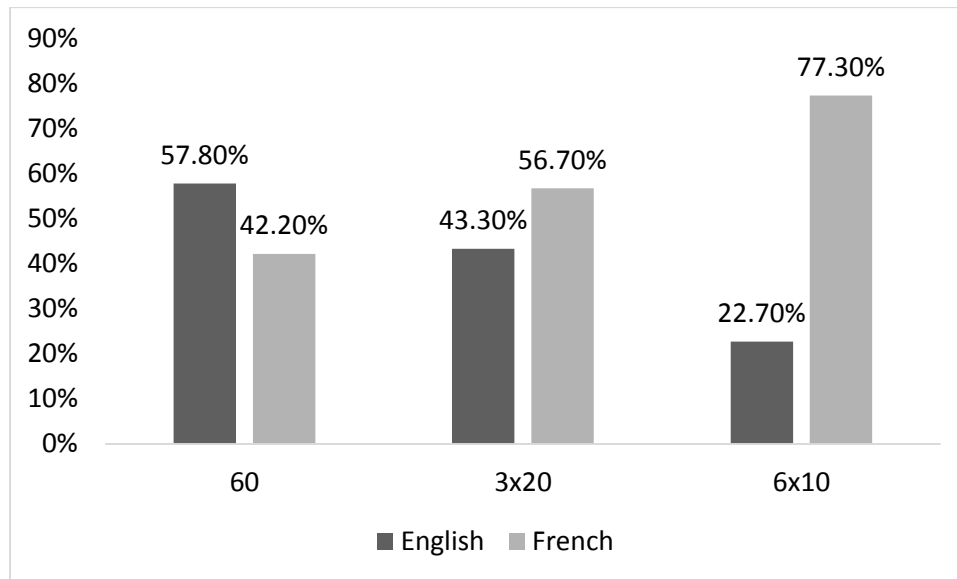


FIGURE 2  
NUMEROSITY RESULTS OF STUDY 7



APPENDIX A  
NUMBERS USED IN STUDIES

**H3A: TRANSPARENT DECIMAL > VIGESIMAL**

<b>STUDY 2</b>		Dyson ANB Numbers	
Language		<b>22</b>	<b>88</b>
Chinese	Number Word	er-shi-er	ba-shi-ba
	In English	two-ten-two	eight-ten-eight
	Mathematical	$2 \times 10 + 2$	$8 \times 10 + 8$
French	Number Word	vingt-deux	quatre-vingt-huit
	In English	twenty-two	four-twenty-eight
	Mathematical	$20 + 2$	$4 \times 20 + 8$

**H3B: TRANSPARENT DECIMAL > NON-TRANSPARENT DECIMAL**

<b>STUDY 3</b>		TomTom ANB Numbers	
Language		<b>28</b>	<b>82</b>
English	Number Word	twenty-eight	eighty-two
	Mathematical	$20 + 8$	$80 + 2$
Chinese	Number Word	er-shi-ba	ba-shi-er
	In English	two-ten-eight	eight-ten-two
	Mathematical	$2 \times 10 + 8$	$8 \times 10 + 2$

**H3C: VIGESIMAL > NON-TRANSPARENT DECIMAL**

<b>STUDY 4 and STUDY 7</b>		Base Difference Condition		No Base Difference Condition	
Language		<b>27</b>	<b>87</b>	<b>38</b>	<b>68</b>
English	Number Word	twenty-seven	eighty-seven	thirty-eight	sixty-eight
	Mathematical	$20 + 7$	$80 + 7$	$30 + 8$	$60 + 8$
French	Number Word	vingt-sept	quatre-vingt-sept	trente-huit	soixante-huit
	In English	twenty-seven	four-twenty-seven	thirty-eight	sixty-eight
	Mathematical	$20 + 7$	$4 \times 20 + 7$	$30 + 8$	$60 + 8$

## APPENDIX B STIMULI USED IN STUDIES

### The Stimulus in Study 2



Are you a tired of dust that never completely goes away? Do you want a dustfree environment to breathe? Dyson has satisfied your need for years with **Dyson EasyDust 22**.

Now Dyson is introducing a new vacuum cleaner that is both portable and of the high efficiency for dust cleaning, you expect from Dyson. **Dyson EasyDust88** is here now to help you create your fresh, clean and dust free places. Besides it is easier to use, carry and store **Dyson EasyDust88!** Go and grab one before it is too late!

### The Stimulus in Study 3



We know you hate getting lost while driving. TOMTOM has helped you accurately navigate for years with **TOMTOM T28** portable GPS car navigation system.

Now TOMTOM is on the stage with a new portable GPS car navigation system: **TOMTOM T82** is here to help you find your way eliminating concerns of getting lost for less stressful driving. You say you don't have a TOMTOM GPS product yet? Head to your closest TOMTOM retailer to get your T82. Let this be your last ride without a TOMTOM. To purchase online please visit us at [www.tomtom.com](http://www.tomtom.com). TOMTOM is here to save you from getting lost.

### The Stimulus in Study 4



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 **Twenty seven**.

Now Sony is introducing a camera that is both convenient and of high quality. Sony CyberShot **Eighty seven** is on the stage enabling you to take great pictures while enjoying the moment. Capture life's moments with Sony CyberShot **Eighty seven** just like you have been doing with CyberShot **Twenty seven**. Sony, Make Believe!

### Scale Used for Measuring Comparative Photo Quality in Studies 4 and 7

(4)



(3)



(2)



(1)





### The Stimulus in Study 5

Which of the following options (A, B, C) defines the difference between the following number pair?

English Condition	French Condition	Chinese Condition
<b>20</b> and <b>80</b>	<b>20</b> and <b>4x20</b>	<b>2x10</b> and <b>8x10</b>

A) 60

B) 3x20

C) 6x10

### The Stimulus in Study 6

Please evaluate the difference between the following numbers on the following scale

English Condition	French Condition
<b>20 + 7</b> and <b>80 + 7</b>	<b>20 + 7</b> and <b>4x20 + 7</b>

The difference is very small ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ The difference is very large

# APPENDIX C

## SUBJECTIVE NUMERACY SCALE

Item	Scale
1. How good are you working with fractions?	<i>1 = Not at all good, 6 = Extremely good</i>
2. How good are you at working with percentages?	<i>1 = Not at all good, 6 = Extremely good</i>
3. How good are you at calculating a 15% tip?	<i>1 = Not at all good, 6 = Extremely good</i>
4. How good are you at figuring out how much a shirt will cost if it is 25% off?	<i>1 = Not at all good, 6 = Extremely good</i>
5. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?	<i>1 = Not at all, 6 = Extremely</i>
6. When people tell the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there is a 1% chance")?	<i>1 = Always prefer words 6 = Always prefer numbers</i>
7. When you hear a weather forecast do you prefer predictions using percentages (e.g., "there will be a 20% chance of rain today") or predictions using only words (e.g., there is a small chance of rain today)?	<i>1 = Always prefer words 6 = Always prefer percentages</i>
8. How often do you find numerical information to be useful?	<i>1 = Never 6 = Very often</i>

(Fagerlin et al. 2007)