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Small Sounds, Big Deals: Phonetic Symbolism Effects in Pricing

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Studies suggest that certain vowel and consonant sounds (or phonemes) can be associated with perceptions of large and small size. Mental rehearsal of prices containing numbers with small phonemes results in overestimation of price discounts, whereas mental rehearsal of prices containing numbers with large phonemes results in underestimation. Mental rehearsal of the same sale prices characterized by small phonemes in one language and large phonemes in another language can yield differential effects. For example, when sale prices are rehearsed in English, an $11.00 – $7.88 (28.4%) discount is perceived as greater than a $10.00 – $7.01 (29.9%) discount; however, when these same prices are rehearsed in Chinese, the latter discount is perceived as greater. Non-price-related phonemes do not yield these same discount distortions. Collectively, findings indicate that the mere sounds of numbers can nonconsciously affect and distort numerical magnitude perceptions.

When exposed to comparative price information, consumers may process that information consciously and deliberately. Yet, research suggests that other less relevant aspects of the numerical stimulus, such as font size (Coulter and Coulter 2005) or physical distance between prices (Coulter and Norberg 2009), may nonconsciously affect price perceptions. These nonconscious effects may occur because price information processing can result in the encoding in memory of magnitude representations, which are judgments of relative size arrayed in analog format along a left-to-right-oriented mental number line (Dehaene, Bossini, and Giraux 1993). Importantly, the data actually encoded in memory may not involve exact numerical values but rather more global assessments of a product's price (e.g., it is expensive or highly discounted). Consumers encode and subsequently retrieve numeric value-related magnitude representations effortlessly, automatically, and apparently without awareness (Coulter and Coulter 2007; Pavese and Umilta 1998; Tzelgov, Meyer, and Henik 1992). These implicit assessments may drive purchase decisions in the absence of more precise empirical information (Roediger and McDermott 1993).

Dehaene (1989, 1992) has argued that the magnitude representation that sustains the processing of numeric values may be highly related to the underlying magnitude code that sustains the processing of physical stimuli. In support of this argument, recent work in cognitive neuroscience documents close behavioral parallels between the processing of quantitative information associated with the numerical difference between numbers (e.g., large or small) and that associated with the physical distance (e.g., close or far) between numbers or other sets of visual stimuli, such as lines and angles (Fias et al. 2003; Seron and Fias 2006). Those parallels have led researchers to posit that there exists a common cerebral representation of magnitude or quantity (Dehaene, Dehaene-Lambertz, and Cohen 1998). Studies using fMRI brain-imaging technology confirm that the processing of various forms of quantitative information has a common neural basis and that the activated processing substrate occurs in the vicinity of the intraparietal sulcus (Pesenti et al. 2000; Pinel et al. 2004; Seron and Fias 2006). With regard to numerical information, this commonality of processing implies that magnitude representations related to both numeric value and sensory-related stimuli (e.g., physical font size) may be automatically evoked on stimulus exposure (Dehaene and Akhavein 1995), and each can affect how the other is encoded (Coulter and Coulter 2005).

The purpose of our research is to examine the effects of one such (magnitude-representation-inducing) sensory-related stimulus, that is, the sounds associated with particular numbers. More specifically, in the context of four experi-

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ments, we investigate the effects of auditory encoding of price sounds on consumer perceptions of relative discount, sale price value, and purchase intentions. We use multiple regular versus sale price combinations chosen to reflect phonetically relevant sounds that have been demonstrated to affect size perceptions. In experiments 1 and 2, our hypothesized effects are examined across prices in English; in experiments 3 and 4, we test the same price combinations that are posited to have different effects across English, Chinese, and Spanish languages.

THEORETICAL DEVELOPMENT

Visual, Auditory, and Analog Coding of Price Information

Research in the field of numerical cognition suggests that individuals process numerical information, and hence prices, through a dedicated cognitive subsystem (Ashcraft 1992; Dehaene 1992, 1997; McCloskey 1992; Vanhuele, Laurent, and Dreze 2006). According to McCloskey's (1992) modular theory, this subsystem consists of unitary, abstract representations of quantity (i.e., number-semantic representations) that serve as a mental platform on which all numerical operations, such as arithmetic fact retrieval and mental calculation, are performed (McCloskey and Macaruso 1995). Alternatively, Dehaene (1992) has proposed a triple-code model of the cognitive numerical subsystem, which maintains that numbers can be mentally represented and manipulated in three different forms: visual, auditory, and analog. The visual (Arabic) code represents numbers on a spatial-visual medium given their written form in Arabic numerals (e.g., 72); these representations can be processed or generated in each of the cerebral hemispheres in the occipital-temporal regions of the ventral-visual pathway (Dehaene and Cohen 1995). The auditory (phonological) code is represented by a sequence of word sounds or phonemes (e.g., "seventy" and "two") and is present only in the left hemisphere within the classic perisylvian language areas (Dehaene and Cohen 1995). Finally, the analog magnitude code represents numbers as judgments of relative size arrayed in parallel format along a left-to-right-oriented mental number line (Dehaene et al. 1993; Dehaene, Dupoux, and Muehler 1990). Both hemispheres possess an analog magnitude representation of numbers in the vicinity of the parieto-occipito-temporal junction (Dehaene and Cohen 1995; Pinel et al. 1999).

Research studies demonstrate that the various internal codes and processing routes are independent of the stimulus code (e.g., Arabic or verbal number forms) in which the input is presented (Dehaene 1992; Gallistel and Gelman 1992; McCloskey 1992) and that each of the three codes is differentially involved in various kinds of arithmetic operations, computational tasks, and number processing (Cohen and Dehaene 1996; Dehaene et al. 1998). For example, simple arithmetic operations, such as multiplication and addition, which rely on rote verbal memory acquired through overt and covert oral rehearsal (e.g., "three dollars times four dollars equals twelve dollars") are tasks that involve the auditory code (Lee and Kang 2002). Further, tasks that require some degree of mental calculation (e.g., computing total shopping expenditure or estimating the relative discount associated with a regular vs. sale price) are likely to involve phonological representations (Luna and Kim 2006; McCloskey and Macaruso 1995).

Despite their functional specificity, however, research has demonstrated that the visual, auditory, and analog representations are neurologically connected (Noel 2001). Further, studies indicate that a representation in the analog magnitude code is generated automatically and nonconsciously whenever a number is represented in the auditory or visual code (Dehaene et al. 1990). Recently, Vanhuele et al. (2006) examined the processing of price information in a simulated online comparative shopping environment. By demonstrating that working memory capacity limitations exist for price information and that capacity is a function of the number of syllables in a price name (e.g., "twenty-three"), they affirm that both phonological and analog representations are encoded during mental rehearsal of price information. These findings suggest that sensory-related magnitude representations associated with the verbal code could influence numeric-value-related magnitude representations associated with the analog code. In other words, the mere sound of the number in a price might influence the numerical value associated with that price, depending on the meaning associated with the sound.

Phonetic Symbolism and Number Sounds

Phonetic symbolism refers to the ability of particular word sounds or phonemes (i.e., the fundamental building blocks of sound in a language) to convey information and hence influence perceptions (Eysenck 1979). Some research has suggested that the phonetic aspects of a word (i.e., how it sounds) may have an impact on a semantic dimension (i.e., what that word conveys), which in turn may influence perceptions through a semantic association (Lowrey, Shrum, and Dubitsky 2003). Other work has demonstrated that vowel and consonant sounds can symbolize concepts such as size (Sapir 1929) and degree of darkness (Newman 1933) in and of themselves, regardless of the underlying word meaning in which these letters are embedded.

At the broadest level, phonetic symbolism researchers categorize phonemes in terms of vowels and consonants. Vowels are then subcategorized on a front versus back distinction. Specifically, front vowels are characterized by the highest position of the tongue being more toward the front of the mouth during pronunciation (e.g., the "ee" in "three" or the "i" in "six"), whereas back vowels are characterized by the highest position of the tongue being more toward the back of the mouth (e.g., the "o" in "two" or the "u" in "duck"; Klink 2000). Although consonants can also be classified in terms of the front/back distinction, they are more typically categorized as fricatives (spirants) or stops (initial plosives). Fricatives ("s," "f," "v," and "z") are formed by allowing air to flow past the articulators (i.e., lips, teeth, and tongue), which creates friction. Stops ("p," "k," "t," "b," "g," "d," and hard "c") are formed from the complete closure of the articulators, which impedes air flow. Table 1 reports a front/back classification of English vowel sounds (Klink 2000), as well as English, Chinese, and Spanish number words in which these sounds are applicable.

The front/back vowel and fricative/stop consonant distinctions have been consistently related to a variety of spatial dimensions and thus are of particular interest in the present study. A key finding is that back (front) vowel sounds typically are associated with perceptions of large (small) size (Birch and Erickson 1958; Klink 2000; Newman 1933), and these effects have appeared consistent across 125 languages (Ultan 1978). Sapir (1929) suggests that the effect may be due to the fact that the volume of certain vowel sounds is greater than others. For the front vowels, in which the tongue is higher and at the front of the mouth, the resonant cavity is small relative to back vowels, in which the tongue is lower and toward the back of the mouth (Becker and Fisher 1988; Pinker 1994; Shrum and Lowrey 2007). Differential perceptions of size associated with the front and back vowels may be the evolutionary result of humans using resonant cavity and formant dispersion (i.e., the difference between resonance frequencies, which is tied to vocal tract length) as a cue to body size (Fitch 1994, 1997). In addition, Morton (1994) argues that because front vowels are of a higher frequency than back vowels and because frequency and mass of the vibrating tissue are inversely related, higher (lower) frequency sounds may convey a smaller (larger) size.

Research has also investigated phonetic symbolism effects associated with various consonant sounds (see table 1). Similar to back (front) vowels, stops (fricatives) typically are associated with perceptions of large (small) size (Klink 2000; Newman 1933; Sapir 1929). Market researchers have found that brand names containing fricatives tend to be perceived as smaller, faster, and lighter than those containing stops (Klink 2000; Ohala 1994). In addition, Klink (2003) found that front vowels and fricatives tend to be associated with smaller and more angular shapes than back vowels and stops. Moreover, Yorkston and Menon (2004) demonstrate that sound symbolism occurs automatically at a nonconscious level and has a greater effect when cognitive resources are constrained than when they are abundantly available.

Hypotheses

As noted earlier, magnitude representations related to both numeric value and sensory-related (e.g., phonetic symbolism) stimulus dimensions may be automatically evoked upon stimulus exposure (Dehaene and Akhavein 1995), and each can have an impact on how the other is encoded. For example, research involving visual dimensions (e.g., font size) in comparative price advertising has demonstrated that when lower sale prices appear in smaller font than higher regular prices, those sale prices are more likely to be perceived as small in comparison to the regular prices, and the regular prices are more likely to be perceived as large in comparison to the sale prices (Coulter and Coulter 2005). By reinforcing numeric value perceptions, physical font size "congruency" (Dehaene 1992) facilitates consumers' ability to distinguish between regular and sale prices, which in turn increases the perceived difference between them (i.e., discount magnitude). Conversely, physical font size incongruency interferes with price comparisons, making it more difficult to distinguish between the two numeric values and therefore decreasing the perceived difference.

TABLE 1

PHONETIC SYMBOLISM ACROSS LANGUAGES

	Letter and pronunciation	Hypothesized perceptual effect	Language: English[a]	Language: Chinese[b]	Language: Spanish[c]
Vowel:					
Front	e (bee), i (hit), a (hate), e (test)	Smaller	3, 6, 7, 8, 10	1 (*yee*), 7 (*chee*)	3 (*tres*), 6 (*seis*), 7 (*siete*)
Back	a (ban), u (food), u (put), o (home), o (caught), u (duck), a (cot)	Larger	1, 2	2 (*uhr*), 3 (*sahn*), 4 (*suh*), 5 (*woo*), 8 (*bah*), 9 (*jyo*), 10 (*shi*)	1 (*uno*), 2 (*dos*), 8 (*ocho*)
Consonant:					
Fricative	s, f, v, z	Smaller	4, 5, 6, 7	3 (*sahn*), 4 (*suh*), 10 (*shi*)	6 (*seis*)
Stop	p, k, t, b, g, d, hard c	Larger	2, 10	8 (*bah*)	2 (*dos*), 3 (*tres*), 4 (*cuatro*), 10 (*diez*)
Vowel/consonant:					
Front/fricative	fizz	Smaller[d]	3, 6, 7, 8	1, 7	3, 6, 7
Back/stop	pad	Larger	1, 2	2, 5, 8, 9	1, 2, 4, 8, 10

[a]English number "nine" does not fall into listed categories and therefore is not included in table.
[b]Chinese number *lyo* (6) does not fall into listed categories and therefore is not included in table.
[c]Spanish numbers *cinco* (5) and *nueve* (9) contain both front and back vowel sounds and therefore are not included in table.
[d]The (th) diphthong in the English number "three" is typically not classified within either fricative or stop consonant categories, and hence, 3 may be associated with perceptions of smallness.

In the case of phonetic symbolism effects, we argue that a sound-related phonological representation may reinforce or interfere with the encoding of a numeric-value-related analog magnitude representation in a similar manner (Brysbaert, Fias, and Noel 1998; Whorf 1956). We expect that these phonological codes will be elicited when the consumer is actively engaged in the shopping process, such that he/she either verbalizes or mentally rehearses the sale price, as when looking to find the lowest priced item (Vanhuele et al. 2006). As a consequence, sale price phonological codes that are associated with perceptions of smallness (largeness) should increase the likelihood that consumers perceive sale prices as small (large) in comparison to regular prices and hence perceive larger (smaller) discounts. Further, we expect that if consumers are to some degree price sensitive and product quality is uniform, the value that they associate with the product will reflect the perceived price difference: greater perceived discounts will foster greater sale price value assessments and increase purchase intentions (Grewal, Monroe, and Krishnan 1998; Urbany, Bearden, and Weilbaker 1988). These perspectives suggest a phonological rehearsal by price phoneme interaction, such that:

H1: When sale price rehearsal leads to auditory price-representation encoding, price discounts will be overestimated (underestimated) for sale prices containing front vowels/fricatives (back vowels/stops); in the absence of sale price rehearsal, phonetic symbolism effects will not occur, and consumer perceptions will reflect actual discounts (**H1a**). We also expect that sale price value assessments (**H1b**) and purchase intentions (**H1c**) will reflect participants' price discount perceptions.

EXPERIMENT 1: THE EFFECTS OF PRICE-RELATED PHONEMES

Method

Stimulus Development. In selecting the sale prices for our experiments, we concentrate on price numbers for which vowel and consonant sounds are predicted to have consistent small or large size effects. Specifically, the English number words for 3, 6, 7, and 8 involve front vowels and fricative consonants and therefore are expected to be associated with perceptions of smallness, whereas the number words for 1 and 2 involve back vowels and stop consonants and are expected to be associated with perceptions of largeness (see table 1). Thus, we chose 6's and 3's to manipulate small perceptions and 2's to manipulate large perceptions and created two sets of regular-sale price combinations in which we held the dollars digits constant and manipulated phonemes by varying the sale price endings (cents digits): \$10.00 − \$7.66 (front vowel/fricative, 23.4% discount), \$10.00 − \$7.22 (back vowel/stop, 27.8% discount), \$3.00 − \$2.33 (front vowel, 22.3% discount), and \$3.00 − \$2.22 (back vowel/stop, 26.0% discount). By holding the sale price dollar digits constant at 7 or 2, we are able to hold invariant total phonological length (i.e., at five or four syllables, respectively), maintain consistent ease of computation across all price-pair comparisons (Thomas and Morwitz 2009), and ensure that the total number of syllables is less than the average memory span of 13 (Vanhuele et al. 2006). This procedure also allowed us to compare reinforcement/interference effects across price combinations as a test of our hypotheses.

We next constructed four comparative price ads for a fictitious brand of ice cream scoop, which could be associated with a range of prices. The ads had the identical headline, copy, and illustration; they differed only with regard to the stated regular and sale prices. Prices were placed side by side (3 inches apart) to facilitate serial rather than columnar digit-by-digit comparison. Pretest results ($n = 25$) indicated no significant ($p > .05$) difference in attitude toward the four ads; thus, any affect transfer associated with particular price combinations was not expected to confound our experimental results. We also constructed seven filler ads for different products; they were visually similar to the target ad but without price information. The eight ads, with the ice cream scoop target ad in position three, were combined into a booklet.

Procedures. Graduate and undergraduate students ($n = 201$) from a major northeastern university participated in experiment 1 for course credit. Participants were randomly assigned to one of eight conditions: 2 (rehearsal: sale price vs. no rehearsal) × 4 (sale price phonemes: front vowels/fricatives [\$7.66, \$2.33] vs. back vowels/stops [\$7.22, \$2.22]). The students were instructed that they would be analyzing a video case study involving a local retail department store chain and, as background for that case study, should first look through a booklet of print ads for products carried by the retailer. Participants viewed each ad for 10 seconds. To ensure verbal encoding, participants in the phonological rehearsal conditions were instructed to "read to yourself, without speaking out loud" any sale prices they encountered. They were further told to rehearse the prices internally to keep them in memory because they would be asked to recall sale (but not regular) prices. Our experimental manipulation is consistent with previous studies that have based their design on in-store price comparisons (e.g., Vanhuele et al. 2006). Specifically, because products are not located contiguously, consumers who are comparing prices must retain the prices associated with particular products or brands in short-term working memory. This paired-associate learning is facilitated through internal price recitation. In the non-phonological conditions, instructions regarding rehearsal of sale prices were omitted. Immediately after viewing the ad booklet, participants completed a 5-minute distraction task. They then completed a questionnaire to measure their value assessments, purchase likelihood, perceived price discounts (in percentage terms), level of attention to and recall of prices, and ad involvement (in that order) related to the ice cream scoop. Finally, participants were debriefed.

Measures. Participants rated the sale-priced target product on a 7-point less-to-more value item (Monroe and Lee 1999) and purchase likelihood of the target product at the sale price (assuming they were in the market for an ice cream scoop) on a 7-point very unlikely–very likely scale (Coulter and Coulter 2005). To measure perceived price discount, we asked participants to "list the approximate sale price discount for the ice cream scoop in percentage terms" (i.e., to list how much lower the sale price was compared to the regular price). To assess possible confounds, participants reported their degree of attention to (very little–very much 7-point scale) and recall of (subsequently coded as correct/incorrect) the ice cream scoop regular and sale prices and ad involvement (two 7-point Likert-scale items: "paid attention to the advertisement" and "was involved in the ad"; $r = .81$; Laczniak and Muehling 1993).

Results

Hypothesis 1a posited that price discounts would be overestimated for sale prices containing front vowel/fricatives and underestimated for sale prices containing back vowel/stops. Because we held regular prices constant at \$10.00 and \$3.00 and the respective sale price dollar digits constant at 7 and 2, the front vowel/fricative sale price numbers represented smaller actual discounts (23.4%, 22.3%), whereas the back vowel/stop sale price numbers represented larger actual discounts (27.8%, 26.0%). Thus, we were able to compare phonological reinforcement/interference effects across price combinations (i.e., \$10.00 − \$7.66 vs. \$10.00 − \$7.22, \$3.00 − \$2.33 vs. \$3.00 − \$2.22) as a stringent test of our hypothesis. Therefore, we first conducted a between-subjects ANOVA with perceived discount as the dependent measure and rehearsal (sale price vs. no rehearsal) and sale price phonemes (front vowels/fricatives [\$7.66, \$2.33] vs. back vowels/stops [\$7.22, \$2.22]) as independent variables. As expected, we found a significant rehearsal by sale price phoneme (disordinal) interaction ($F(3, 193) = 8.68$, $p < .001$; partial $\eta^2 = .12$). Planned contrasts revealed that participants rehearsing the front vowel/fricative phonemes (\$7.66 and \$2.33 sale prices) perceived greater discounts than those rehearsing the back vowel/stop phonemes (\$7.22 and \$2.22 sale prices; $M_{\$7.66} = 28.70$ vs. $M_{\$7.22} = 25.93$; $t(58) = 2.32$, $p < .05$; $M_{\$2.33} = 28.10$ vs. $M_{\$2.22} = 24.13$; $t(45) = 2.55$, $p < .05$). In the no-rehearsal conditions, perceived discounts reflected actual discounts, and participants exposed to the higher-discounted sale prices perceived greater discounts than did those exposed to the lower-discounted sale prices ($M_{\$7.66} = 23.21$ vs. $M_{\$7.22} = 27.33$; $t(36) = 5.55$, $p < .001$; $M_{\$2.33} = 22.50$ vs. $M_{\$2.22} = 25.05$; $t(37) = 2.38$, $p < .05$). Thus, hypothesis 1a is supported.

ANOVA results also revealed significant sale price phoneme by rehearsal interactions for both sale price value assessment ($F(3, 193) = 7.33$, $p < .001$; partial $\eta^2 = .10$) and purchase likelihood ($F(3, 193) = 4.08$, $p < .01$; partial $\eta^2 = .06$). Consistent with discount perceptions, participants in the phonological rehearsal conditions perceived that the front vowel/fricative sale prices reflected greater value than the back vowel/stop sale prices ($M_{\$7.66} = 4.87$ vs. $M_{\$7.22} = 3.73$; $t(55) = 3.32$, $p < .01$; $M_{\$2.33} = 4.73$ vs. $M_{\$2.22} = 3.70$; $t(52) = 2.85$, $p < .01$), even though in both cases the former prices were actually discounted less. Moreover, participants expressed greater purchase likelihood for the front vowel/fricative sale prices than the back vowel/stop sale prices ($M_{\$7.66} = 4.20$ vs. $M_{\$7.22} = 3.10$; $t(57) = 3.51$, $p < .001$; $M_{\$2.33} = 4.20$ vs. $M_{\$2.22} = 3.20$; $t(55) = 2.63$, $p < .05$). These results are consistent with hypotheses 1b and 1c. In the no-rehearsal conditions (with the exception of the \$7.22 vs. \$7.66 value comparison; $M_{\$7.22} = 4.67$ vs. $M_{\$7.66} = 3.97$; $t(35) = 2.81$, $p < .05$), value perceptions and purchase intentions were directionally consistent with expectations (i.e., greater for the higher-discounted \$7.22 and \$2.22 sale prices) but not statistically different ($p > .05$).

As noted, we considered several possible confounds. Consistent with our instructions, participants paid greater attention to the sale than to the regular price ($M = 5.11$ vs. $M = 3.72$; $t(200) = 10.61$, $p < .001$). However, one-way ANOVAs across the four price combinations revealed no significant differences in level of attention to the sale price or regular price and no difference in level of ad involvement ($p > .05$). Also, we observed more accurate recall of both regular and sale prices in the phonological rehearsal conditions (79%, 87%) than in the non-rehearsal conditions (53%, 59%). However, in each of the four price rehearsal conditions, we found no significant difference in discount perceptions between participants who recalled the sale price versus those who did not ($p > .10$). These results indicate that sale price recall is not a necessary condition for phonetic symbolism manifestation. They may also suggest that price discount assessments were made at (or near) the time of target ad exposure rather than at the time of questionnaire item completion, because one might argue that accurate recall of regular and sale prices should assuage (rather than increase) the distortion of discount estimates. Finally, during the post-experimental debriefing, no participants guessed the hypothesized linkage between independent and dependent variables, implying that the effects of phonetic symbolism occur below the threshold of conscious awareness.

Summary and Discussion

Our results demonstrate that within the phonological rehearsal conditions, perceived discount was greater for the front vowel/fricative (\$7.66, \$2.33) than for the back vowel/stop (\$7.22, \$2.22) sale prices. Because the actual relative discounts were greater in each of the latter two instances, our results indicate that the mentally rehearsed sound phonemes either reinforced (\$7.66, \$2.33) or interfered with (\$7.22, \$2.22) the analog magnitude representations associated with the sale price discounts. More specifically, we posit that rehearsal of price words containing fricatives and front vowels (e.g., "seven sixty-six") caused the analog magnitude representations to be perceived and encoded as smaller than actual, whereas rehearsal of price words containing stops and back vowels (e.g., "seven twenty-two") caused the analog magnitude representations to be perceived and encoded as larger than actual. These perceptions of smallness (largeness), which apparently occurred at a nonconscious level, increased (decreased) the magnitude of the perceived discount, thereby affecting the value associated with the sale price.

EXPERIMENT 2: EXPLORING PRICE VERSUS NON-PRICE-RELATED PHONEMES

Consistent with Dehaene's (1992) triple-code model, we have maintained that prices with large versus small size-evoking phonemes were processed and encoded in memory as phonological representations (Dehaene 1992). A proponent of McCloskey's (1992) modular theory, however, might argue that exposure to phonetic symbolism involving a non-price-related auditory dimension could yield similar results. In other words, mental rehearsal of the term "sissy" and the number "six" could have the same effects. In experiment 2, we examine the possible effects of non-price-related words on discount assessments by employing phonological suppression to impede auditory price encoding (Dehaene 1992). Specifically, we ask participants to recite to themselves an alternate word or phrase, consistent with the price phonemes under investigation, at the time of visual exposure to the price stimuli. This controlling manipulation should cause participants to suppress the phonological codes associated with the observed prices, while still encoding the appropriate analog magnitude representations (Lee and Kang 2002). We maintain that a necessary condition for our hypothesized phonetic symbolism effects to manifest is that the phonemes are directly linked to the price names, rather than to non-price-related words or phrases. Thus, we anticipate a phoneme by rehearsal type (price vs. non-price-related) interaction, such that:

H2: When sale prices are rehearsed, price discount will be overestimated (underestimated) for sale prices containing front vowels/fricatives (back vowels/stops). Rehearsal of non-price-related phonemes (suppression) will result in perceived discounts closely mirroring actual discounts (**H2a**). Sale price value assessments are expected to reflect participants' perceived price discounts (**H2b**).

Method

Graduate and undergraduate students ($n = 171$) from a major U.S. university participated in experiment 2 for course credit. Sale prices employed the same cents digits as in experiment 1 (6's to manipulate small perceptions and 2's to manipulate large perceptions) but a different dollar digit (6), in order to rule out the effects of a specific dollar frame of reference on dependent variable results. We also held the regular price constant ($10.00), such that the fricative/front vowel sale price represented the smaller actual discount (33.4%), and the stop/back vowel sale price represented the larger actual discount (37.8%). Specifically, we employed a 2 (sale price phoneme: front vowel/fricative [$6.66] vs. back vowel/stop [$6.22]) × 4 (rehearsal: price, fricative suppression, stop suppression, neutral suppression) between-subjects design. Procedures, target ad format, measures, and price rehearsal instructions were identical to experiment 1. We changed the target product to a steak knife to examine the robustness of phonetic price symbolism effects across another product category, and we manipulated three non-price-related phoneme conditions in which participants were instructed to read and rehearse specific attribute-related phrases because they would subsequently be asked to recall those particular product attributes. The phrases were (1) "silver serrated edges," containing a preponderance of fricatives and front vowels (fricative suppression); (2) "cuts cooking time," containing a preponderance of stops and back vowels (stop suppression); and (3) "easy grip handle," containing both front vowel/fricatives and back vowel/stops (neutral suppression).

Results

In experiment 2, because we held the regular price constant at $10.00 and the sale price dollar digit constant at 6, the front vowel/fricative sale price ($6.66) represented the smaller actual discount, whereas the back vowel/stop sale price ($6.22) represented the larger actual discount. Thus, we were again able to compare phonological reinforcement/interference effects across price combinations as a more stringent test of our hypothesis. We first conducted a between-subjects ANOVA, which revealed a significant sale price phoneme by rehearsal (disordinal) interaction ($F(3, 163) = 8.17$, $p < .001$; partial $\eta^2 = .13$). Follow-up planned contrasts indicated that participants who rehearsed the lower-discounted (33.4%) $6.66 front vowel/fricative sale price perceived a greater price discount than did those who rehearsed the higher-discounted (37.8%) $6.22 back vowel/stop sale price ($M_{\$6.66} = 37.02$ vs. $M_{\$6.22} = 33.56$; $t(49) = 3.28, p < .01$). Perceived price discounts in the phonological suppression conditions were not significantly different from actual discounts ($p > .10$); thus, the discount associated with the $6.22 sale price was perceived as greater than that associated with the $6.66 sale price in the neutral ($M_{\$6.22} = 38.16$ vs. $M_{\$6.66} = 34.45$; $t(37) = 2.50, p < .05$), fricative ($M_{\$6.22} = 37.98$ vs. $M_{\$6.66} = 33.83$; $t(31) = 2.74$, $p < .01$), and stop ($M_{\$6.22} = 36.26$ vs. $M_{\$6.66} = 32.50$; $t(37) = 2.54, p < .05$) suppression conditions. These results support hypothesis 2a.

With regard to sale price value assessment, ANOVA results again revealed a significant phoneme by rehearsal interaction ($F(3, 163) = 6.23$, $p < .001$; partial $\eta^2 = .10$). Consistent with the perceived price discount results and hypothesis 2b, contrasts revealed that participants in the price rehearsal condition attributed greater value to the (higher-priced, lower-discounted) front vowel/fricative sale price than to the (lower-priced, higher-discounted) back vowel/stop sale price ($M_{\$6.66} = 4.85$ vs. $M_{\$6.22} = 3.60$; $t(47) = 3.31$, $p < .01$). As expected, sale price value assessments in the suppression conditions were greater for the lower-priced ($6.22), higher-discounted items.

We conducted a series of mean comparisons across price conditions and found no significant differences in regular or sale price attention or ad involvement ($p > .05$). A smaller percentage of participants in experiment 2 than in experiment 1 correctly recalled the regular (52%) and sale (59%) prices, reflecting the suppression of phonological representation encoding in six of our eight conditions. As in experiment 1, in each of the price rehearsal conditions we found no significant difference in discount perceptions between participants who recalled the sale price versus those who did not ($p > .10$). During the post-experimental debriefing process, no participants guessed the hypothesized relationships.

Summary and Discussion

Results from experiments 1 and 2 indicate that consumers who rehearsed prices ascribed greater value to the sale prices containing front vowels and fricatives than to those containing back vowels and stops. However, in the absence of rehearsal (experiment 1) or when non-price-related phonological phrases were rehearsed (experiment 2), perceived discounts reflected actual discounts. Recitation of non-price-related phonemes appears to suppress the generation of auditory/phonological codes associated with front vowel/fricative and back vowel/stop sale prices. Further, our results suggest that the mere sound of the words contained in front vowel/fricative or back vowel/stop phrases is not sufficient to directly affect analog magnitude representations. Rather, the phonemes must be associated with auditory price encoding, and some form of auditory-analog neurological linkage, as proposed by Dehaene's (1992) triple-code model, must be present for analog magnitude representation distortion to occur.

Despite the non-price-related rehearsal in the suppression conditions, participants were relatively accurate in their price discount assessments (range = 32.50%–38.16%). This result is not surprising, given that phonological suppression represents only a partial diversion of attention. The controlling manipulation causes participants to suppress the phonological codes associated with the observed prices, while still encoding (i.e., at the time of target ad exposure) the appropriate analog magnitude representations. Those analog codes appear to remain relatively unaffected, unless subsequently distorted by phonetic rehearsal along a price-related dimension. Our findings of a relatively high degree of accuracy in the suppression as well as the control conditions in experiment 1 are consistent with studies involving non-relevant dimensional reinforcement/interference effects that have appeared in the behavioral pricing literature (e.g., Adaval and Monroe 2002; Coulter and Norberg 2009; Kruger and Vargas 2008).

EXPERIMENTS 3 AND 4: EXPLORING PRICE PHONEMES ACROSS LANGUAGES

Our assessment of the sound phonemes associated with specific numbers reveals that they can vary across languages. For example, the word for the number 3 contains a front vowel in English ("ee" in "three") but a back vowel in Chinese ("a" in *sahn*; see table 1). Thus, in our final two experiments, we investigate our proposed phonetic symbolism effects across languages. Specifically, we examine effects in English and Chinese languages in experiment 3 and English, Chinese, and Spanish languages in experiment 4.

Experiment 3

In experiment 3, we examine price number words that are predicted to have consistent small versus large size vowel and consonant effects within the English and Chinese languages but that vary across the two languages. Specifically, we selected $7.88 and $7.01 as sale prices because the (88) cents digits are pronounced as front vowels in English but as back vowels/stops in Chinese, and the (1) cents digit is pronounced as a back vowel in English but as a front vowel in Chinese (we chose not to employ two 1's as cents digits because 11 [pronounced as "eleven" in English] contains different phonemes). Further, we selected regular prices ($12.00 and $9.50) such that the actual discount associated with the Chinese front vowel/fricative sale price combination was less than the actual discount associated with the back vowel/stop sale price combination. Thus, we extend hypotheses 2a and 2b to include a price rehearsal/language comparison and expect a (language by sale price phoneme by rehearsal) interaction, such that:

> **H3:** When sale prices are rehearsed in different languages (with different phonemes), price discount will be overestimated (underestimated) for sale prices containing front vowels/fricatives (back vowels/stops); rehearsal of non-price-related phonemes will result in perceived discounts closely mirroring actual discounts (**H3a**). Sale price value assessments should reflect perceived price discounts (**H3b**).

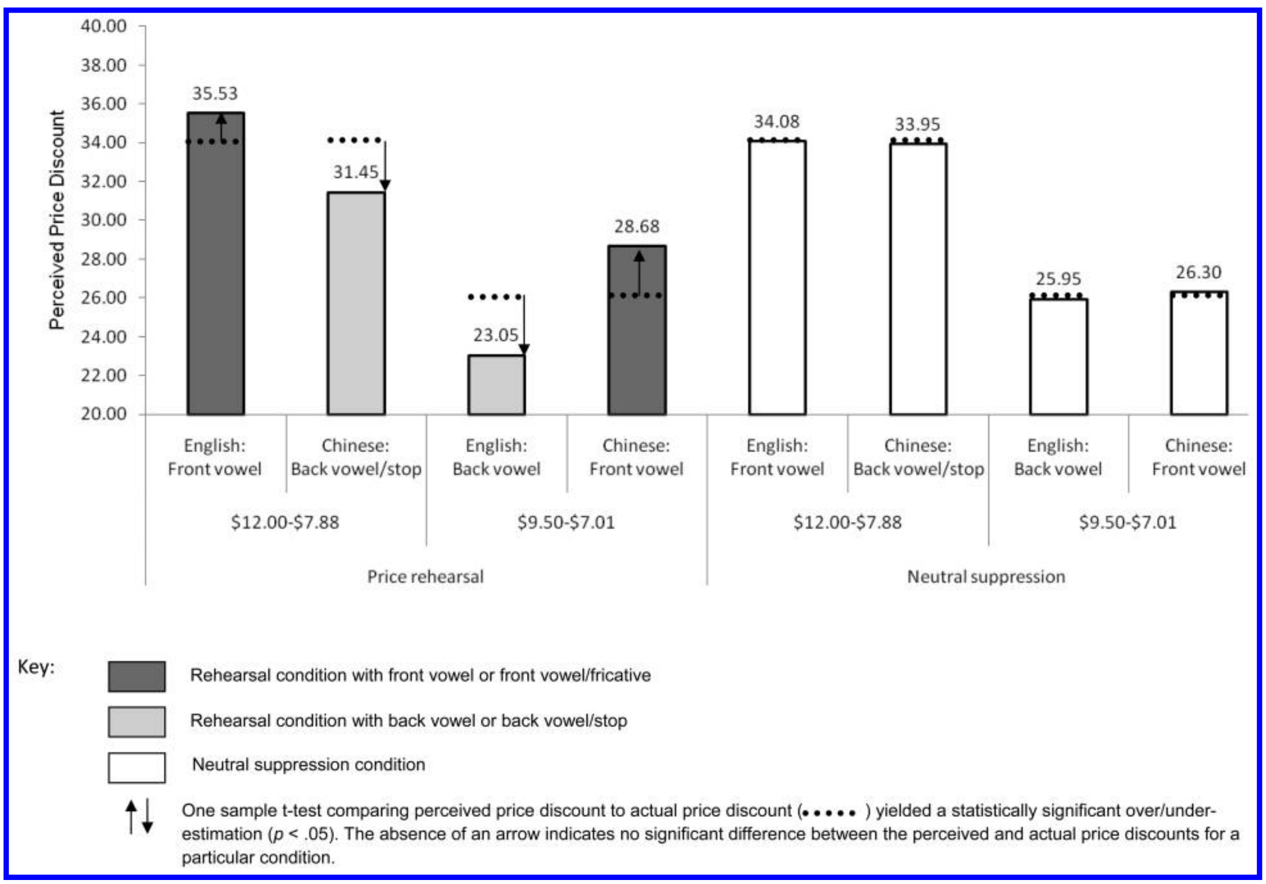
Method. Native English-speaking and Chinese/English bilingual students ($n = 160$) from a major northeastern university participated in experiment 3 for course credit. We used the same target product (steak knife) and ad stimuli as in experiment 2 (i.e., the ads were in English), except we varied our sale prices to reflect differences in phonemes across English/Chinese languages (see table 1). We used a 2 (sale price phoneme: $7.88 vs. $7.01) × 2 (rehearsal: sale price vs. neutral suppression) × 2 (language: English vs. Chinese) between-subjects experimental design. Native English-speaking participants were randomly assigned to the English language conditions, and bilingual Chinese/English-speaking participants (native Chinese) were randomly assigned to the Chinese language conditions. Participants were instructed to rehearse, in their native language, either the sale price or the neutral, attribute-related phrase (corresponding to the neutral suppression condition in experiment 2), which contained a preponderance of neither front vowel/fricatives nor back vowel/stops in either English or Chinese languages. Measures and all other procedures were identical to experiment 2.

Results. Consistent with hypothesis 3a, ANOVA results revealed a significant language by sale price phoneme by rehearsal interaction ($F(1, 152) = 37.91$, $p < .001$; partial $\eta^2 = .20$); means are reported in figure 1. Because the English front vowel (\$12.00 − \$7.88) actual discount (34.3%) was greater than the English back vowel (\$9.50 − \$7.01) actual discount (26.2%) and because phonetic symbolism effects could be expected to only increase that difference, we employed one-sample *t*-tests within experimental conditions (rather than cross-price comparisons) to test hypothesis 3a. In the rehearsal conditions, these tests indicated that the English- and Chinese-speaking participants significantly overestimated the front vowel/fricative sale price discounts ($t_{\$7.88}(19) = 2.05$, $p = .059$; $t_{\$7.01}(19) = 3.87$, $p < .001$), whereas English- and Chinese-speaking participants significantly underestimated the back-vowel/stop sale price discounts ($t_{\$7.01}(19) = 5.35$, $p < .001$; $t_{\$7.88}(19) = 3.57$, $p < .01$; see fig. 1). As expected, participants' perceived price discounts in the neutral suppression conditions reflected actual discounts; we found no significant ($p > .10$) over/underestimation effects. These results support hypothesis 3a. Further, in the price rehearsal conditions, planned contrasts revealed significant differences in perceived discount between English- and Chinese-speaking participants for the \$7.88 ($t(35) = 4.09$, $p < .001$) and \$7.01 ($t(38) = 6.48$, $p < .001$) sale prices and no significant differences across language in the neutral suppression conditions ($p > .10$).

Results for value assessment reflected those for perceived discount; we found a significant language by sale price phoneme by rehearsal interaction ($F(1, 152) = 38.44$, $p < .001$; partial $\eta^2 = .20$). In the price rehearsal conditions, contrasts revealed significant perceived value differences across English- versus Chinese-speaking participants for the \$7.88 ($M_{\text{Eng}} = 5.20$ vs. $M_{\text{Chi}} = 3.60$; $t(35) = 5.51$, $p <$

FIGURE 1

EXPERIMENT 3: PERCEIVED MEANS AND ACTUAL PRICE DISCOUNTS FOR PRICE REHEARSAL AND NEUTRAL SUPPRESSION CONDITIONS



.001) and \$7.01 ($M_{Eng} = 3.00$ vs. $M_{Chi} = 5.40$; $t(35) = 6.00$, $p < .001$) sale prices but no significant difference across languages in the neutral suppression conditions ($p > .10$). These results support hypothesis 3b.

Summary. Experiment 3 results provide additional support for our hypothesized phonetic symbolism effects; perceived price discount is overestimated for sale prices containing front vowels/fricatives (i.e., 8 in English and 1 in Chinese) and underestimated for prices containing back vowels/stops (i.e., 1 in English and 8 in Chinese). Because we find the same linguistic symbolism effects for 8's and 1's as we did for 6's, 3's, and 2's in experiments 1 and 2 and because we find opposite effects for identical prices when manipulating the phonemes across languages, we effectively eliminate the possibility that non-phonetic characteristics of the specific numbers or number combinations caused the observed effects. Thus, it appears unlikely that the numbers 1, 2, 3, 6, and 8 convey some special meaning outside the realm of phonetic symbolism, such as the price image effects (e.g., the product is on sale) that have often been ascribed to 9-ending prices (Schindler 1991). Rather, these results provide further evidence that the sounds associated with price numbers can lead to distortion of perceived price discounts.

Experiment 4

Research indicates that individual and cultural differences in mathematics proficiency may be linked to systematic disparities in basic number representations, which can vary as a function of linguistic, notational, and pedagogical factors (Fuson 1990; Miura et al. 1988). Thus, although experiment 3 findings argue against specific number meaning conveyance, there could be systematic nationality effects in terms of how Chinese versus Americans perceive sale prices in general or non-phonetic cultural or linguistic differences in the processing of numbers. To discriminate between linguistic symbolism and cultural or nationality effects, in experiment 4 we recruit bilingual participants and extend our number-word examination to include prices rehearsed in English, Chinese, and Spanish. We expect a language by rehearsal by sale price phoneme interaction, such that:

H4: When sale prices are rehearsed in different languages (with different phonemes), price discount will be overestimated (underestimated) in languages for which sale prices contain front vowels/fricatives (back vowels/stops); in the absence of sale price rehearsal, phonetic symbolism effects will not occur, and consumer perceptions will reflect actual discounts (**H4a**). Sale price value assessments (**H4b**) and purchase intentions (**H4c**) will reflect participants' price discount perceptions.

Stimuli Development. In selecting cents digits for our manipulations, we considered number phonemes in English, Chinese, and Spanish. We chose the number 8, which is classified as a back vowel in Chinese and Spanish and as a front vowel in English and therefore is expected to convey largeness in the former two languages and smallness in the latter (see table 1). There is no digit that can be classified as a front vowel/fricative in Spanish but as a back vowel/stop in English; thus, we chose the number 1 which involves a back vowel in English and Spanish but a front vowel in Chinese. It is therefore expected to convey largeness in the former two languages and smallness in the latter. Our target sale prices were set at \$7.88 and \$7.01, with respective regular prices of \$11.00 and \$10.00. The English front vowel/fricative sale price discount (\$11.00 − \$7.88; 28.4%) was less than the English (and Spanish) back vowel/stop sale price discount (\$10.00 − \$7.01; 29.9%), whereas the Chinese front vowel sale price discount (\$10.00 − \$7.01; 29.9%) was greater than the Chinese (and Spanish) back vowel/stop sale price discount (\$11.00 − \$7.88; 28.4%). Thus, one-sample *t*-tests, rather than cross-price comparisons, are again the appropriate analytical test of theory.

We next constructed a set of six computer screens, each of which contained illustrations of five products with fictitious brand names and relevant product information. We again used the steak knife as our target product; it appeared on screens 1 and 5. In order to induce language-specific rehearsal without the need for external instruction, we created a version of the product assortment stimuli in English, Spanish, and Chinese, including the name of the retailer (Great Buy, Gran Compra, 重要的), all product item descriptions, and related target (e.g., \$7.88) sale price information ("Just seven eighty-eight!" "¡Sólo siete ochenta y ocho!" "七十八").

Procedures. On entering the experimental session, participants were instructed to imagine that they were in the market for a steak knife and that a (fictitious) retailer was advertising several brands of steak knives, and they were to look through an assortment of the retailer's products. Participants in the price rehearsal conditions were instructed to click on the computer screen to check the regular and sale prices when they came upon any steak knife and to "find the best deal" on that item, whereas participants in the no-rehearsal conditions were told to click on the target product in order to locate a brand with ergonomic handle design. Regular and sale price information was provided for the steak knives only, and the information was the same for the target products appearing on screens 1 and 5. If a participant clicked on an illustration of any other product, the screen provided additional product attribute information but no price information. We expected that participants in the price rehearsal conditions would mentally rehearse the target price for the steak knife while scrolling through the products and be reminded of that price after viewing the second target product illustration. We expected that little (if any) price rehearsal would occur in the non-rehearsal conditions (although the identical price appeared) because participants were instructed to focus on the product attribute information. Thus, we broaden the ecological validity of our findings by manipulating mental rehearsal of price information that is internally motivated by shopping context.

Method. A total of 341 English/Chinese-speaking bilinguals and English/Spanish-speaking bilinguals (81% native American) from a major northeastern university participated in experiment 4. The English/Chinese (English/Spanish) bilinguals were randomly assigned across price combination, rehearsal, and English or Chinese (English or Spanish) language groups (see fig. 2). Because this procedure resulted in two English-language subgroups (representing either Chinese or Spanish bilingual participants), we employed a four-factor partial hierarchical design: 2 (sale price phoneme: \$7.88 vs. \$7.01) × 2 (rehearsal: sale price vs. no rehearsal) × 3 (language: English, Chinese, Spanish) within 2 (subsample: bilingual Chinese/English, bilingual Spanish/English; Winer 1971, 359–66). Measures were identical to experiments 2 and 3; additionally, participants were asked whether they had thought about the sale price during the experiment and, if so, in what language they had thought about it.

Results. Nearly all (98%) participants in the price rehearsal conditions (vs. 17% in the no-rehearsal conditions) indicated they had thought about or rehearsed the target prices ($\chi^2(1) = 212.40$, $p < .001$). For those who correctly rehearsed (as per our manipulation), approximately 95% indicated that they had thought about or rehearsed the target prices in the primed language ($\chi^2(4) = 266.32$, $p < .001$). Thus, rehearsal type and language were successfully manipulated.

With regard to hypothesis 4a, the mixed-model ANOVA revealed a significant sale price phoneme by rehearsal by language (within bilingual subsample) interaction ($F(15, 304) = 2.85$, $p < .001$); means are reported in figure 2. Consistent with our expectations, one-sample *t*-tests indicated that when rehearsing sale prices in English, both bilingual subsamples overestimated the front vowel \$7.88 sale price discount ($t_{\mathrm{Chi}}(19) = 3.61$, $p < .01$; $t_{\mathrm{Sp}}(19) = 4.15$, $p < .001$) and underestimated the back vowel \$7.01 sale price discount ($t_{\mathrm{Chi}}(19) = 3.16$, $p < .01$; $t_{\mathrm{Sp}}(19) = 3.66$, $p < .01$). These results support hypothesis 4a and replicate findings from our other experiments. Also as expected, planned contrasts indicated no significant perceived discount differences between Chinese and Spanish bilingual subsample participants who rehearsed (in English) either the \$7.88 ($t(38) = .28$, $p > .10$) or the \$7.01 ($t(38) = .28$, $p > .10$) sale price. When Chinese and Spanish bilingual participants rehearsed prices in their native languages, all perceived price discount means were directionally consistent with theory; however, the one-sample *t*-tests revealed that the degree of discount under/overestimation (relative to actual discount) did not achieve statistical significance ($p > .05$; see fig. 2).

Our results affirm that language-related phonemes, rather than culture-specific processing effects, are driving our results. Consistent with our expectations, we found that Chinese bilinguals who rehearsed the \$7.88 sale price in English (front vowel) perceived a greater discount than did those who rehearsed the same sale price in Chinese (back vowel/stop; $t(34) = 4.04$, $p < .001$). Similarly, we found that Spanish bilinguals who rehearsed the \$7.88 sale price in English (front vowel) perceived a greater discount than did those who rehearsed the same sale price in Spanish (back vowel; $t(38) = 3.20$, $p < .01$). With regard to the \$7.01 sale price, Chinese bilinguals who rehearsed the price in English (back vowel) perceived a smaller discount than did those who rehearsed the price in Chinese (front vowel; $t(35) = 3.38$, $p < .01$). Also as expected (because the cents digit involves a back vowel in both languages), we found no difference in perceived discount between Spanish bilinguals who rehearsed the \$7.01 sale price in English versus Spanish ($t(37) = 1.71$, $p > .10$).

Finally, cross-price contrasts revealed that when sale prices were rehearsed in English, both Chinese and Spanish bilinguals perceived the front vowel \$11.00 − \$7.88 (28.4%) discount as greater than the back vowel \$10.00 − \$7.01 (29.9%) discount ($t_{\mathrm{Chi}}(33) = 3.11$, $p < .01$; $t_{\mathrm{Sp}}(33) = 3.78$, $p < .001$). In contrast, when sale prices were rehearsed in Chinese, the front vowel \$10.00 − \$7.01 discount was perceived as greater than the \$11.00 − \$7.88 discount ($t(34) = 4.67$, $p < .001$). In the eight no-rehearsal conditions, one-sample *t*-tests indicated no difference between perceived and actual discounts ($p > .10$), and we found no significant difference in perceived discount across the four \$11.00 − \$7.88 or four \$10.00 − \$7.01 conditions ($p > .10$).

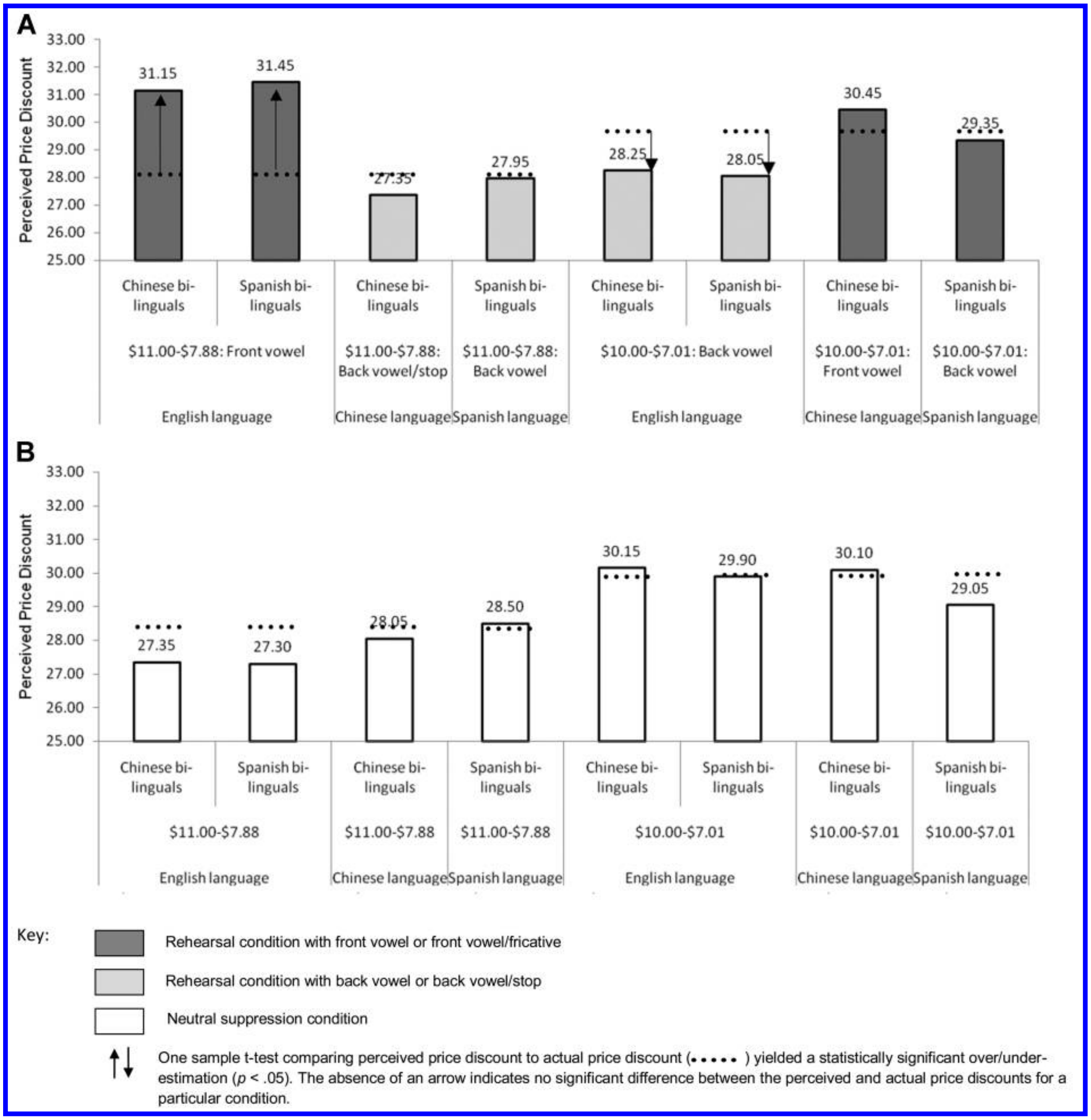
The mixed-model ANOVA revealed a significant interaction effect for value assessment ($F(15, 304) = 3.12$, $p < .001$; see table 2 for means and specific contrast test results). The pattern of means, as well as planned contrast results, mirrored those for perceived discount, providing support for hypothesis 4b. The purchase intention interaction ($F(15, 304) = 1.40$, $p > .05$), as well as the \$11.00 − \$7.88 cross-language price rehearsal contrasts, were nonsignificant. However, the \$10.00 − \$7.01 cross-language price rehearsal comparisons were significant ($p < .05$) and in the predicted direction, lending partial support to hypothesis 4c.

GENERAL DISCUSSION

Results from our four experiments suggest that the phonemes associated with price names, specifically those that occur as a result of price endings, affect numerical magnitude and value perceptions. We demonstrate that perceptions of small and large size that occur as a result of mental rehearsal of front/back vowel and fricative/stop consonant price endings affect analog magnitude representations associated with perceived price discount. Across four experiments, we find that when sale price rehearsal leads to auditory price-representation encoding, perceived price discount is overestimated (underestimated) for sale prices containing front vowels/fricatives (back vowels/stops). In some cases, these over/underestimation effects can result in greater perceived discounts (with concurrent increased perceptions of value and greater purchase intention) for a higher-priced, lower-discounted item than for a lower-priced, higher-discounted item. Additionally, in the absence of sale price rehearsal

FIGURE 2

EXPERIMENT 4: PERCEIVED MEANS AND ACTUAL PRICE DISCOUNTS FOR PRICE REHEARSAL CONDITIONS (*A*) AND NO-REHEARSAL CONDITIONS (*B*)



(experiments 1 and 4) or when non-price-related phonemes are rehearsed (experiments 2 and 3), we find that phonetic symbolism effects do not occur, and consumer perceptions reflect actual discount amounts. The apparent need for mental rehearsal of the sale price suggests that the effects of linguistic characteristics on comparative price perceptions may be limited to highly involving or point-of-purchase settings (Vanhuele et al. 2006).

From a theoretical perspective, the proposed linguistic symbolism effects are hypothesized to occur because consumers encode and process visual pricing information in visual, auditory, and analog formats. Size perceptions appear to be a nonconscious by-product of the sounds associated with phonological price encoding; these perceptions reinforce or interfere with numerical value encoding (analog magnitude representations) at a level below the threshold of conscious awareness. Reinforcement leads to perceptions of greater numerical value; interference leads to perceptions of

TABLE 2

EXPERIMENT 4: SUMMARY OF MEANS FOR VALUE ASSESSMENT AND PURCHASE LIKELIHOOD

	English SL		Chinese SL	Spanish SL
	Chinese bilingual	Spanish bilingual	Chinese bilingual	Spanish bilingual
Value assessment:				
Price rehearsal:				
11.00 − 7.88	5.20[a]	4.95[b]	4.05[a]	3.90[b]
10.00 − 7.01	3.85[c]	3.55[d]	4.90[c]	4.20[d]
No price rehearsal:				
11.00 − 7.88	4.05[e]	4.15[e]	4.10[e]	4.05[e]
10.00 − 7.01	4.55[f]	4.80[f]	4.75[f]	4.75[f]
Purchase likelihood:				
Price rehearsal:				
11.00 − 7.88	4.40[g]	4.50[h]	3.80[g]	3.90[h]
10.00 − 7.01	3.75[i]	3.55[j]	4.35[i]	4.45[j]
No price rehearsal:				
11.00 − 7.88	4.15[k]	4.20[k]	3.50[k]	4.10[k]
10.00 − 7.01	4.25[l]	4.50[l]	3.65[l]	4.20[l]

NOTE.—SL = stimulus language. Planned contrast results shown for means with the same superscripts (a–d and g–j); ANOVA results shown for means with the same superscript (e, f, k, l); a, $t(32) = 3.54$, $p < .001$; b, $t(36) = 2.63$, $p < .05$; c, $t(37) = 2.37$, $p < .05$; d, $t(38) = 2.63$, $p = .09$; e, $F(3,79) = .04$, $p > .10$; f, $F(3,79) = .14$, $p > .10$; g, $t(35) = 1.54$, $p = .13$; h, $t(37) = 1.61$, $p = .12$; i, $t(29) = 2.28$, $p < .05$; j, $t(38) = 2.44$, $p < .05$; k, $F(3,79) = .91$, $p > .10$; l, $F(3,79) = 1.39$, $p > .10$.

smaller numerical value. In experiment 2, we find that nonrelevant, non-price-related phonemes do not generate the same effect as price (name) related phonemes and hence conclude that multiple format encoding is a necessary condition for linguistic symbolism effects to occur. Although we cannot conclude with certainty that auditory representations will always be encoded if not actively suppressed, at the broadest level, our findings lend strong support to Dehaene's (1992) triple-code model and argue against McCloskey's (1992) modular theory of numerical processing.

Within each of the rehearsal conditions in experiments 1 and 2, we found no difference in price discount perceptions between participants who did versus those who did not recall the sale price. Consistent with previous findings (Adaval and Monroe 2002), these results may suggest that price discount assessments were made at (or close to) the time of target ad exposure rather than at the time of questionnaire item completion because accurate recall of regular and sale prices might be expected to assuage the distortion of discount estimates. Alternatively, the results may reflect a relative autonomy among the analog, visual, and auditory numerical traces. Linkages between and among those representations may decay over time, such that at the time of retrieval, representations in the analog magnitude code may be functionally independent of representations in the verbal or visual code. Thus, analog representations could be distorted, even though phonological or visual codes may be accurately represented. Although participants were not asked to mentally rehearse regular prices, we posit that the relatively high level of regular (vs. sale) price recall occurred because participants needed to remember only two regular price (dollars) digits versus three sale price (dollars and cents) digits.

Research has suggested that when no explicit (or internal) frame of reference is available, consumers may be more likely to encode a price as an exact value or an approximation of an exact value (Dehaene 1997). In our experiments, however, we incorporated regular prices within a comparative price-advertising context, and our results indicate that these regular prices served as frames of reference in forming implicit discount assessments. We expect that analog magnitude representations that incorporate relative (i.e., large/small) judgments of numerical size are more likely to be affected by phonological codes (or other size-related dimensions) than exact values (Monroe and Lee 1999). Thus, it is important to emphasize that our research does not suggest that 66, 33, or 88-ending prices should always be selected over 22 or 01-ending prices. Rather, perceptions of sale price smallness might also be reinforced by raising the external (e.g., regular) reference price.

LIMITATIONS AND RESEARCH OPPORTUNITIES

Our work is the first to examine phonetic symbolism effects with regard to price names and points to several areas for future investigation. First, the majority of phonemes in our sale price names consisted of the sounds associated with cents-digit endings, yet one might argue that the sale price dollar digits could also have a phonological impact. Thus, additional research might investigate how the inclusion of additional dollar digits might affect the phonological impact of the right-most-digit price endings. We speculate that it is unlikely that phonological effects will manifest in straightforward (e.g., single-digit) numerical comparisons (e.g., $5 vs. $4) due to the minimal cognitive effort involved. Second, in some instances we created dollar digit/cents digit sound symbolism inconsistency (e.g., 7 [front vowel/fricative] and 22 [back vowel/stop]) by holding sale price dollar digits constant. One might argue that this inconsistency could reduce the degree of discount over/underestimation for certain regular-sale price comparisons (e.g., $3.00 − $2.33 vs. $3.00 − $2.22). Although we did not observe such a pattern, future studies might use different dollar digits to further examine the effects of inconsistent phonemes. Further investigation might also attempt to isolate vowel versus consonant phoneme effects through the selection of specific prices or languages. Finally, researchers might investigate possible multisensory processing effects by examining scenarios in which the price-sound phonemes are (in)consistent with the perceived magnitude of the Arabic visual symbols.

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