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## How much was your shopping basket? Working memory processes in total basket price estimation

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### Abstract

Although much attention has been paid to recall of a single price, research is lacking in understanding the process of how consumers estimate the total price of a shopping basket. Drawing on research on numeric cognition, memory processes, and mental accounting, we show in five studies that the accuracy of total price estimation as well as the timing of such estimation is systematically influenced by several factors. We find that the length (in syllables) of the prices in the basket and the attention that consumers pay to the prices influence the accuracy of the calculation of the total basket price. Furthermore, our studies also show that the timing of the calculation is influenced by the nature of the items in the basket (i.e., unrelated vs. complementary items).

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A shopper enters a clothing store and buys a pair of jeans for \$108 and a shirt that would go perfectly with them for \$49. Another shopper enters a discount store and purchases a fishing pole for \$108 and a writable DVD pack for \$49. Later, their friends ask them how much they spent on their shopping trip and both shoppers attempt to estimate the total price. When will they calculate the total price of their basket? At the time of the purchase, or when they are asked later? Will the timing of the calculation influence price estimate accuracy? What factors might influence their estimates' accuracy?

Price estimation can be a complex process. Prices, like all other marketplace cues, are not processed in isolation; they are processed in a context—for instance, in conjunction with the prices of other items (e.g., buying a shirt and a pair of jeans that fit well together vs. buying a fishing pole and a writable DVD pack). Price recall has been a topic of concern in marketing, but little attention has been paid to the factors influencing estimates of the total price of a basket of items or to other potential contextual influences on price estimation and recall (Dickson & Sawyer, 1990; Estelami, 2003; Estelami & Lehmann, 2001; Monroe & Lee, 1999; Vanhuele & Drèze, 2002; Vanhuele, Laurent, & Drèze, 2006).

A systematic understanding of the factors surrounding total price estimation is important because most consumers buy multiple items in a single shopping trip (Manchanda, Ansari, & Gupta, 1999) and thus being aware of the total amount spent influences their future spending decisions more than remembering the price of only one item, especially because most consumers do have a budget (Blackorby, Lady, Nissen, & Russell, 1970). Therefore, we focus on the estimation of the total price of multiple items in this research. We argue that linguistic processing is important in total price calculations. In particular, we investigate the role of phonological encoding and show that prices with longer number names (e.g., “seven” vs. “two”) lead to worse total price estimate accuracy compared to prices with short number names. Thus, our findings extend recent research that investigates single price recall (Vanhuele et al., 2006).

We provide a theoretical framework for the cognitive processing of multiple prices. Our theoretical framework revolves around the notions of (a) stimulus length limits on the capacity of working memory (Baddeley, Thomson, & Buchanan, 1975), and (b) information *chunking* in working memory (Miller, 1956). The calculation of multiple prices can be seen as an instance of chunking of several pieces of information into a higher-level piece. The memory literature suggests that two factors can influence chunking: the length of the items to be processed and non-length factors (e.g., semantic relatedness of items in basket,

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attention to stimuli). Based on the working memory literature (Baddeley, 1986), we suggest that length and non-length factors influence total basket price estimation, but via different components of working memory (i.e., the phonological loop and the central executive, respectively). We argue that both types of factors should be considered jointly to understand the process of estimating the total price of shopping baskets.

### Number length and total price calculation

After a stimulus is perceived and attention is drawn to it, it enters working memory. Working memory consists of three components: the central executive, a component that performs a supervisory attentional role; the visuo-spatial scratch pad, which is specialized for visual/spatial tasks, and the phonological loop, which holds information in a phonological form (Baddeley & Hitch, 1974). The phonological loop is the key component in our research, although as we will see later, the central executive also has a role in calculation when it comes to factors unrelated to number length that influence calculation accuracy (Fürst & Hitch, 2000; Logie, Gilhooly, & Wynn, 1994). In particular, we focus on the phonological loop's function as a passive phonological store directly concerned with speech perception. The phonological loop captures language that is visually or aurally presented and holds it for further processing. The capacity of this store is limited to the information that can be phonologically rehearsed approximately in two seconds (Baddeley, 1986). One strategy to increase the amount of information that can be held in working memory, therefore, would be to shorten the length of words so more of them can fit into the phonological loop (Baddeley et al., 1975). Recent consumer research has investigated the role of number name length (henceforth *number length*) on single price recall (Vanhuele et al., 2006). The key process we examine is the calculation that takes place when consumers encounter multiple prices.

#### *The phonological coding of multiple prices*

The triple-code model developed by Dehaene (1992) implies that consumers may process numbers (i.e., price information) in three types of codes. Consumers may vocally or subvocally read a price (e.g., “79” as “seventy-nine”) and process it using the phonological, or sound-based, code. Alternatively, consumers could process a price as a visual symbol (e.g., “79” as “79”), thus using the visual code, or they could rely on the analogue magnitude code, processing only the relative magnitude of a price (e.g., “\$79” as “expensive”). As suggested by Vanhuele and Drèze (2002), the encoding of a price depends on the task at hand. For example, in a price recognition task, consumers tend to rely on the visual code, and when comparing a price with a reference price, consumers tend to use the analogue magnitude code. In contrast, when asked to recall prices, consumers rely more on the phonological code. Therefore, estimates of the total price of multiple items should be influenced more by phonological encoding than by visual or analogical processes (see also Wyer, Hung, & Jiang, 2008).

Research on numeric cognition and mental arithmetic provides further support for the idea that multiple prices are phonologically encoded. Consider shoppers who see an ad for a camera phone, listed at \$327, and the charger for the phone, a necessary item, priced at an additional \$17. How do they calculate the total price? The phonological loop of working memory plays an important role in mental calculations of that type (for a review, see DeStefano & LeFevre, 2004). In particular, the phonological loop tends to be more involved in mental calculations when the calculation is not presented in a form that facilitates graphic solution of the problem (Trbovich & LeFevre, 2003).

It follows from this discussion that when stimuli (e.g., prices) are encoded phonologically in a more efficient manner (i.e., in shorter words), the amount of information that can fit into working memory can increase. Thus, if we shorten the names of objects or numbers, we can hold more of them in working memory. In other words, memory span will increase inversely proportionally to the time it takes to rehearse the information being encoded.

In particular, if price  $X$  has a shorter number name than price  $Y$ , individuals' working memory span for numbers should be longer when they process  $X$  than  $Y$ . The difference in length between  $X$  and  $Y$  can arise if number names in one language are generally shorter than their equivalents in a different language (e.g., English and Korean, respectively), or it can happen within a single language (e.g., “seven” vs. “two”). In this research, we investigate both cases. Confirming cross-language differences, Ellis and Hennelly (1980) found that working memory span was shorter in Welsh than in English and attributed this effect to the longer number names in Welsh. Similar differences have been found in other languages (Vanhuele et al., 2006).

So far, we have argued that the phonological loop is involved in the processing of multiple prices and, therefore, individuals can hold more numerical information in their working memories when the prices are short. We now focus on the calculation of the total price, suggesting that such estimation can be considered an instance of chunking.

#### *Chunking in working memory*

Chunking refers to the grouping of several single stimuli into a compound element. For instance, the digits 1-9-9-5 could be grouped into one compound element, 1995, which would have a unique meaning to the individual (i.e., a particular calendar year). The notion of chunking dates back to Miller (1956), who argued that approximately seven chunks could be held in memory at any one time, although more recent research puts that limit at about four chunks (Cowan, 2000). We suggest that calculating the total price of a multiple-item basket is similar to chunking diverse elements into one. In both processes various items are combined into one; both result in more efficient information processing, expanding the capacity of working memory, and both are influenced by similar factors.

One of those factors is stimulus (e.g., number) length. The phonological loop can be overtaxed by long numbers, so the ability to chunk them—that is, to add them up, would be limited by number length. Contextual and long-term memory factors

also play a role on the successful chunking of incoming information items (Bousfield, 1953; Tulving & Patkau, 1962), and we suggest they do so via the central executive component of working memory, which is in charge of interacting with long term memory and directing resources to specific tasks (Baddeley, 1986). Contextual factors include the external punctuation of some items, which may serve to create groupings of those stimulus items (McLean & Gregg, 1967). Long-term memory influences chunking operations. For example, if individuals do not know that IBM is a company, they would not be able to chunk the letter I-B-M together (Eysenck & Keane, 1995). Long-term memory factors that can influence whether individual items are chunked together include item co-occurrence (Deese, 1959; Hulme, Stuart, Brown, & Morin, 2003; Stuart & Hulme, 2000). The results of that research suggest that items that typically co-occur in individuals' everyday experiences are more readily chunked together than non-co-occurring items.

In summary, mental calculations of multiple prices seem to involve both the phonological loop and the central executive. The pilot study and studies 1–2 address the phonological loop and its limitations. This component of working memory has severe capacity constraints, which can make it difficult to process prices with long number names. Therefore, the ability to mentally perform price calculations (i.e., chunk multiple prices) will depend on the number name length of the individual prices (Ellis, 1992). Studies 3–5 center around the role of the central executive in the chunking process.

### Pilot study

In this study, we test the hypothesis that number length influences calculation accuracy for the total price of multiple items. To ensure that we can generalize to relatively small and large numbers/prices, we utilize 2-digit and 3-digit component prices. If number length determines calculation accuracy, we should find that longer number names lead to less accurate total price estimates than prices with shorter number names.

### Method

One hundred twenty undergraduate students at a Korean university participated in the study. The study manipulated the total number length (long vs. short) of the components of 2-digit and 3-digit multiple prices. The 2-digit component prices were \$28, \$23, \$36 (long: nine syllables), and \$19, \$18, \$50 (short: six syllables). The 3-digit prices were \$139, \$362, \$124 (long: 13 syllables), and \$108, \$408, \$109 (short: seven syllables). Syllable counts represent the total number length of the three component prices in Korean. The prices were selected so that the total prices were the same for both long and short prices within each digit condition (a total of \$87 for the 2-digit multiple prices and a total of \$625 for the 3-digit multiple prices).

Participants were randomly assigned to one of the four multiple prices. They read the following scenario in Korean: “You are having a great time at an upscale resort theme park in California. The entrance fee was [first component price] and an

all-day ride ticket cost [second component price]. You also bought souvenirs worth [third component price].” The prices themselves were always presented in Arabic numerals. This is consistent with the way Koreans write numbers. Even though Korean logographic script is used for text, numbers are always written using Arabic numerals (and, of course, read in Korean). Participants then answered several demographic scales and were asked to write down the total price of the items without looking back at the scenario. Participants' familiarity with prices of U.S. theme parks was assessed on a seven-point scale: “How familiar are you with general prices of having a good day at an upscale theme park in the U.S.?” (1 = Not at all; 7 = Very well).

### Results and discussion

Four participants did not follow the instructions (they merely attempted to write the original prices) and thus were dropped from the analysis. We tested the main effect of number length on estimation accuracy for 2-digit and 3-digit multiple prices. Estimate accuracy was measured by the Absolute Percentage Deviation—or APD (Estelami & Lehmann, 2001). Thus, smaller values of APD represent greater accuracy.

$$\text{APD} = \frac{|\text{actual price} - \text{recalled price}|}{\text{actual price}}$$

The results confirm that long prices result in worse accuracy than short prices. We found this for 2-digit prices ( $M = .10$  vs.  $M = .06$ ;  $t(57) = 2.88$ ,  $p < .01$ ) and for 3-digit prices ( $M = .14$  vs.  $M = .07$ ;  $t(55) = 3.89$ ,  $p < .01$ ). The magnitude of prices (2-digit vs. 3-digit) did not influence calculation accuracy ( $t < 1$ ). Neither gender, price familiarity ( $M = 1.75$ ), nor age had a significant impact on accuracy ( $p$ 's  $> .15$ ). These results support our theorizing regarding the effect of number length on total price estimation. The results are consistent with prior research that investigated phonological encoding effects on single price recall (Vanhuele et al., 2006).

Studies 1 and 2 take a closer look at the process underlying the findings of the pilot study. The studies were designed to examine whether the effect of number length on total price estimates generally occurs when consumers are initially presented with the prices—at the time of encoding the component prices. Also, studies 1 and 2 investigate the number length effect as it arises from cross-linguistic differences (Ellis & Hennelly, 1980).

### Study 1

One crucial question in this research involves whether the number length effect on total price estimation occurs when consumers are initially exposed to multiple prices (at encoding) or when later they are asked to produce the total price (at test). Research in numeric cognition suggests that the effect is likely to take place at encoding. Individuals tend to perform mental additions when they are presented with several numbers at the same time, as may be the case with multiple prices (for a recent review and experimental evidence in psychology, see Galfano, Rusconi, & Umiltà, 2003). Therefore, we might expect that

multiple prices are subject to at least some calculation at the time of encoding. Thus, long component prices would probably overtax working memory capacity at this time, since calculations involve retaining several pieces of information simultaneously in working memory. After the initial encoding and calculation, individuals would store an approximate (or exact) total that they would later retrieve as needed without much effort.

Study 1 was conducted with bilingual participants. As mentioned earlier, some languages can be considered “short” languages and others “long” languages, depending on how long number names generally tend to be in that language (Ellis & Hennelly, 1980; Naveh-Benjamin & Ayres, 1986). In this research, Korean represents a short language, and English a long language. The use of bilinguals was instrumental in testing our predictions because we were able to manipulate the encoding and retrieval languages, which systematically influenced the number length of the prices independent of the prices themselves. To ensure that differences in total price estimation across languages were not due to factors other than number length, we also manipulated whether the particular prices we used were longer or equal in length in English vs. Korean. Korean numbers can never have more syllables than English numbers, so a condition in which English is shorter than Korean was not possible. Thus, we expected that when English prices were longer than Korean prices, Korean encoding would result in greater estimate accuracy than English encoding. However, when English prices were of equal length to Korean prices, there would not be a difference between English or Korean encoding. Our expectations are summarized in Table 1.

Bilingual participants serve as their own control group in cross-linguistic studies and minimize the risk of potential cultural confounds (Tavassoli & Han, 2001). By sampling bilingual consumers, we extend previous cross-linguistic price research based on comparisons between individuals from different countries (Vanhuele et al., 2006). Thus, we seek to confirm that the results of previous research were not due to cultural differences in processing number facts. For instance, consumers in a particular culture may be able to calculate total prices more accurately due to their higher math proficiency (Engelbret, 1993).

### Method

The study had a 2 (encoding language: English, Korean) × 2 (number length: English=Korean, English>Korean) between-

subjects design. Eighty-three Korean bilinguals in a large U.S. metropolitan area participated in the study. Participants were presented with the scenario and later, after the experimenter collected the scenarios, they were asked to write down the total price of the items. The encoding language was manipulated by presenting the price scenarios in either English (written in alphabetic script) or Korean (written in Korean script). Participants were asked to read the prices in Korean (English) when exposed to a purchase scenario in Korean (English) script. As in the pilot, the prices were always written using Arabic numerals.

Number length was manipulated by having participants read one of two different scenarios. In the English=Korean condition, where we did not expect a number length effect, participants were told that they needed to replenish their store's inventory. They had to go to a store and buy the following items: white wine for a total of \$25; beer for a total of \$13, and potato chips for a total of \$15. In English, the prices are pronounced as follows: “twen-ty-five,” “thir-teen,” and “fif-teen.” In Korean, they are pronounced “e-ship-o,” “ship-sam,” and “ship-o.” Therefore, the total number of syllables in English and Korean was seven. In the English>Korean condition, where we expected the number length effect to favor Korean encoding, the prices in the scenario were changed to \$260, \$77, and \$9. These prices are pronounced in English as “two-hundred-six-ty,” “se-ven-ty-se-ven,” and “nine.” In Korean, they are pronounced “e-bak-yuk-ship,” “chil-ship-chil,” and “gu.” Therefore, in English, the total number of syllables was 11, and in Korean it was eight. This means that the English pronunciation should tax working memory to a greater degree than the Korean pronunciation.

All participants were asked, in questions worded in Korean, to use Korean to estimate the total price. This was done to maximize the likelihood that the retrieval language would be Korean for all participants. After the test, we collected demographic and background information, including gender, age, and language proficiency (1=I am better at English than Korean; 7=I am better at Korean than English). We also measured product involvement for each of the products in the scenario on a three-item scale (Jain & Srinivasan, 1990). The items were: I attach no importance to it/great importance to it, I am not at all interested in it/very interested in it, and I am indifferent to it/not indifferent to it. In addition, a manipulation check was included asking participants what languages they had used to encode and retrieve the price during the price estimation test.

### Results and discussion

Three participants did not follow the instructions, as indicated by the self-reported checks on encoding and retrieval languages, and thus were removed from the analysis. All the others reported that they had used Korean to estimate the price. The lack of a main effect of number length on calculation accuracy ( $F < 1$ ) suggests that the difference in magnitude of the numbers across conditions did not influence the results, as in the pilot study.

Table 1  
Study 1: expected results.

	English encoding	Korean encoding
<i>English = Korean</i> (English numbers are equal in length to Korean numbers)		No difference due to encoding language
<i>English &gt; Korean</i> (English numbers are longer than Korean numbers)	Less accurate	More accurate

Note. Expectations refer to comparisons across encoding languages and within length conditions.

An analysis of the APD scores yielded the expected results. We found a significant interaction of encoding language  $\times$  number length ( $F(1, 77)=4.50, p<.04$ ). A closer analysis of the interaction showed that, in the English>Korean condition, participants were able to calculate the total price of the multiple products more accurately when they read them in Korean than when they read them in English ( $M_{\text{Korean}}=.06$  vs.  $M_{\text{English}}=.14; F(1, 77)=12.02, p<.01$ ). However, in the English=Korean condition, there was no difference in accuracy ( $M_{\text{Korean}}=.06$  vs.  $M_{\text{English}}=.05; F<1$ ). The absence of the number length effect in this condition suggests that estimation accuracy differences across number length conditions were not due to cultural or any other language-related factor except for the number–name length effect. When multiple prices take a shorter time to encode phonologically, they lead to more accurate calculations of the total price. We also included the demographic/background variables as covariates. They neither covaried with accuracy nor resulted in differences across conditions ( $p$ 's>.20).

Study 1 manipulated the number length of multiple price components by varying encoding language but maintaining retrieval language constant. The significant results of this manipulation suggest that the accuracy of total price calculations seems to be determined at the encoding stage. If prices are encoded in Korean, a language in which phonological rehearsing of numbers tends to take a lighter toll on working memory, the total price can be estimated more accurately than if they are encoded in English. However, there is a possible alternative explanation for our findings: Study 1 held the retrieval language constant (Korean), finding that when participants encoded different number-length prices in Korean and were tested in Korean, the calculation was more accurate than if they encoded them in English and were tested in Korean. Therefore, our findings could have been due to the match between encoding and retrieval language, which could lead to greater accuracy when the prices overtax working memory. We conducted another study to discount this alternative explanation. Study 2 was similar to study 1 in that it manipulated the encoding language (Korean or English), but it forced English retrieval. Hence, we expected that participants would estimate the total price more accurately when they encoded them in Korean, even if they had to retrieve them in English.

## Study 2

The purpose of this study was to confirm that the number length effect takes place at the encoding stage, when participants read the prices of a basket of products. The study design was identical to that of study 1. It had a 2 (encoding language: English, Korean)  $\times$  2 (number length: English=Korean, English>Korean) between-subjects design. Seventy-seven Korean bilinguals at a large U.S. university participated in the study. The procedure was the same as in study 1, except that the estimation test was performed in English. Thus, we conditioned English as the retrieval language in order to discount an encoding specificity explanation of study 1's results.

## Results and discussion

Two participants did not follow the instructions, as confirmed by the self-reported checks on encoding and retrieval language, and thus were dropped from the analysis. We found a significant interaction of encoding language  $\times$  number length on APD scores ( $F(1, 71)=4.01, p<.05$ ). As in study 1, we found that participants in the English>Korean condition were more accurate in Korean than in English ( $M_{\text{Korean}}=.06$  vs.  $M_{\text{English}}=.14; F(1, 71)=10.68, p<.01$ ). However, there was no effect of number length in the English=Korean condition ( $M_{\text{Korean}}=.05$  vs.  $M_{\text{English}}=.06; F<1$ ). Also as in study 1, the demographic and involvement variables neither covaried with accuracy nor resulted in differences across conditions ( $F$ s<1). We again did not find a main effect of number length (i.e., English=Korean vs. English>Korean) on calculation accuracy ( $F<1$ ).

These results show that matching languages at encoding and retrieval is not what produces the pattern of results obtained in study 1. Rather, our results seem to be driven by the difference in number length alone. Study 3 will extend this finding by showing that the timing of the computation is influenced by whether the products in the shopping basket are complementary or unrelated. Note that in studies 1 and 2, the products in the experimental scenarios were related to each other (complementary). Thus, we now begin to examine non-length factors that influence the chunking process.

### Non-length factors: relatedness of items in basket

Traditionally, research on immediate recall and working/short-term memory capacity has followed either the chunking (Miller, 1956) or the stimulus length paradigm (Baddeley et al., 1975). More recent research attempts to integrate both frameworks (Chen & Cowan, 2005; Simon, 1974; Zhang & Simon, 1985), suggesting that both stimulus length and stimulus chunking can play a simultaneous role in information processing, both influencing immediate recall. Based on that research, we posit that there are two influences on consumers' ability to chunk individual prices when they encode them: (a) the length of the prices and, as the chunking literature suggests, (b) other, non-length factors such as item relatedness or level of attention. We now consider the first of those non-length factors: how the nature of the items in the shopping basket can influence the timing and accuracy of the total price estimation. Studies 3 and 4 investigate that process. Study 5 focuses on how increasing attention can facilitate chunking.

The results of studies 1–2 were consistent with numeric cognition research, suggesting that individuals tend to perform mental additions when they are presented with several numbers at the same time, as may be the case with multiple prices (Galfano et al., 2003). However, in a pricing context, the timing of the calculation/chunking may depend on how related the products are to each other. Generally, most products in a shopping basket are related, so consumers would naturally chunk them at encoding, as the numerical cognition research

suggests. But it is also possible that the products could be unrelated to each other, as we now consider.

#### *A memory-based perspective*

As mentioned above, information related to items that typically co-occur will be chunked together more efficiently in working memory (Stuart & Hulme, 2000). Complementary items are those that are typically purchased and/or used together. Therefore, the products are generally found together at the store and in consumers' homes. Following our theorizing, the prices of such products are more likely to be chunked together than the prices of unrelated products. This means that consumers will typically calculate the total price of complementary products as they encounter them. However, for unrelated products, consumers will not tend to calculate/chunk their prices together as they encode them. Instead, they will tend to process each price individually. Therefore, if they are asked to estimate the total price of a basket made up of unrelated items, they will perform the required calculation only later, when they are asked.

This perspective is supported by research on working memory (e.g., Baddeley, 1986), which discusses how both the phonological loop and the central executive have a role in mental arithmetic. The phonological loop is involved in the retention of information and thus number length can overtax its capacity constraints, as discussed in this paper. One of the central executive's roles is to interact with long term memory. In the case of mental arithmetic, the central executive would be involved in retrieving number facts and other relevant information for the operation. That would include information about the complementary (vs. unrelated) nature of the items to be processed (Fürst & Hitch, 2000; Logie et al., 1994; see also Ashcraft, 1995 for a discussion of the aspects that can overload working memory, including stimulus length and operation coordination factors). Hence, we suggest that number length influences calculation accuracy via the phonological loop, and non-length factors such as complementarity influence accuracy via the central executive.

#### *A mental accounting perspective*

In addition to memory research, other streams of literature also support our expectation. For instance, according to Thaler's (1985) mental accounting, individuals maintain separate mental accounts, and multiple events can be either integrated and encoded into a single account or segregated and stored into separate accounts. How multiple events are stored is influenced by various factors (see Thaler, 1999, for detailed discussion). A key factor that affects the use of single vs. separate mental accounts is the strength of association among events (Joyce & Shapiro, 1995; Kahneman & Tversky, 1984). Categorization research demonstrates that people strongly integrate related events because it is easier to think about a single category that encompasses all related events than to think about each individual event (Henderson & Peterson, 1992). For example, it is easier for consumers to tell how much money they spent to

buy fruit than to specify separate expenses for three bananas, two apples, and six oranges. Consistent with this finding, consumers often set budgets for different categories of expenses rather than for individual items (e.g., household items, groceries; Heath & Soll, 1996).

Thus, we argue that prices of highly related items are encoded into a single mental account, whereas prices of unrelated items are encoded into separate mental accounts. If so, consumers are expected to calculate the total price of highly related items when initially exposed to them because they keep track of total expenses of items in a category by computing the amount of money in their budget as they spend (Heath & Soll, 1996). In contrast, when processing unrelated items, consumers will likely store each price in separate mental accounts and compute the total price later, when explicitly asked. These results would qualify the theory that multiple numbers are generally submitted to some calculation when initially presented (Galfano et al., 2003). That theory, developed in the area of numerical cognition, using numbers without a context, may need to be revised for the pricing domain, where contextual influences are important—in studies 1 and 2, the products in the experimental scenarios were related to each other; therefore, we found that the number length effect happened at encoding.

### Study 3

This study aims to show that, for complementary items, number length influences total price estimate accuracy during initial encoding (but not during testing) of the component prices. This is because number length would overtax working memory most substantially during total price calculation, which happens at encoding for complementary items. However, for unrelated items, number length should influence total price estimate accuracy during testing (but not during encoding).

#### *Method*

One hundred sixty-two Korean bilinguals in a large U.S. metropolitan area participated in this study. They were randomly assigned to a condition in a 2 (encoding language: English, Korean) × 2 (product: complementary, unrelated) × 2 (retrieval language: English, Korean) between-subjects design. We only used prices for which the number length in English is longer than in Korean. In the complementary condition, the prices were \$257 for grass seeds, \$77 for fertilizer, and \$8 for a seed spreader (syllables: English=13, Korean=7). In the unrelated condition, the prices were the same but the items were changed to office supplies, fruit, and light bulbs, respectively.

The procedure was identical to study 1. In addition, we included a manipulation check measuring the perceived complementarity of the three products on a two-item scale ("How related are the products that you purchased?" and "How complementary are the products that you purchased?" 1=not much at all, 7=very much;  $r=.94$ ).

Results and discussion

We expected participants to compute the total price of complementary (unrelated) items at the encoding (retrieval) stage. In other words, we should expect a significant interaction of encoding number length by product and a significant interaction of retrieval number length by product in a 2 (encoding: English, Korean) × 2 (product: complementary, unrelated) × 2 (retrieval: English, Korean) ANOVA on price estimation accuracy.

Supporting our expectations, we found significant interactions of encoding × product ( $F(1, 154)=3.78, p<.05$ ) and retrieval × product ( $F(1, 154)=5.85, p<.02$ ). The results are summarized in Table 2, and Fig. 1 depicts the two-way interactions.

Further analysis revealed that (1) for complementary products, only the encoding (vs. retrieval) number length influenced estimation accuracy (for encoding  $F(1, 154)=3.89, p<.03$ ; for retrieval  $F<1$ ), and (2) for unrelated products, only the retrieval (vs. encoding) number length affected accuracy (for retrieval  $F(1, 154)=6.99, p<.01$ ; for encoding  $F<1$ ). These results provided strong evidence that the total price of complementary products was calculated at the time of encoding, whereas that of unrelated products was computed at the time of retrieval. The demographic and background variables neither covaried with estimation accuracy nor resulted in differences across conditions ( $p's>.18$ ).

Study 4 was conducted to further investigate the processing differences between the prices of baskets including complementary vs. unrelated products.

Study 4

Study 3 shows that the total price of complementary products tends to be calculated at the encoding stage, rather than retrieval, so the number length effect influences calculation accuracy at encoding. The reverse was observed for unrelated products. Study 4 aims to confirm our theorizing showing that, for complementary products, because consumers tend to calculate the total price at encoding, they do not commit to memory the prices of individual items. The opposite is expected for unrelated products: consumers do not calculate the total price at encoding. Rather, they encode each price separately and then calculate the total price only when asked later. If this reasoning is correct, we should find that individual item prices in baskets of unrelated items are remembered more

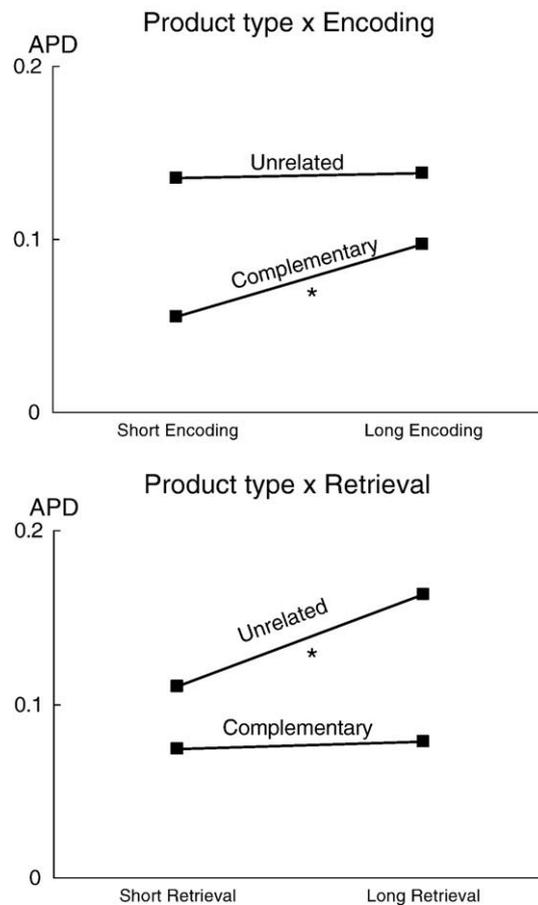


Fig. 1. Study 3: two-way interactions. Note: Higher APD scores mean lower price estimation accuracy. Contrasts of interest are marked with an asterisk (\*).

accurately than individual item prices in baskets of complementary items.

Method

The study manipulated the nature of the items in a shopping basket. In one condition, participants were exposed to three items that were complementary (\$125 cappuccino maker, \$79 cappuccino cup set, and \$58 teaspoon set); in the other condition, the items were unrelated (\$125 kitchen mixer, \$79 fishing pole, and \$58 laptop carrying bag). A total of 84 English-speaking individuals participated in the study. The procedure was similar to study 3, except that instead of asking

Table 2  
Study 3: estimation accuracy (APD) as a function of encoding number length, product type, and retrieval number length.

Type of products	Short encoding number length (Korean)		Long encoding number length (English)	
	Short retrieval number length (Korean)	Long retrieval number length (English)	Short retrieval number length (Korean)	Long retrieval number length (English)
Complementary	.052 <sub>a</sub>	.059 <sub>a</sub>	.096 <sub>b</sub>	.098 <sub>b</sub>
Unrelated	.110 <sub>b</sub>	.161 <sub>c</sub>	.111 <sub>b</sub>	.165 <sub>c</sub>

Note. Cells with unlike subscripts differ at  $p<.05$ .

for the total price of the basket, we asked participants to recall the prices of each item after a brief delay. Between initial exposure and the individual price test there was a 15-minute interval during which participants performed an unrelated task that measured their self-esteem. We used APDs of individual items as our measure of individual price recall.

### Results and discussion

A manipulation check similar to study 3 revealed that participants perceived the complementary items as complementary ( $M=6.05$ ) and the unrelated items as unrelated ( $M=2.25$ ;  $t(82)=18.75$ ,  $p<.001$ ). Product involvement did not interact with our product manipulation ( $F<1$ ).

We expected a main effect of product on individual price recall such that the individual prices of unrelated items would be better remembered than the individual prices of complementary items. We found this pattern for the APDs of the three products in the shopping baskets. We compared the items with the same prices across the manipulation: the \$125 cappuccino maker vs. kitchen mixer ( $M_{\text{Complimentary}}=.05$  vs.  $M_{\text{Unrelated}}=.03$ ;  $t(82)=2.14$ ,  $p<.05$ ), the \$79 cappuccino cup set vs. fishing pole ( $M_{\text{Complimentary}}=.05$  vs.  $M_{\text{Unrelated}}=.02$ ;  $t(82)=2.00$ ,  $p<.05$ ), and the \$58 teaspoon set vs. laptop carrying bag ( $M_{\text{Complimentary}}=.05$  vs.  $M_{\text{Unrelated}}=.02$ ;  $t(82)=1.96$ ,  $p<.05$ ). This pattern confirms that consumers tend to chunk individual prices at encoding but that this occurs mainly for complementary items. The fact that individual price memory is lower for complementary items than for unrelated items suggests that one of the reasons for chunking is to economize resources. Once the total basket price is calculated, individual item prices are not necessarily retained in memory.

To this point, we have shown that number length influences chunking ability (i.e., the accuracy of total price estimates). We have also begun to investigate non-length influences on (1) the likelihood of chunking information when it is presented, and (2) the accuracy of total price estimates. Relatedness of items in the shopping basket is one such non-length influence. Based on the working memory literature (Baddeley, 1986), we suggest that, while number length influences calculation accuracy via the phonological loop, non-length factors that rely on consumers' knowledge of the items in the shopping basket (e.g., item complementarity) influence calculation accuracy via the central executive.

We now report a study that investigates another non-length influence on chunking, attention. Study 5 manipulates the attention that participants pay to the prices to be chunked. We expect that the greater the attention to the prices, the more likely chunking is to occur because the central executive will dedicate more resources to the task. Consequently, the total price estimates will be more accurate, even if the numbers of the prices are relatively long.

### Non-length factors: the role of attention

The notion of selective attention to stimuli has played a significant role in the chunking literature (Chen & Cowan,

2005; Cowan, 2000; Saults & Cowan, 1996). Chunking is typically accomplished by rehearsal of the stimuli and elaborative activities in working memory, so focusing attention on the stimuli should increase the likelihood of successful chunking. Previous research has shown this by limiting, rather than enhancing, the attention dedicated to the stimuli. For instance, Cowan, Nugent, Elliott, Ponomarev, and Saults (1999) limited the ability to form chunks (preventing the rehearsal of test items and their combination with elements in long term memory) by decreasing the level of attention paid to particular test items. Thus, although chunking results in more efficient information processing in working memory, the process of chunking itself requires cognitive resources. Therefore, chunking likelihood and accuracy should be enhanced when more attention is dedicated to the task.

In consumer psychology, a factor often used to vary the level of attention that individuals direct toward a stimulus is processing motivation (MacInnis & Jaworski, 1989). Therefore, we investigate whether motivation facilitates the chunking process. Previous research has found that motivation improves memory (Unnava & Burnkrant, 1991) and calculation accuracy (Kruger & Vargas, 2007). Motivation has been defined as the desire to process information in marketing communication. Such desire can increase the intensity of processing and dictate the focus of individuals' attention. This occurs through the central executive component of working memory. Under high motivation, the central executive allocates more cognitive resources to the task at hand, leading to greater elaboration with other elements in long-term memory (Baddeley, 1986; MacInnis & Jaworski, 1989). Hence, motivated individuals would be more likely to successfully chunk complex information than unmotivated individuals.

### Study 5

We manipulated the level of processing motivation of the study's participants to examine the possibility that, in general, motivated consumers estimate a shopping basket's total price more accurately regardless of number length (Petty, Cacioppo, & Schumann, 1983).

### Method

Eighty-one college students at a Korean University participated in this study. They were randomly assigned to conditions in a 2 (number length: short, long)  $\times$  2 (motivation: high, low) between-subjects design. They were exposed to a scenario including prices regarding a trip to New York City. The use of Korean participants served as a control for their price expectations. Thus, participants had a vague idea of how much the price components approximately cost, but they did not have specific knowledge of the real prices for the products in the scenario. The questionnaire was written in Korean, including the pricing scenario.

In the long number condition, the prices were \$608 (limousine tour), \$115 (French dinner), and \$709 (Broadway show); 14 syllables in Korean. In the short number condition, the prices

were \$519, \$255, and \$656, respectively; nine syllables in Korean. Note that our scenario was based on complementary items. Motivation was manipulated following Kardes (1988). That is, in the high motivation condition, participants were told that researchers were surveying a small sample of consumers in their geographic area and that their opinions were important and would weigh heavily in the decision. In contrast, participants in the low motivation condition were told that they were part of several large samples across different locations and that their individual opinions were not important because they would be averaged with other opinions. We included the following scales translated into Korean as a check on the motivation manipulation: (1) “When reading the scenario, you were interested,” and “When reading the scenario, you were involved,” 1=not at all, 7=very much, and (2) “You thought the survey was interesting,” and “You thought the survey was involving,” 1=not at all, 7=very much (Kardes, 1988). These items were highly correlated and thus were averaged into a motivation index ( $\alpha=.83$ ). Furthermore, we measured participants’ knowledge of prices in New York City on a two-item scale, “How familiar are you with prices in NYC?” and “How much do you know about prices in NYC?” 1=not at all, 7=very much. These items were averaged to form a knowledge index ( $r=.92$ ). The other aspects of study 5 were identical to those of study 1.

### Results and discussion

We expected that high motivation would lead to more accurate estimates of the total price than low motivation, regardless of number length. Conversely, accuracy in the low motivation condition would be influenced by number length. These results were reflected on a 2 (number length)  $\times$  2 (motivation) interaction ( $F(1, 77)=4.44, p<.04$ ). In particular, the results showed that (1) for high motivation, no difference in accuracy was observed whether number length was long or short ( $M=.06$  vs.  $M=.06, F<1$ ), (2) for low motivation, the long prices led to less accurate estimates than the short prices ( $M=.20$  vs.  $M=.11, F(1, 77)=9.24, p<.01$ ), and (3) overall, high motivation resulted in more accurate estimates than low motivation ( $M=.06$  vs.  $M=.15, F(1, 77)=24.84, p<.01$ ). In summary, these results show that motivation facilitates chunking and offsets the effect of the number length on total price estimate accuracy.

A manipulation check followed the expected pattern. We ran a 2 (number length: short, long)  $\times$  2 (motivation: high, low) ANOVA on the motivation index. Only the main effect of motivation emerged ( $M_{\text{high}}=5.35$  vs.  $M_{\text{low}}=4.40, F(1, 77)=17.78, p<.01$ ). Furthermore, the price knowledge index showed a very low level of knowledge of prices in NYC ( $M_s<2.13$ ), and a 2  $\times$  2 ANOVA on the price knowledge index did not result in significant effects at all (all  $F_s<1$ ). The demographic variables neither covaried with accuracy nor resulted in differences across conditions ( $p's>.23$ ).

### General discussion

The studies reported in this paper suggest that total price calculation is not as straightforward as it may seem. When total

price calculation is viewed as an instance of chunking in working memory, we can identify a series of factors that influence when the calculation takes place and when it will be more or less accurate. Thus, based on the immediate recall literature, we find that item prices with long number names can overtax the phonological loop of working memory and lead to less accurate estimations of the total price of a shopping basket. Also, non-length factors like attention can influence the chunking/calculation process via the central executive component of working memory. The pilot study and studies 1 and 2 focus on establishing the number length effect in the calculation of a total price. Study 3 investigates the timing of the calculation based on whether the items in the shopping basket are complementary or unrelated. Study 4 further examines the processing differences between complementary and unrelated items. Study 5 shows the role of attention and its ability to offset the number length effect.

We find support for our theorizing in multiple populations (bilinguals and monolinguals), languages (English and Korean), and price stimuli (different sets of multiple prices in the pilot study, studies 1–2, study 3, study 4, and study 5). By finding evidence for our hypothesized process with bilingual consumers, we help discount the potential confounding effect of cultural variables in prior research that investigated linguistic influences on single price recall (e.g., Vanhuele et al., 2006).

This research provides some important insights into the understanding of multiple price processing, where there is an acute need for research. We show that the processing of prices should be understood in a context. That is, product types (complementary vs. unrelated), price salience, and motivation all influence total price calculation accuracy. Our studies also contribute to the growing consumer behavior literature examining linguistic influences on information processing. Our findings suggest that the language in which consumers encode prices matters for later information retrieval. Overall, our research opens a new direction for researchers interested in the influence of language on the processing of marketing stimuli. To date, few studies (e.g., Vanhuele et al., 2006) have investigated the interplay between prices and language—that is, the linguistic processing of prices. To our knowledge, there are no prior studies of how consumers calculate total basket prices and the influence that language has on that process. Future research could examine how our findings apply to subjective estimates of individual prices in a basket (Briley, Shrum, & Wyer, 2007), or scenarios with different levels of linguistic complexity (Dimofte & Yalch, 2007).

In summary, we provide useful insights regarding price processing in multiple price situations. Although multiple prices are encountered every day by consumers, there is a dearth of studies examining how they are processed. Therefore, although our studies do represent a step forward, much research remains to be done in this area.

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