WHAT DOES YOUR BRAND "STATE" TO YOU?: AN EXPLORATORY EXAMINATION OF LANGUAGE EFFECTS ON COMPARISON OF ALPHANUMERIC BRAND NAMES

Kunter Gunasti

Selcan Kara

William T. Ross, Jr.

Rod Duclos *

* Kunter Gunasti (e-mail: gunasti@uconn.edu) is an Assistant Professor of Marketing, Selcan Kara (e-mail: selcan.kara@business.uconn.edu) is a PhD student, William T. Ross, Jr. (e-mail: bill.ross@business.uconn.edu) is Voya Financial Chair and Professor of Marketing at the School of Business, University of Connecticut, and Rod Duclos (email: rod.duclos@ust.hk) is an Assistant Professor of Marketing at the School of Business, HKUST. The authors thank David Norton for his helpful comments. This research was partially funded by University of Connecticut Summer Research Grant provided to Kunter Gunasti. Please address all correspondence to Selcan Kara.

WHAT DOES YOUR BRAND "STATE" TO YOU?: AN EXPLORATORY EXAMINATION OF HOW LANGUAGE AFFECTS COMPARISON OF ALPHANUMERIC BRAND NAMES

Abstract

In four studies across five languages, we investigate the potential roles of three numeral system characteristics (base, inversion and transparency) on consumers' alphanumeric brand name (ANB) evaluations. For example, *Chinese* has a very systematized, "transparent" numeral system; once you know the numbers 1 through 10 you can process any number (e.g., 82 is eight-ten-two). Other languages, such as *Turkish*, require the knowledge of a new word for each decade (e.g., 82 is "eighty"-two) whereas *English* has unstructured wording for numbers below twenty (e.g., 18 is eighteen as opposed to ten-eight). *German* uses backward wording for a verbal representation known as inversion (e.g., 82 is two-and-eighty) whereas *French* has a partial-vigesimal (20) system (e.g., 82 is four-twenty-two). Results of multiple international studies indicate that the aforementioned linguistic properties in numeral parts of ABNs create different perceptions of product features and new products.

Key words: Alphanumeric brand names, numerical cognition, linguistics, language, numbers

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). Growing literature on the effect of ANBs on consumer evaluations investigated the effect of fluency in number processing (King and Janiszewski 2011) and anchored meanings in numbers (Yan and Duclos 2013) on consumers' reactions to ANBs. For example, past research documents that the inclusion of numbers in ANBs affects consumers' evaluation of attribute inferences and price perceptions (Pavia and Costa 1993). 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)

However, the effect of linguistic numeral properties on consumers' ANB evaluations and comparisons has not been investigated. How consumers process numbers in ANBs may be strongly related to the language structure of the numeral system. Let us consider the number 82. In English it is verbalized in forward order as 80-2 (eighty-two). However, in German, this order is reversed, and the same number is expressed as 2-and-80 (zwei-und-achtzig). In French, 82 is expressed 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). Finally Turkish also has an almost regular counting system in which one has to memorize a new word for each tens digit so that 82 is 80-2 (seksen-iki). While Turkish resembles English for numbers larger than 20, below 20 it lacks reversals (e.g., thirteen: *dreizehn*, fourteen: *vierzehn*) and irregularities (e.g., eleven*: elf*, twelve: *zwölf*) shared by English and *German*. For example, 18 is ten-eight (on-sekiz) in Turkish and (shi-ba) in Chinese as opposed to resembling 8-10 (eighteen, eight-ten) in English and (acht-zehn) in German.

As 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 influence 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. Hence, the question of whether consumers' ability to compare these two ANBs 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. Moreover, the research herein explores the degree to which the effect of language on consumers' comparative ANB evaluations is influenced by differences in contexts. Specifically, another important effect of language on number cognition lies in the effects of the codes of number processing such as verbal, and digital (Campbell 1994; Colome et al. 2010; Dehaene 1992). Thus, comparative evaluations of ANBs 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 aim of the research herein is to examine whether verbal versus digital exposure to numbers in ANBs is a critical factor to drive the effect of language on consumers' 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; 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 on consumer behavior (Bagchi and Davis 2012; Thomas and Morwitz 2009). First, our investigation, involving four studies across five languages documents that language influences consumers' comparative ANB evaluations. Specifically, we examine three characteristics of linguistic numeral properties: Number base, inversion, and transparency, and we show how they affect consumers' comparative ANB evaluations for line extensions (Studies 1, 2, 3 and 4). Second, we demonstrate that the effect of the linguistic properties of numeral systems on ANB evaluations occurs in both verbal and visual exposure to numbers in ANBs (Studies 1, 2, 3 and 4). Third, this research enriches the theoretical understanding of the effect of language on number processing by providing evidence that linguistic characteristics is a prominent factor to drive between-language differences in evaluation of ANBs over and above socio-cultural differences (Study 1). 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.

THEORETICAL FRAMEWORK

Effect of Language on Number Processing

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 et al. 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, Lemer, Izard, and Dehaene 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 arises. 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 et al. 2010). Therefore, in this research context, Dehaene's framework would likely suggest that language should not influence 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 stronger in verbal format (Campbell 1994; Campbell and Clark 1992; Campbell and Epp 2004; Colome et al. 2010). This model suggests that evaluation of ANBs (i.e., comparison of numeric components in ANBs) will be influenced by the language. Thus, we follow the Encoding-Complex Hypothesis, and expect linguistic numeral systems to influence consumers' ability to compare numbers in ANBs of extensions. Consequently, we posit that:

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

Numeral Systems

Linguistic numeral systems display significant differences in various aspects each of which constitute a characteristic of number processing system. Table 1 summarizes the linguistic differences in numeral systems of some widely used languages and Table 2 provides more examples of numbers in different languages. We focus on three properties of linguistic numeral properties, which will influence consumers' ability to compare ANBs: Numeral Base, Inversion property, and Transparency property (Comrie 2005; Zuber et al. 2009) as discussed next.

"Insert Table 1 and Table 2 about here"

Property 1: Numeral Base. 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 and Turkish use the decimal, base ten (10), system (Bender and Beller 2006), among these three languages, Chinese follows a stricter 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 on base sixty (sexagesimal), such as the sum of 60 and 17 as in soixante-dix-sept (sixty-seven-teen) for 77.

We expect to observe differences in consumers' ANB evaluations resulting from differences in the base for two theoretically grounded reasons. First, prior 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, we expect vigesimal, compared to decimal, numeral systems to influence consumers' ability to compare ANBs formed with the numbers 20 and 80 (e.g., 4-20; mathematically 4x20). Consequently, we anticipate this expression of "four-twenty" (quatre-vingt) in French to result in ease of number processing when comparing the two ANBs formed with these numbers. Knowing that previous literature suggests higher preference, likeability and more favorable evaluations for higher processing fluency (Lee and Labroo 2004; King and Janiszewski 2011), in a vigesimal, compared to decimal system, we expect to observe higher preference for and/or more favorable evaluations of the ANB formed with 80 in comparison to the ANB formed with 20.

Second, understanding of place value, which refers to representation of the base 10 system by written symbols (Miura and Okamoto 1989), enables and facilitates individuals to process numbers. Specifically, because place value denotes the numeric value that a digit has because of its position in a number, individuals' mental arithmetic for constructing numbers is usually based on the base ten. We expect to see a shift in understanding of place value from ten to twenty in vigesimal, compared to decimal systems. For example, for the number 87, which is expressed as 8-10-7 (i.e., mathematically 8x10+7) in Chinese, and 4-20-7 (i.e., mathematically 4x20+7) in French, the place value is clearly 10 in Chinese, whereas it can increase to 20 in French. Hence, this increase in place value can result in increased difference in ANB evaluations for the vigesimal system, such as in French, compared to a strict decimal system, such as in Chinese.

Hypothesis 1a: The vigesimal system increases the perceived differences between two ANBs when the numbers compared are expressed in vigesimal vs. decimal base in a language (e.g., 21 vs. 81 in French vs. English).

Property 2: Inversion. 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 et al. 2009). For example, the number 27 is expressed as seven-and-twenty (sieben-und-zwanzig) in German. This inversion property may lead German speakers to pay more attention to the units digit, because individuals learn how to process number words depending on the linguistic structure of the numeral systems (Macizo and Herrera 2011). Prior research has demonstrated that because of the inversion property they use, German-speaking children experience problems with transcoding numbers from verbal (number words and audio) form to Arabic/visual form (Zuber et al. 2009). Thus, we examine whether the inversion property in numeral systems influences consumers' ability to make comparative ANB evaluations. For example, let us consider two ANBs formed with the numbers 28 and 82. In German the number 28 is expressed as 8-and-20 (acht-und-zwanzig), and the number 82 is expressed as 2-and-80 (zwei-und-achtzig). Based on the logic suggesting that German speaking consumers pay more attention to the units digit because of the inversion property, we anticipate German-speaking consumers to have a lessened difference perception between the numbers 28 and 82, because the units digit of the larger number (82) is smaller than the units digit of the smaller number (28).

Hypothesis 1b: The inversion property in numeral systems decreases the perceived differences between two ANBs, when the unit digit of the larger number is smaller than the unit digit of the smaller number (e.g., 82 vs. 28).

Property 3: Non-Transparency. 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). Accordingly, variations in the level of transparency across these three languages lead us to consider whether these irregularities or a new word for each tens digit or both influence consumers’ ability to make comparative ANB evaluations across languages.

Unlike the base (vigesimal) and inversion properties, less is known about how levels of non-transparency can influence number comparisons. Specifically, previous literature suggests that regularity of numeral systems is known to positively influence efficacy in mathematics and arithmetic performance (Dowker, Bala, and Lloyd 2008; Miller, Smith, Zhu, and Zhang 1995). For example, Chinese, Korean, and Japanese children learn numbers in a regular (transparent) counting system, which involves easy formation of numbers. At earlier ages, these children demonstrate superior mathematical performance compared to English speaking children who are exposed to numbers in an irregular (non-transparent) counting system, which requires memorization of some numbers (Dowker, Bala, and Lloyd 2008). However, less is known regarding the effect of non-transparency on number comparisons and for adult populations. Thus, although we expect an influence of non-transparency to influence consumers' comparative ANB evaluations, we do not have concrete theoretical evidence for the direction (e.g., increasing or decreasing) of the effect of language on consumers' ANB evaluations. Specifically, on one hand, because regularity (transparency) of numeral systems facilitates number processing, increases in non-transparency might decrease number processing fluency. Thus, when comparing the ANBs formed with the numbers 11 and 66 (*eleven*, and 60-6 in English; 10-1 and 6-10-1 in Chinese), Chinese speaking consumers may have more favorable evaluations of the ANB with 66 in comparison to the ANB with 11 than English speaking consumers, because they process the number comparison more fluently. In this case, increases in non-transparency in numeral systems should decrease perceived differences between two ANBs.

On the other hand, the elements of non-transparency, such as a new word for each tens digit, number words that do not follow any rules (e.g., eleven), create an irregularity (Dowker, Bala, and Lloyd 2008), which can create an abstraction about the numeric value of the digits. Specifically, calculation based expression of the tens digit, such as 6-10 in Chinese (i.e., mathematically 6 x 10), can trigger a concrete construal, whereas new-word based expression of the tens digit, such as 60 can trigger an abstract construal. This abstract versus concrete construal in numeral systems can increase the perceived numeric difference in ANBs, because (i) literature suggests that numbers can be viuso-spatially represented on a mental number line (Pecher and Boot 2011; Moyer and Landauer 1967), and (ii) abstract (e.g., having fun), compared to concrete (e.g., playing basketball) construal increases perceived spatial distances (Liberman and Trope 2008). Specifically, because numbers can be represented spatially on a mental number line, abstract construals, such as “sixty” and “eleven”, can lead to larger perceived difference between the numbers 11 and 66 on this spatial number line than concrete construals, such as “six-ten” and “ten-one”. Thus, unlike base (vigesimal) and inversion numeral properties, for the non-transparency we adopt an exploratory approach, and propose a non-directional hypothesis as follows:

Hypothesis 1c: Increases in levels of non-transparency in numeral systems lead to variations in consumers’ comparative ANB evaluations.

As demonstrated in the aforementioned research hypotheses, three properties of numeral systems emerge as significant reasons for the effect of language on number cognition: because they lead to different mechanisms of number processing, which in turn influences consumers’ ability to compare numbers. We develop a taxonomy of linguistic numeral systems based on these three properties of number word structures. Figure 1 illustrates this taxonomy.

“Insert Figure 1 about here”

Specifically, as noted before, Chinese, which belongs to the Sino-Tibetian language family, has a highly regular and transparent number system. Turkish, which belongs to the Altaic-Turkic language family, is more non-transparent than Chinese, because one needs to know the specific number word for each new decimal as well as one through nine in Turkish. In this sense Turkish and English display similar characteristics. However, as in most other Indo-European languages, in English, the order of digits is reversed in number words between 10 and 20, therefore, as shown in Figure 1; the English numeral system has some level of “inversion”. 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 (Figure 1). Similarly, German, another Indo-European language, also has some irregular number words such as elf (11) and zwölf (12), which increase its level of "non-transparency". But, German also has the inversion for all numbers between 10 and 100, so it is positioned higher on the "inversion" axis of Figure 1. Finally, because of its unique linguistic properties such as use of different bases (e.g., vigesimal system after 80; sexagesimal system in 60-70; decimal system until 50), 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, French, is positioned high on both "non-transparency" and "base" axes.

We also test 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 et al. 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 anticipate that verbal exposure to numbers in ANBs may make it easier to observe between language differences.

Hypothesis 2: The effect of linguistic numeral systems on consumers' ANB evaluations is greater when consumers are exposed to numbers in ANBs verbally compared to digitally.

"Insert Figure 2 about here"

Figure 2 summarizes the conceptual model. In support of the Encoding-Complex Hypothesis, and in contrast to the Triple Code Model, the research herein aims to show the effect of linguistic numeral properties (H1), such as base (H1a), inversion (H1b), and non-transparency (H1c) on consumers' comparative ANB evaluations. Moreover, we take effects of contextual variables under consideration, and aim to demonstrate the moderating role of exposure format to numbers in ANBs (H2), on the effect of language on consumers' ANB evaluations. To test our hypotheses we conducted four studies with undergraduate students in five countries including USA, France, Germany, China and Turkey.

STUDY 1: SEMI-VIGESIMAL NUMERAL SYSTEMS AND NUMBER WORDS

The purpose of Study 1 was threefold. First, we aimed to test H1a, by comparing French, which has a partial vigesimal numeral system, and English, which has a decimal numeral system. Specifically, in Study 1, we examined whether a vigesimal, compared to a 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, we aimed to examine the effect of language on consumers' ANB evaluations in verbal exposure to numbers in ANBs. As previously discussed, Dehanene'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 et al. 2010). However, we do not know whether number comparisons in number-word format (i.e., verbal) are influenced by language. Moreover, the Encoding – Complex Hypothesis suggests that language can affect any numeric task, but the effect of language is stronger in verbal format (Campbell 1994; Campbell and Clark 1992; Campbell and Epp 2004). In the light of these theories, we expect that verbal exposure format to numbers in ANBs can be prominent to observe between language differences. Consequently, we test the effect of the vigesimal 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.

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 base ten as 20 + 7, and 80 + 7. 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 x 20 + 7, because of the vigesimal system. Consequently, because of ease in number processing fluency, we anticipate this expression of "four-twenty" in French to result in 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 decimal system both in English and in French (i.e., 30 + 8). Similarly, the number 68 is also is verbalized on a 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. In other words, we expect French-speaking participants, compared to English speaking participants, to evaluate the line extension Sony CyberShot 87 as a larger improvement over the Sony CyberShot 27 due to the shift in base from decimal to vigesimal. However, we expect this effect not to be observed for Sony CyberShot 68 and 38 as they are represented in the same base for both languages. Therefore, the number pair 27 – 87 is referred as "base difference condition" whereas the number pair 38 – 68 is referred as the "no base difference condition".

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: base difference vs. no base 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 base difference condition, whereas the existing brand was Sony CyberShot thirty eight, and the line extension was Sony CyberShot Sixty eight in the no base 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 as 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 H1a, 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 base difference condition (27-87 number pair) ($t(199) = 2.58$, $p < .05$). However, in the no base 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 1 suggest that, in support of H1, linguistic numeral systems lead to variations in perceived differences between ANBs. Specifically, a vigesimal digit structure (i.e., French), compared to a 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 decimal numeral structure in

English, leads consumers to perceive an increased difference between the two ANBs (Sony CyberShot 27 versus Sony CyberShot 87). 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 cultural differences but linguistic differences of numeral systems. Overall, the results of Study 1 suggest that language influences consumers' comparative ANB evaluations, when they are exposed to numbers in number-word (verbal) form. Thus, our next step is to examine whether the effect of linguistic numeral systems is also observed in exposure to numbers in digital format (H2), which we address in Study 2.

STUDY 2: SEMI-VIGESIMAL NUMERAL SYSTEMS AND DIGITAL NUMBERS

In support of the Encoding-Complex Hypothesis, but in contrast to Dehaene's Triple Code Model, we aimed to demonstrate that the effect of vigesimal, compared to decimal, numeral systems on consumers' ANB evaluations is also observed in digital exposure to numbers in ANBs. Hence, we tested H1a, by comparing French, which has a partial vigesimal numeral system, and Chinese, which has a highly regular decimal numeral system. Furthermore, we aimed to examine the effect of linguistic numeral systems on consumers' ANB evaluations with a more quantifiable dependent variable. Specifically, to have an objective measure of the difference between the numbers included in two ANBs, we collected favorability ratings for the existing product and the new products as separate measures; and we compared the differences in favorability ratings of the new and existing brands between the two languages.

Study Design

The design of Study 2 was similar to that of Study 1, except for the product category and the numbers used in ANBs. As illustrated on 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 regular forward structure so that the number word for 28 is formed in forward order as 2 x 10 + 8, and the number word 82 is formed in forward order as 8 x 10 + 2. In French the number 28 is also expressed in forward order as 20 + 8. However, diverging from Chinese, the number 82 is verbalized in a completely different structure. In French, as previously described, the number 82 is expressed as 4 x 20 + 2. Consequently, we anticipate this expression of "four-twenty" in French to result in an increased understanding of lace value that leads to increased difference perception between the numbers 28 and 82 for French speaking participants compared to Chinese speaking participants. Following Study 1, print advertorials that describe the existing brand and introduce the line extension were created to provide consumers with the ANBs. As in Study 1, the ads did not include any product attribute information but instead emphasized the ANBs (See Appendix B for details).

Procedure

Eighty-one undergraduate students participated in an international experiment to evaluate a hypothetical new product offering of the TomTom GPS Navigation System. Similar to Study 1, Study 2 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 2 was a 2 condition (Language: French 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 1, 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, participants were asked to indicate their favorability for both the existing (TomTom T28) and new (TomTom T82) brands on the same 7-point sliding scales (1= very unfavorable, 7= very favorable).

Results and Discussion

To have an objective measure of the difference between the two ANBs, we created a measure for "favorability difference" by subtracting "favorability for the existing TomTom T28" from "favorability for the new TomTom T82" and we compared the perceived differences between the two brands across the two language conditions. As in Study 1, in support of H1a, the favorability difference between the old and the new TomTom was higher in French (M_{French} = .86) than in Chinese ($M_{Chinese}$ = .28; t (79) = 2.48, p < .05)**.** Because the vigesimal structure of the number 82 in French (4 x 20 + 2) can lead to an increase in consumers' understanding of place value, the favorability difference between TomTom T28 and TomTom T82 is perceived to be higher in French, than in Chinese.

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. Hence, it is important to explore if verbal versus digital exposure to numbers in ANBs has a differential effect on how linguistic numeral systems influence consumers' ANB evaluations (H2). In the next set of studies we addressed this issue and we also examined the effects of other linguistic properties (transparency and inversion) on consumer processing of ANBs.

STUDY 3: NON-TRANSPARENCY: CHINESE, TURKISH AND ENGLISH – DIGITAL AND AUDIO EXPOSURE TO NUMBERS

Studies 1 and 2 provided evidence for H1a by demonstrating the effect of vigesimal, compared to decimal, digit structures on consumers' ANB evaluations. Thus, the first purpose of Study 3 was to examine the effect of another linguistic numeral property, the level of non-transparency (H1c). We compared one Indo-European (English), one Altaic-Turkic (Turkish), and one Sino-Tibetian (Chinese) language. Specifically, we aimed to explore (i) the effect of a new word for each tens digit in numeral systems, such as "twenty" in English and "yirmi" in Turkish but "er shi" (two tens) in Chinese for the number 20, and (ii) the effect of irregular number words that do not follow any rules, such as eleven in English on consumers' ANB evaluations. The second purpose of Study 3, as previously discussed, was to examine whether the exposure format to numbers in ANBs (verbal versus digital) leads to variations in how linguistics numeral sytems influence consumers' ANB evaluations (H2). To test the differential effect of verbal vs. digital exposure to numbers in ANBs, we used audio exposure instead of number words for two reasons. First, from a theoretical perspective, to increase the robustness of our findings, we aimed to test the effect of another verbal representation of number processing on consumers' ANB evaluations. Second, from a managerial perspective, we aimed to increase the generalizability of our findings, because one might argue that number words are not widely used as parts of brand names by the practitioners. The third purpose of Study 3 was to test the effect of linguistic numeral systems, such as the level of non-transparency, with a slightly different measure that enables participants to directly compare the two ANBs.

Study Design

Appendix A summarizes the details of the stimulus. The parent brand was Sony CyberShot 11 and the line extension was Sony CyberShot 66. Specifically, 11 is verbalized as 10 + 1, and 66 is verbalized as 6 x 10 + 6 in Chinese. Hence, out of these three languages Chinese is the most transparent one. Similar to Chinese, in Turkish, 11 is also structured as 10 + 1. However, in Turkish verbalization of the number 66 requires knowledge of a new word for 60, just as in English (i.e., 66 = 60 + 6). In addition to this, in English the number word for 11 (eleven) does not follow any structures or rules. Hence, there are two different types of non-transparency in comparisons among these three languages. First one is the knowledge of a new word for the tens digit, such as sixty in English and altmis in Turkish for 60. Second one is the irregularity of a number word, such as eleven that does not follow any rules or formulations in English. As previously discussed, H1c has an exploratory nature so that it does not have a direction, such as increasing or decreasing, for the effect of non-transparency on comparative ANB evaluations. On one hand, from a number processing fluency perspective, increasing levels of non-transparency may lead to lessened difference perception, because transparency and regularity of numeral structures facilitates number processing, specifically mathematical performance (Dowker, Bala, and Lloyd 2008; Miller et al. 1995). On the other hand, from abstract versus concrete construal perspective, the elements leading to non-transparency, such as "sixty" in English and in Turkish, can trigger abstract construal, whereas transparent numeral structures, such as "six-ten" in Chinese can trigger concrete construal. Based on the premise that (i) numbers can be processed spatially because of mental number line representation (Moyer and Landauer 1967; Pecher and Boot 2011), and (ii) abstract, compared to concrete construal leads to increased spatial distance perceptions (Liberman and Trope 2008) increasing levels of non-transparency may lead to increased difference perception. Thus, we aimed to understand which theoretical reasoning explains the effect of non-transparency on consumers' comparative ANB evaluations.

Diverging from the previous studies, both print and audio advertorials that describe the existing brand and introduce the line extension were created to provide consumers with the ANBs. Hence, participants either listened to, or read the same ad script, depending on their condition. While listening to the ad, participants were exposed to the picture of the camera. As in previous studies, the purpose of these ads was not providing participants with product attribute information but was emphasizing the ANBs.

Procedure

One hundred and ninety seven undergraduate students participated in a 3 (Language: Chinese vs. Turkish vs. English) x 2 (Exposure Format: audio vs. digital) between subject design experiment to evaluate a hypothetical new product offering of the Sony CyberShot 11. The procedure of Study 3 was almost identical to those of studies 1 and 2, except the dependent variable, which enables participants to directly compare Sony CyberShot 11 and Sony CyberShot 66. After exposure to the ads, respondents were asked to evaluate the new versus the old brands on an attribute improvement dimension. Specifically, participants were asked to assess whether the new product has better attributes on a 201-point sliding scale (-100=The new product is worse, +100=The new product is better).

Results

Non-transparency property had a significant effect on comparative attribute evaluations for the two ANBs ($F(2, 191) = 9.99$; $p < .01$). Supporting the abstract versus concrete conceptualization, which suggests non-transparency in digit structures might lead to a more abstract construal for English and Turkish compared to Chinese, comparative attribute evaluations for Sony CyberShot 11 and Sony CyberShot 66 were higher in English ($M_{English}$ =

35.05) and in Turkish ($M_{Turkish}$ = 43.43) than in Chinese ($M_{Chinese}$ = 18.17) ($F_{English\text{-}Chinese}$ (1, 191) = 11.38, p < .01; $F_{Turkish\text{-}Chinese}$ (1, 191) = 17.56, p < .01, see Table 3). Specifically, because of the first type of non-transparency in English and Turkish, using a new word for the tens digit, comparison of the two ANBs can be abstract, whereas it is more concrete in Chinese. For the second type of non-transparency, which is the irregularity of the number word eleven in English, in contrast to our expectation, there were not any significant differences in comparative attribute evaluations of the two ANBs between Turkish ($M_{Turkish}$ = 43.43) and English ($M_{English}$ = 35.05; F (1, 191) = 2.17, p = .14). Specifically, for the number pair 11 and 66, the only difference in terms of the non-transparency between English and Turkish is the number word eleven that does not follow any rules or structures in English. Hence, any difference in comparative attribute evaluations for Sony CyberShot 11 and Sony CyberShot 66 between English and Turkish should be attributed to the second type of non-transparency, which is the irregularity in “eleven”. However, Turkish and English were not different in terms of consumers’ ANB evaluations.

Insert Table 3 about here

The aforementioned effects were not significantly influenced by the exposure format to the numbers, because neither the main effect of exposure format (F(1, 191) = 1.6; p = .21), nor its interaction effect with the language on consumers’ comparative attribute evaluations (F(2, 191) = .96; p = .39) was significant. Specifically, in the audio exposure condition, comparative attribute evaluations for Sony CyberShot 11 and Sony CyberShot 66 were higher in English ($M_{English}$ = 37.18) and in Turkish ($M_{Turkish}$ = 50.86) than in Chinese ($M_{Chinese}$ = 17.28) ($t_{English\text{-}Chinese}$ (191) = 2.82, p < .05; $t_{Turkish\text{-}Chinese}$ (191) = 3.92, p < .01). Similarly, in the digital exposure condition, comparative attribute evaluations for the two ANBs were higher in English ($M_{English}$ = 32.91) and in Turkish ($M_{Turkish}$ = 36.00) than in Chinese ($M_{Chinese}$ = 19.06) ($t_{English\text{-}Chinese}$ (191) =

1.95, $p = .052$; $t_{Turkish\text{-}Chinese}$ (191) = 1.99, $p < .05$). It is important to note that the difference in ANB evaluations between English and Chinese was marginally significant in the digital exposure condition. This implies that despite the non-significant effect of the exposure format on consumers' ANB evaluations; the effect of linguistic numeral systems may be stronger in the audio exposure condition than in the digital exposure condition. Moreover, both in the audio and digital exposure conditions, there were not any significant differences in comparative attribute evaluations of Sony CyberShot 11 and Sony CyberShot 66 between Turkish ($M_{Turkish\_Audio}$ = 50.86; $M_{Turkish\_Digital}$ = 36.00) and English ($M_{English\_Audio}$ = 37.18; t_{Audio} (191) = -1.68, $p = .094$; $M_{English\_Digital}$ = 32.91; $t_{Digital}$ (191) = -.39, $p = .7$).

Discussion

The results of Study 3 provide further evidence for H1, and suggest that non-transparency (H1c), leads to a variation in perceived differences between ANBs. Specifically, we identify two different types of non-transparency: (i) using a new word for each tens digit, such as 60 in English (sixty) and in Turkish (altmis) as opposed to 6 x 10 in Chinese, and (ii) using number words that do not follow any rules or formulations, such as eleven for 11 in English as opposed to 10 + 1 in Turkish and in Chinese. Results revealed that, in support of H1c and abstract versus concrete theorization, the first type of non-transparency leads to evaluation of higher differences between the two ANBs in English and in Turkish than in Chinese. Specifically, because “sixty” in English and “altmis” in Turkish are more abstract (they require memorization of new words), whereas “six-ten” in Chinese is concrete in terms of denoting the numeric value (does not require memorization and can be systematically constructed), participants may have evaluated a larger spatial numeric difference for the abstract construal than for the concrete construal. However, the second type of non-transparency did not have any effect on consumers' comparative ANB evaluations. Therefore, there were not any differences in consumers' ANB evaluations between the languages English and Turkish.

Regarding the effect of exposure format (e.g., audio/verbal versus digital), the results provide support for the Encoding-Complex Hypothesis. Specifically, on one hand, the exposure format does not significantly influence the aforementioned results for the effect of non-transparency on consumers' ANB evaluations. On the other hand, the effect of linguistic numeral systems (non-transparency) is marginally stronger in the audio/verbal exposure to than it is in the digital exposure. Hence, the potential effect of the exposure format to numbers needs further exploration, which we address in Study 4.

STUDY 4: INVERSION, AND DIGITAL AND AUDIO EXPOSURE TO NUMBERS

We showed the effect of linguistic numeral systems such as differences in bases (vigesimal system) (H1a), and levels or types of non-transparency (H1c) on consumers' ANB evaluations in studies 1, 2, and 3. Hence, our next step was to test another linguistic numeral property, the inversion, on consumers' comparative ANB evaluations. Specifically, the first purpose of Study 4 was to test H1b by comparing the two Indo-European languages. Thus, in Study 4 we explored differences in consumers' evaluation of ANBs between English, which serves as a basis for comparison, and German, which has an inverted numeral system. The second purpose of Study 4, as previously discussed, was to further explore the potential effect of the exposure format to numbers in ANBs (audio versus digital) on consumers' ANB evaluations (H2). Finally, the third purpose of Study 4 was to replicate the results with an additional dependent variable, and an additional brand/product.

Study Design

Diverging from the previous studies, in Study 4, two different products/brands were used to assess consumers' reactions to changes in ANBs. Appendix A summarizes the details of the stimuli. For the Sony Camera, the parent brand was Sony CyberShot 17, and the line extension was Sony CyberShot 72. As illustrated in Appendix A and Table 2, in terms of the numeral structure, the number 72 is different in English and in German. Specifically, although the number 17 has the inversion property both in English and in German, the number 72 has the inversion property only in German. The number 17 is verbalized in backward order in both English and German, such as 7 + 10. However, the number 72 is verbalized in forward order as 70 + 2 in English; whereas it is verbalized in backward order as 2 + 70 in German. Because of this inversion, German-speaking participants can pay more attention to the units digit (Macizo and Herrera 2011), which will decrease the perceived difference between the two ANBs for these number pairs. Specifically, for the number pair 17-72, verbalizing 'two' before 'seventy', compared to verbalizing 'seventy' before 'two', can result in a lessened difference perception between the numbers 17 and 72 in German compared to English. Consequently, we expect German-speaking participants, compared to English speaking participants, to evaluate the line extension Sony CyberShot 72 as a smaller improvement of the parent brand Sony CyberShot 17 because of the inversion property in German.

A similar rationale also pertains to the Dyson brands. Particularly, 12 is verbalized as twelve in English and zwölf in German, and neither of these number words follows a formulation or a structure. However, as previously described, the number 72 is verbalized differently in German, compared to English, because of the inversion property in the German numeral system. Hence, we expect German-speaking participants to evaluate a smaller difference between Dyson

EasyDust 12 and Dyson EasyDust 72 than English-speaking participants do. Similar to Study 3, both print and audio advertorials (that did not include any attribute information, but emphasized the ANBs) were created to provide consumers with the brand names.

Procedure

One hundred and fifty three undergraduate students participated in a 2 (Language: English vs. German) x 2 (Exposure Format: audio vs. digital) between subject design experiment to evaluate hypothetical new product offerings of the Sony CyberShot 17 and Dyson EasyDust 12. For both of the parent brands, the line extension ANB was formed with the number 72, such as Sony CyberShot 72 and Dyson EasyDust 72. All participants evaluated the two brands and their extensions. As in previous studies, participants, depending on their condition, either listened to or read the ads. Next, similar to Study 3, participants were asked to evaluate the new versus the old brands on an attribute improvement dimension on a 201-point sliding scale (-100=The new product is worse, +100=The new product is better). Finally, participants were also asked to evaluate whether the new product has higher quality on a 10-point sliding scale (1=The new product has lower quality, 10=The new product has higher quality).

Results

The inversion property in the numeral systems had a significant effect on comparative attribute evaluations ($F(1, 149) = 24.12$; $p < .01$) and quality evaluations ($F(1, 149) = 11.00$; $p < .01$) for the Sony brands. Supporting H1b, the inversion property in the German numeral system led to a lessened difference perception between Sony CyberShot 17 and Sony CyberShot 72. Therefore, comparative attribute evaluations for Sony CyberShot 17 and Sony CyberShot 72 were higher in English ($M_{English} = 39.28$) than in German ($M_{German} = 15.39$; $F(1, 149) = 24.12$; $p < .01$, see Table 3). Similarly, comparative quality judgments for Sony CyberShot 17 and Sony CyberShot 72 were higher in English ($M_{English} = 7.26$) than in German ($M_{German} = 6.38$; $F(1, 149)$

= 11.00; $p < .01$). The same pattern was also observed in the results for Dyson brands. Specifically, the inversion had a significant effect on comparative attribute evaluations ($F(1, 149) = 7.78$; $p < .01$) and quality perceptions ($F(1, 149) = 13.42$; $p < .01$) for the Dyson brands. Increasing the robustness of the findings, perceived attribute and quality differences between Dyson EasyDust 12 and Dyson EasyDust 72 were less in German than in English condition. Particularly, comparative attribute evaluations for Dyson EasyDust 12 and Dyson EasyDust 72 were higher in English ($M_{English} = 50.54$) than in German ($M_{German} = 35.84$; $F(1, 149) = 7.78$; $p < .01$, see Table 3). Similarly, comparative quality judgments for Dyson EasyDust 12 and Dyson EasyDust 72 were higher in English ($M_{English} = 7.69$) than in German ($M_{German} = 6.77$; $F(1, 149) = 13.42$; $p < .01$).

None of the aforementioned effects were significantly influenced by the exposure format to the numbers, because neither the effect of the exposure format, nor the interaction effect of the language and the exposure format on consumers' comparative attribute and quality evaluations was significant. Specifically, in the audio exposure condition, comparative attribute evlauations and quality perceptions for Sony CyberShot 17 and Sony CyberShot 72 were higher in English ($M_{English\_Attribute} = 44.21$; $M_{English\_Quality} = 7.25$) than in German ($M_{German\_Attribute} = 15.43$; $M_{German\_Quality} = 6.16$) ($t_{Attribute}(149) = 4.37$, $p < .01$; $t_{Quality}(149) = 3.16$, $p < .01$). Similarly, in the digital exposure condition, comparative attribute evaluations for Sony CyberShot 17 and Sony CyberShot 72 were higher in English ($M_{English\_Attribute} = 34.47$) than in German ($M_{German\_Attribute} = 15.33$) ($t_{Attribute}(149) = 2.66$, $p < .01$). However, comparative quality judgments for Sony CyberShot 17 and Sony CyberShot 72 were not significantly higher in English ($M_{English\_Quality} = 7.27$) than in German ($M_{German\_Quality} = 6.67$) in the digital condition ($t_{Quality}(149) = 1.60$, $p = .112$). Despite the statistical non-significance of the main effect of the exposure format, these results can imply that the influence of the linguistic numeral systems on consumers' ANB evaluations is lower in digital exposure than in audio exposure. However, we do not have statistical evidence to support H2. Additionally, the pattern of the results for Dyson brands was somehow different. Particularly, in the audio exposure condition, comparative quality judgments for Dyson EasyDust 12 and Dyson EsayDust 72 were higher in English ($M_{English\_Quality}$ = 7.59) than in German ($M_{German\_Quality}$ = 6.54; t (149) = 3.25, $p < .01$). The same effect was also observed in the digital exposure condition so that, in the digital exposure condition comparative quality judgments for Dyson EasyDust 12 and Dyson EsayDust 72 were also higher in English ($M_{English\_Quality}$ = 7.78) than in German ($M_{German\_Quality}$ = 7.08; t (149) = 1.99, $p < .05$). Similarly, in the digital exposure condition comparative attribute evaluations for Dyson EasyDust 12 and Dyson EsayDust 72 were higher in English ($M_{English\_Attribute}$ = 53.42) than in German ($M_{German\_Attribute}$ = 36.33; t (149) = 2.22, $p < .05$). However, in contrast to our expectations and previous results, in the audio exposure condition comparative attribute evaluations for Dyson EasyDust 12 and Dyson EsayDust 72 were higher in English ($M_{English\_Quality}$ = 47.59) than in German ($M_{German\_Quality}$ = 35.49), but this difference was marginally significant (t (149) = 1.71, p = .089)

Discussion

In addition to replicating the effect of linguistic numeral systems on consumers' ANB evaluations (H1), the results of Study 4 specifically revealed that the inversion in numeral systems also influences how consumers make comparative ANB evaluations (H1b). Specifically, as suggested in H1b, perceived differences between the parent and the extension ANBs are higher in English than they are in German, which has the inversion in its numeral system. And, this effect was replicated with two measures in two different product categories.

The results on the effect of exposure format (e.g., audio/verbal versus digital) do not clearly support H2 for three reasons. First, as in Study 3, the effect of the exposure format and the interaction effect of the exposure format and the language were not statistically significant. Second, similar to Study 3, for the Sony brands, digital, compared to audio, exposure to numbers in ANBs decreased the effect of the language (e.g., the inversion) on consumers' ANB evaluations. This result seems to support the Encoding-Complex Hypothesis. Third, in contrast to the aforementioned result and the results of Study 3, for Dyson brands, digital, compared to audio, exposure to numbers in ANBs did not decrease, but increased the effect of the inversion on ANB evaluations. Hence, in contrast to H2 and the Encoding-Complex Hypothesis, audio/verbal, compared to digital, exposure to numbers in ANBs did not increase the effect of linguistics numeral systems on consumers' ANB evaluations. Taken together, the results of Study 3 and 4 imply that audio/verbal exposure to numbers may increase the effect of linguistic numeral systems on consumers' comparative ANB evaluations, but it is not a prominent factor to drive between language differences. Moreover, we have enough evidence to deduce that digital exposure to numbers in ANBs is an adequate contextual setting to observe the effect of linguistics numeral systems on consumers' ANB evaluations. The mixed structure of these results may also be attributed to various circumstantial factors, such as participants' attention levels. Specifically, extant literature suggests that "remembering what you have *heard* is usually more difficult than remembering what you have *read*" (Pauk 1984, p. 5) as you hear what you read in your mind, and reading is more effective than listening in terms of engaging the motor system (Labruna et al. 2011). Hence, mixed results regarding the effect of audio/verbal versus digital exposure to numbers in ANBs can be due to consumers' varying levels of attention between these two exposure formats.

GENERAL DISCUSSION

This research contributes to the growing literature on ANBs, and numerical cognition 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, such as different bases (e.g., vigesimal vs. decimal), inverted order of digits, and non-transparency influences consumers' ability to make comparative ANB evaluations. Second, we tested for the moderating 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, 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 literature and our findings suggest that culture is not the 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, which is operationalized as consumers' ANB comparisons in our research context.

Specifically, our findings uncover the dimensions of the effects of linguistic properties on number comparisons. First, because vigesimal system can provide an advantage in terms of facilitating number processing over decimal system at formation of large numbers (Zhang and Norman 1995), we found that vigesimal, compared to decimal base, leads to larger differences on consumers' comparative evaluations of ANB. Thus, our findings provide support for the effect of higher processing fluency for comparison of vigesimal numerals than for decimal numerals. Second, knowing that consumers who have an inverted linguistic numeral system, such as German, can pay more attention to the units digit (Macizo and Herrera 2011), we showed 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. Finally, although we had an exploratory approach for the effect of non-transparency on consumers' ANB evaluations, we demonstrated an increasing effect of the non-transparency on consumers' comparative ANB evaluations. Because the elements leading to non-transparency (e.g., a new word for each tens digit) can be deemed to be more abstract, compared to perfectly transparent numerals (e.g., "six-tens" instead if "sixty"), thus, consumers evaluate the spatial distance between the two numbers on the mental line as being larger. This finding is consistent with previous literature on abstract versus concrete construal (Liberman and Trope 2008), and numbers being represented spatially on a mental number line (Moyer and Landauer 1967; Pecher and Boot 2011). Consequently, our findings suggest that these three linguistic numeral systems operate on or trigger different processing routes.

Furthermore, we did not find statistical support for the moderating role of exposure format (verbal vs. digital) to numbers in the effect of language on consumers' ANB evaluations, 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) 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, 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 et al. 1994), past literature does not provide any guidance to marketers on the linguistic differences in processing of 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, which 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. Although we have hypotheses grounded in theories on number processing, empirically showing the underlying mechanism for each linguistic numeral system on consumers' ANB evaluations represent a future research opportunity. Similarly, role of consumer characteristics, such as individual differences, in the influence of language on ANB evaluations can also be a future research direction.

In this research we purposefully focused on ANBs, 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 or Germans perceive higher differences when it comes to engine sizes. However, comparison of differences in brand name numbers as a proxy for product advancement perceptions decreases the likelihood of such arguments 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 predominant factors altering general consumer behavior.

References

Ang, Swee Hoon (1997), "Chinese Consumers' Perception of Alpha-Numeric Brand Names," *Journal of Consumer Marketing*, 14 (3), 220–33.

Bagchi, Rajesh and Derick F. Davis (2012), "$29 for 70 items or 70 items for $29? How Presentation Order Affects Package Perceptions," *Journal of Consumer Research*, 39 (1), 62-73.

Barton, George A. (1908), "On the Babylonian Origin of Plato's Nuptial Number," *Journal of the American Oriental Society,* 29, 210-219.

Bender, Andrea, and Sieghard Beller (2006), "Fanciful" Or Genuine? Bases and High Numerals in Polynesian Number Systems." *The Journal of the Polynesian Society*, 7-46.

Boyd, Colin W. (1985), "Point of View: Alpha-Numeric Brand Names," *Journal of Advertising Research,* 25 (5), 48–52.

Campbell, Jamie I. D. (1994) "Architectures for Numerical Cognition," *Cognition,* 53 (1), 1-44.

Campbell, Jamie I. D., and James M. Clark (1992), "Numerical Cognition: An Encoding-complex Perspective," in *The Nature and Origins of Mathematical Skills,* Jamie I. D. Campbell ed. Amsterdam: Elsevier Science, 457 – 491.

Campbell, Jamie I. D, and Lynette J. Epp (2004), "An Encoding-Complex Approach To Numerical Cognition In Chinese-English Bilinguals" *Canadian Journal of Experimental Psychology*, l58(4), 229-244.

Colome, Angels, Itziar Laka, and Nuria Sebastian-Galles (2010), "Language Effects in Addition: How You Say It Counts," *The Quarterly Journal of Experimental Psychology*, 63 (5), 965-983.

Comrie, Bernard (2005): "Numeral Bases," in *The World Atlas Of Language Structures*, Martin Haspelmath, Matthew S. Dryer, David Gil, Bernard Comrie, Hans-Jörg Bibiko, Hagen Jung, Claudia Schmidt, eds. Oxford: Oxford University Press, 530–533.

De Cruz, Helen (2009), "Is Linguistic Determinism An Empirically Testable Hypothesis?" *Logique and Analyse,* 52 (208), 327-341.

De Cruz, Helen, and Pierre Pica (2008), "Knowledge of Number and Knowledge of Language: Number as a Test Case for the Role of Language in Cognition," *Philosophical Psychology*, 21(4), 437-441.

Dehaene, Stanislas (1992), "Varieties of Numerical Abilities," *Cognition,* 44 (1–2), 1–42.

Dehaene, Stanislas, and Laurent Cohen (1995), "Towards an Anatomical and Functional Model of Number Processing," *Mathematical Cognition*, 1 (1), 83 – 120.

Dehaene, Stanislas, Serge Bossini, and Pascal Giraux (1993), "The Mental Representation of Parity and Number Magnitude," *Journal of Experimental Psychology: General*, 122, 371–96.

Dowker, Ann, Shelia Bala and Delyth Lloyd (2008), "Linguistic Influences on Mathematical Development: How Important is the Transparency of the Counting System?," *Philosophical Psychology*, 21(4), 523- 538.

Frank, Michael C., Daniel R. Everett, Evelina Fedorenko, and Edward Gibson (2008), "Number as a Cognitive Technology: Evidence form Piraha Language and Cognition, *Cognition*, 108 (3), 819 – 824.

Gelman, Rochel and C. R. Gallistel (2004), "Language and the Origin of Numerical Concepts," *Science*, 306 (5695), 441 – 443.

Gordon, Peter (2004), "Numerical Cognition without Words," *Science*, 306 (5695), 496 – 499.

Gunasti, Kunter and William T. Ross Jr. (2010), “How and When Alphanumeric Brand Names Affect Consumer Preferences,” *Journal of Marketing Research*, 47 (6), 1177-1192.

Hardin, Curtis and Mahzarin R. Banaji (1993), “The Influence of Language on Thought,” *Social Cognition*, 11 (3), 277-308.

Hunt, Earl. and Franca Agnoli (1991), “The Worfian Hypothesis: A Cognitive Psychology Perspective,” *Psychological Review*, 98 (3), 377-389.

Ifrah, Georges. (2000), *The Universal History of Numbers: From Prehistory to the Invention of the Computer*, translated by David Bellos, E. F. Harding, Sophie Wood and Ian Monk, John Wiley and Sons: New York.

King, Dan and Chris Janiszewski (2011), “The Sources and Consequences of The Fluent Processing of Numbers,” *Journal of Marketing Research*, 48 (2), 327–341.

Klink, Richard R. (2000), “Creating Brand Names with Meaning: The Use of Sound Symbolism,” *Marketing Letters*, 11(1), 5–20.

Labruna, Ludovica, Miguesl Fernandez-del-Olmo, Ayelet Landau, Julie Duque, and Richard B. Ivry (2011), “Modulation of the Motor System during Visual and Auditory Language Processing,” *Experimental Brain Research*, 211(2), 243-250.

LeClerc, France, Bernd H. Schmitt, and Laurette Dubé (1994) “Foreign Branding and its Effects on Product Perceptions and Evaluations.” *Journal of Marketing Research*, 23 (May), 263-270.

Lee, Angela Y., and Aparna A. Labroo (2004) "The Effect of Conceptual and Perceptual Fluency on Brand Evaluation." *Journal of Marketing Research*, 41 (2), 151-165.

Liberman, Nira, and Yaacov Trope (2008) "The Psychology of Transcending the Here and Now," *Science*, 322 (5905), 1201-1205.

Lowrey, Tina M. and L. J. Shrum (2007), “Phonetic Symbolism and Brand Name Preference,” *Journal of Consumer Research,* 34 (3), 406-414.

Macizo, Pedro, and Amparo Herrera (2011), "Cognitive Control in Number Processing: Evidence from the Unit–Decade Compatibility Effect," *Acta Psychologica,* 136 (1), 112-118.

MacLean, M. & Whitburn, J. (1996) “Number Name Systems and Children’s Early Number Knowledge: A Comparison of Welsh and English Speaking Children,” *International Society for the Study of Behavioral Development (ISSBD) Conference,* XVIth Biennial International Quebec City, Canada.

Miller, Kevin F., Catherine M. Smith, Jianjun Zhu, and Houcan Zhang (1995) "Preschool Origins of Cross-National Differences in Mathematical Competence: The Role of Number-Naming Systems," *Psychological Science* 6 (1), 56-60.

Miura, Irene T., and Yukari Okamoto (1989) "Comparisons of U.S. and Japanese First Graders' Cognitive Representation of Number and Understanding of Place Value," *Journal of Educational Psychology,* 81 (1), 109-114.

Moyer, Robert S., and Thomas K. Landauer (1967) "Time Required for Judgements of Numerical Inequality," *Nature*, 215, 1519-1520.

Pavia, Teresa A. and Janeen Arnold Costa (1993), “The Winning Number: Consumer Perceptions of Alpha-Numeric Brand Names,” *Journal of Marketing*, 57 (3), 85–98.

Pauk, Walter (1984), “Forgetting and Remembering,” *How to Study in College*, Boston, MA: Houghton, Mifflin Co., 82 – 113.

Pecher, Diane, and Inge Boot (2011) "Numbers in Space: Differences between Concrete and Abstract Situations" *Frontiers in psychology,* 2.

Pixner, S., J. Zuber, V. Hermanova, L. Kaufmann, H.-C. Nuerk, and K. Moeller (2011), “One Language, Two Number-word Systems and Many Problems: Numerical Cognition in the Czech Language,” *Research in Developmental Disabilities*, 32 (6), 2683 – 2689.

Pica, Pierre, Cathy Lemer, Véronique Izard, Stanislas Dehaene (2004), “Exact and Approximate Arithmetic in an Amazonian Indigene Group,” *Science*, 306 (5695), 499 – 503.

Thomas, Manoj and Vicki G. Morwitz (2009), “The Ease of Computation Effect: The Interplay of Metacognitive Experience and Naive Theories in Judgments of Numerical Difference,” *Journal of Marketing Research*, 46 (February), 81-91.

Whorf, Benjamin Lee (1956), *Language, Thought, and Reality: Selected Writings of Benjamin Lee*, Whorf, John B. Carroll, eds. Cambridge, MA: Technology Press of Massachusetts Institute of Technology.

Wiese, Heike (2003), *Numbers, Language and the Human Mind*, Cambridge: Cambridge University Press.

Yan, Dengfeng and Rod Duclos, (2013) “Making Sense of Numbers: Effects of Alphanumeric Brands on Consumer Inference,” *International Journal of Research in Marketing*, 30 (2), 179–184.

Zhang, Jiajie, and Donald A. Norman (1995) "A Representational Analysis of Numeration Systems." *Cognition* 57 (3), 271-295.

Zuber, Julia, Silvia Pixner, Korbinian Moeller, and Hans-Christoph Nuerk (2009), “On the Language Specificity of Basic Number Processing: Transcoding in a Language with Inversion and Its Relation to Working Memory Capacity,” *Journal of Experimental Child Psychology*, 102 (1), 60 – 77.

TABLE 1
NUMERAL STRUCTURES IN LANGUAGES

	Base		Digit Order		Non-transparency	
	Decimal (10)	Vigesimal (20)	Inverted (Backward)	Forward	Tens Digit	Irregularities
Chinese	10 = shi 40 = suh (4) shi 80 = ba (8) shi 90 = jyo (9) shi	N/A	N/A	*Forward order Example: 27 = er shi (20) qi (7) 19 = shi (10) jiu (9)	* No new word for each tens digit * Number-word for tens digit = the number and ten Example: 20 = er (2) shi (10)	N/A
Turkish	10 = on 40 = kirk 70 = yetmis 80 = seksen 90 = doksan	N/A	N/A	*Forward order Example: 27 = yirmi (20) yedi (7) 19 = on (10) dokuz (9)	* A new word for each tens digit Example: 20 = yirmi 30 = otuz	N/A
English	10 = ten 40 = forty 70 = seventy 80 = eighty 90 = ninety	N/A	*Inversion between 10 and 20 Example: 19 = nine(9) teen(10) (Similar to German)	*Forward order after 20 Example: 27 = twenty(20) seven(7)	* A new word for each tens digit 20 = twenty 30 = thirty	* 11 = eleven, 12 = twelve * "Teen" instead of "ten" between 10 and 20 Example: 19 = nine (9) teen (10) * Ordinal number-words as units digits Example: 15 = fifteen, not fiveteen
German	10 = zehn 40 = funfzig 70 = siebzig 80 = achtzig 90 = neunzig	N/A	* Inversion property Example: 27 = sieben (7) und (and) zwanzig (20) 19 = neun (9) zehn (10)	N/A	* A new word for each tens digit 20 = zwanzig 30 = dreizig	* 11: elf, 12: zwolf * Missing a portion of "seven" in the number word 17 Example: 17 = sieb zehn (10) not sieben (7) zehn (10)
French	10 = dix 40 = quarante	* Partial vigesimal system Example *Between 80 and 89: 80 = quatre(4) vingt (20) 81 = quatre(4) vingt (20) un (1) *Between 90 and 99: 90 = quatre(4) vingt (20) dix (10) 91 = quatre(4) vingt (20) onze (11)	N/A	* Forward order between 20 and 70 Example: 27 = vingt(20) sept(7) 37 = trente(30) sept(7) 67 = soixante(60) sept(7)	* A new word for each tens digit between 20 and 70 Example: 20 = vingt 30 = trente 40 = quarante 50 = cinquante 60 = soixante	* 11 = onze * 12 = douze * 13 = treize * 14 = quatorze * 15 = quinze * 16 = seize

TABLE 2
SAMPLE NUMBERS IN DIFFERENT LANGUAGES*

#	Chinese	Turkish	English	French	German
1	yi	bir	one	un	eins
2	er	iki	two	deux	zwei
3	san	üç	three	trois	drei
4	si	dört	four	quatre	vier
5	wu	bes	five	cinq	fünf
6	liu	alti	six	Six	sechs
7	qi	yedi	seven	sept	sieben
8	ba	sekiz	eight	Huit	acht
9	jiu	dokuz	nine	neuf	neun
10	**shi**	**on**	**ten**	**dix**	**zehn**
11	shiyi	on bir	*eleven*	*onze*	*elf*
12	shier	on iki	*twelve*	*douze*	*zwölf*
13	shisan	on üç	thirteen	*treize*	dreizehn
14	shisi	on dört	fourteen	*quatorze*	vierzehn
15	shiwu	on bes	fifteen	*quinze*	funfzehn
16	shiliu	on alti	sixteen	*seize*	sechszehn
17	shiqi	on yedi	seventeen	dix-sept	siebzehn
18	shiba	on sekiz	eighteen	dix-huit	achtzehn
19	shijiu	ondokuz	nineteen	dix-neuf	neunzehn
20	**ershi**	**yirmi**	**twenty**	**vingt**	**zwanzig**
21	ershiyi	yirmi bir	twentyone	vingt et un	einundzwanzig
22	ershier	yirmi iki	twentytwo	vingt-deux	zweiundzwanzig
28	ershiba	yirmi sekiz	twentyeight	vingt-huit	achtundzwanzig
29	ershijiu	yirmi dokuz	twentynine	vingt-neuf	neunundzwanzig
30	**sanshi**	**otuz**	**thirty**	**trente**	**dreißig**
40	**sishi**	**kirk**	**forty**	**quarante**	**vierzig**
50	**wushi**	**elli**	**fifty**	**cinquante**	**funfzig**
60	**liushi**	**altmis**	**sixty**	**soixante**	**sechzig**
70	**qishi**	**yetmis**	**seventy**	**soixante-dix**	**siebzig**
71	qishiyi	yetmis bir	seventyone	soixante et onze	einundsiebzig
72	qishier	yetmis iki	seventytwo	soixante-douze	zweiundsiebzig
73	qishisan	yetmis üç	seventythree	soixante-treize	dreiundsiebzig
80	**bashi**	**seksen**	**eighty**	**quatre-vingt**	**achtzig**
81	bashiyi	seksen bir	eightyone	quatre-vingt-un	einundachtzig
82	bashier	seksen iki	eightytwo	quatre-vingt-deux	zweiundachtzig
90	**jiushi**	**doksan**	**ninety**	**quatre-vingt-dix**	**neunzig**
91	jiushiyi	doksan bir	ninetyone	quatre-vingt-onze	einundneunzig
92	jiushier	doksan iki	ninetytwo	quatre-vingt-douze	zweiundneunzig
93	jiushisan	doksan üç	ninetythree	quatre-vingt-treize	dreiundneunzig

** Shaded numbers indicate different properties (inversion, base, non-transparency)*

FIGURE 1
LINGUISTIC PROPERTIES OF NUMERAL SYSTEMS

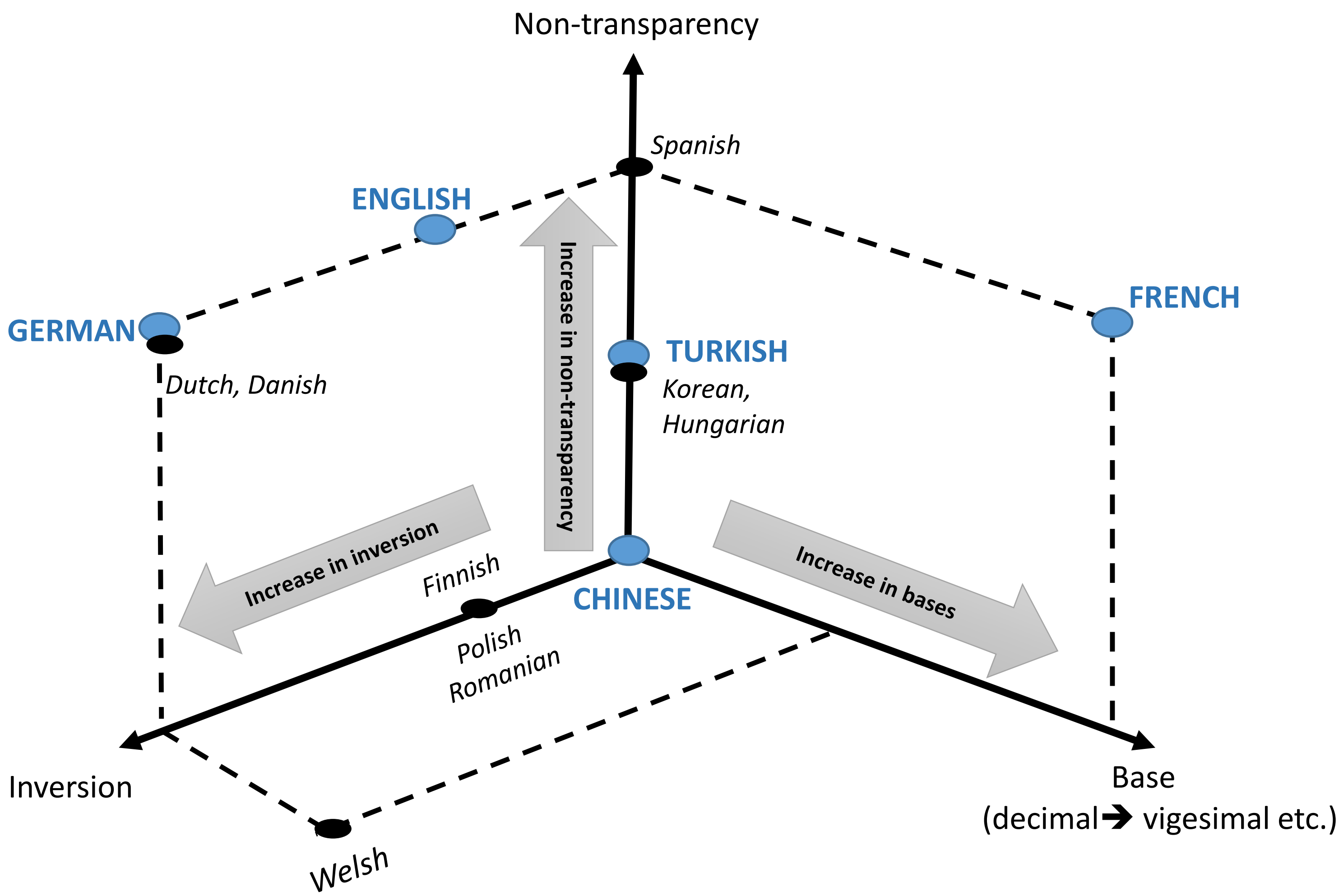


FIGURE 2
THE CONCEPTUAL MODEL

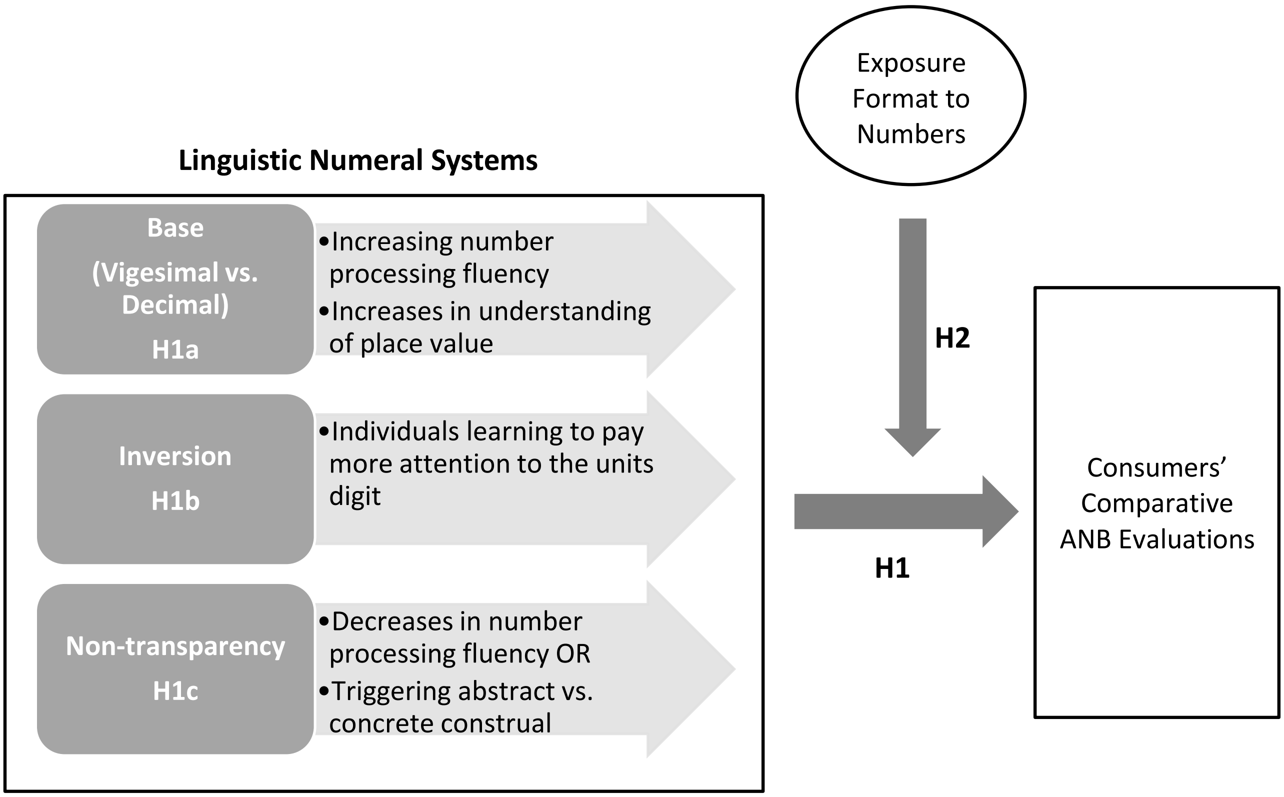
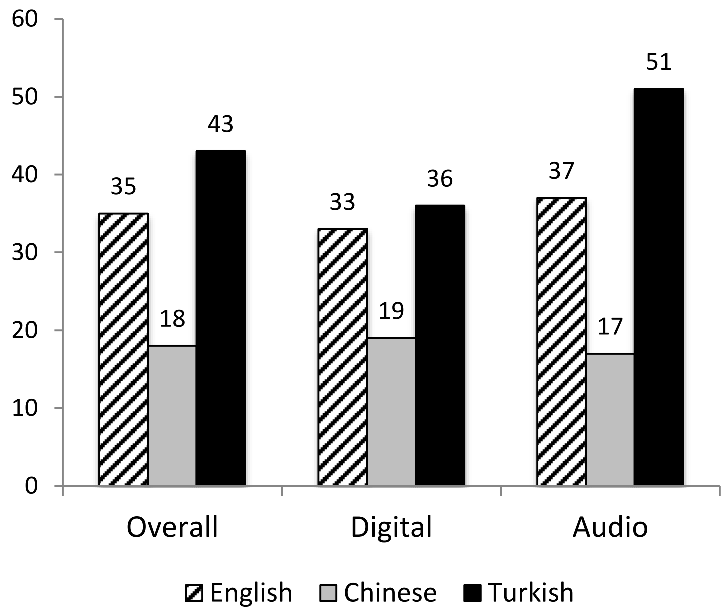
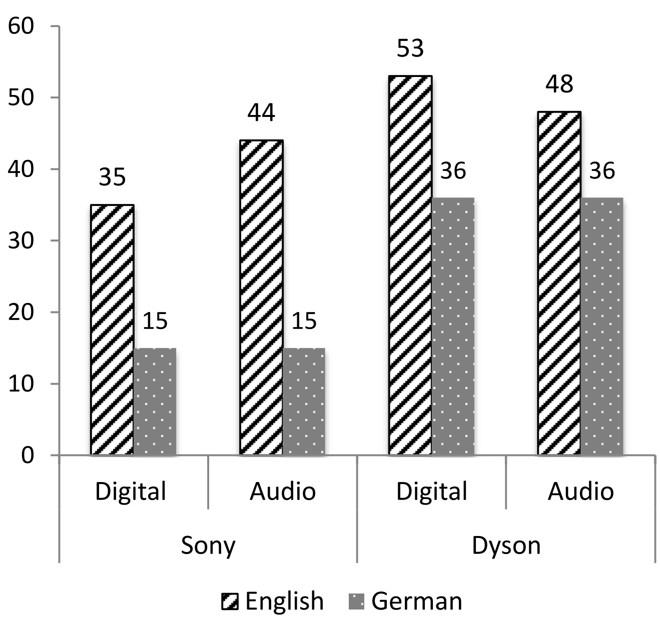


FIGURE 3
COMPARATIVE ATTRIBUTE EVALUATIONS

STUDY 3 – NON-TRANSPARENCY PROPERTY: Sony 11 vs. Sony 66



STUDY 4 – INVERSION PROPERTY: Sony 17 vs. 72 and Dyson 12 vs. 72



APPENDIX A
NUMBERS USED IN STUDIES

STUDY 1		Base Difference Condition		No Base Difference Condition	
Language		27	87	38	68
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 x 20 + 7	30 + 8	60 + 8

STUDY 2		Difference Condition	
Language		28	82
Chinese	Number Word	er-shi-ba	ba-shi-er
	In English	two-ten-eight	eight-ten-two
	Mathematical	2 x 10 + 8	8 x 10 + 2
French	Number Word	vingt-huit	quatre-vingt-deux
	In English	twenty-eight	four-twenty-two
	Mathematical	20 + 8	4 x 20 + 8

STUDY 3		Numbers	
Language		11	66
English	Number Word	eleven	sixty-six
	Mathematical	11	60 + 6
Turkish	Number Word	on-bir	altmis-alti
	In English	ten-one	sixty-six
	Mathematical	10 + 1	60 + 6
Chinese	Number Word	shi-yi	liu-shi-liu
	In English	ten-one	six-ten-six
	Mathematical	10 + 1	6 x 10 + 6

STUDY 4		Numbers for Sony		Numbers for Dyson	
Language		17	72	12	72
English	Number Word	seven-teen	seventy-two	twelve	seventy-two
	Mathematical	7 + 10	70 + 2	12	70 + 2
German	Number Word	sieb-zehn	zwei-und-siebzig	zwolf	zwei-und-siebzig
	In English	seven-ten	two-and-seventy	twelve	two-and-seventy
	Mathematical	7 + 10	2 + 70	12	2 + 70

APPENDIX B
STIMULI USED IN STUDIES

The Stimulus in Study 1

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

(4)

(3)

(2)

(1)

The Stimulus in Study 2

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. TOMTOM is here to save you from getting lost.