Consumer confusion of percent differences

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Abstract

The present research investigated consumers' intuitions about percent differences. We found that the perceived difference between two quantities compared on a percent scale varies as a function of the target of the comparison. The subjective price difference between a $1500 and a $1000 moped, for instance, increased when the former was described as 50% more than the latter than when the latter was described as 33% less than the former (Experiment 1). This effect (1) is limited to comparisons made on a ratio scale, (2) varies as a function of the percent difference between the two quantities, (3) applies not only to price, but to other quantifiable attributes (Experiments 2-4). As well, Experiment 5 found that the bias reduced (but not eliminated) with financial incentives for accuracy, and persists even among highly numerate individuals. Discussion focuses on the source and implications of this bias.

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Consumer confusion of percent differences

In the 1980s California published the results of a survey in an effort to defend its much-maligned public education system. Although scores on standardized tests in the state fell 60% in the 1970s, they had since rebounded by over 70%. Excellent news—things are better than ever! A few moments' thought, however, reveals the folly here. It would take an increase of considerably more than 70% to recover from a 60% decrease (150%, to be exact; Dewdney, 1993). A similar misunderstanding seemed to characterize the response of many investors to the 2000-2001 US recession, who assumed that if they lost, say, 33% (as many investors did), it would take a gain of 33% to recoup their losses. In fact, it would take a gain of 50%.

We suspect that such misunderstandings are common. If quantity A is X% greater than quantity B, intuition suggests that quantity B must be X% less than quantity B. If the leading brand costs 50% more than the competing brand, for instance, intuition suggests that the competing brand ought to be, not 33% less expensive than the leading brand, but 50% less (just like when leading brand is $50 more than the competing brand, the competing brand is $50 less than the leading brand). Similarly, if Bob is 62% heavier than Susan, intuition suggests that Susan ought to be, not 38% lighter than Bob, but 62% lighter—again, just as if Bob is 62lbs heavier than Susan, then Susan is 62lbs lighter than Bob. People seem to forget, in other words, that unlike in the case of whole number differences, the magnitude of a percent difference depends on the referent of the comparison, i.e., the quantity against which the target is compared.

We base our predictions, at least in part, on two related findings in the psychological literature on number representation and innumeracy. The first is that number representations involving fractions, decimals, and (especially) percentages are considerably less intuitive than are whole number representations (Behr, Post, &

Wachsmuth, 1986; Chen & Rao, in press; Gallistel & Gelman, 1992; Lembke & Reys, 1994; Mix, Levine, & Huttenlocher, 1999; Moss & Case, 1999; Parker & Leinhardt, 1995; Parker; 1997; Venezky & Bregar, 1998). Although precisely why this is so—whether the result of pedagogy (Brown & Kinney, 1973; Hunting & Sharpley, 1988; Parker & Leinhardt, 1995), evolutionary pressure (Cosmides & Tooby, 1996), or the mere fact that whole numbers are less complicated than are other numeric representations (Bettman, Johnson & Payne, 1990; Davis, 1988)—is a matter of some debate, this "whole number dominance" means that, second, people reflexively extend mathematical rules that apply to whole numbers to operations where these rules no longer apply. For instance, a common error among children in the addition of fractions is simply to add the respective numerators and denominators as if they represented whole numbers (e.g., 5/6 + 4/7 = 9/13 because 5 + 4 = 9 & 6 + 7 = 13; Behr et al., 1986; see Hoz & Gorodetsky (1989) for an analogous finding with fractions). In much the same way, we argue, people may reflexively assume that if A is X% greater than B, then B is X% less than A (just as if A is X greater than B then B is X less than A).[1] Although adults can learn to question (and correct) these faulty intuitions, whole number dominance means that intuitions they remain.

These intuitions are likely to lead to a number of systematic and consequential biases in consumer behavior. For instance, whenever two quantifiable attributes—be they concerning people, situations, or consumer goods—are compared on a percent scale, the perceived difference is likely to seem greater when the smaller quantity is the referent of the comparison (e.g., Brand A is 50% more expensive than Brand B) than when the larger quantity is the referent of comparison (e.g., Brand B is 33% less expensive than Brand A). The subjective price difference between a $1500 and a $1000 moped, for instance, is likely to be greater when the former is described as 50% more than the latter than when the latter is described as 33% less than the former. The present research was designed to test this hypothesis—as well as several sub-hypotheses derived from it—by focusing on one of the more common and (by definition) costly instances of it: evaluations of price.

Price is one of the most important factors in consumer choice (Monroe, 2003). Although exceptions abound, the decision of whether to buy—or not to buy—a product is in large part a function of how much it costs. All else equal, people tend to choose the cheapest option available. Indeed, people occasionally pursue the cheaper of two options even to the point of irrationality, such as driving across town to save $5 on a $15 pocket calculator (Tversky & Kahneman, 1981).

That said, differences in price can be (and are) expressed in a variety of ways. The difference between a $10 and $15 pocket calculator, for instance, can be expressed on an absolute scale (i.e., in dollars) or a ratio scale (e.g., in percent). On an absolute scale, the cheap calculator costs $5 less than the expensive calculator, and the expensive calculator costs $5 more than the cheap calculator. On a percent scale, the cheap calculator costs 33% less than the expensive calculator, but the expensive calculator costs 50% more than the cheap calculator. (Similarly, a $15 CD costs 25% less than a $20 CD but a $20 CD costs 33% more than a $15 CD, a $30 toaster costs 50% less than a $60 toaster but a $60 toaster costs 100% more than a $30 toaster, and so on.)

Of course, the actual difference in price is independent of the referent of comparison. A $15 calculator does not become more expensive when it is the target of the comparison than when it is the referent of the comparison, nor does the $10 calculator become less expensive. But the subjective difference, we offer, does change. The difference between a $10 and a $15 pocket calculator seems greater when the latter is described as 50% more expensive than the former than when the former is described as

33% less expensive than the latter. (And the difference between a $15 and a $20 CD seems greater when the latter is described as 33% more than the former than when the former is described as 25% less than the latter, and the difference between a $30 toaster and a $60 toaster is greater when the latter is described as 100% greater than the former than when the former is described as 50% less than the former, and so on.)

To put it more generally, we offer the following four hypotheses. First, the perceived difference between any two prices compared on a percent (but not absolute) scale is likely to seem greater when the less expensive price is the referent of the comparison than when the more expensive item is the referent of comparison (Hypothesis 1). Given the importance of price in product evaluations (Monroe, 2003), this should (all else equal) translate into judgments of value, “deal,” and ultimate purchase decisions.

Second, the size of this bias is likely to depend on the percent difference in price between the two products (Hypothesis 2). Whereas the perceived difference in price between a $10 and $15 pocket calculator is likely to vary considerably depending on which is the referent of comparison, the perceived price difference between a $110 and $115 calculator is likely to vary less as a function of which is the referent because the percent difference varies only slightly (4.35% versus 4.55%). (Note, however, that the absolute difference in price—$5—is identical in the two examples.)

Third, just as people are likely to assume that a 50% difference in price between A and C must be larger than a 33% difference between C and B, so too are they likely to reason that a 33% percent difference between A and C must be the same as a 33% difference between C and B. For instance, suppose that the prices of A, B, and C are $99, $122, and $176, respectively. Suppose further that A is described as “A is 44% less than C” and B is described as “C is 44% more than B.” If people treat the percent difference as an absolute difference, A is likely to seem the same price as B (Hypothesis 3).

Finally, these principles are likely to apply not only to differences in price, but to any quantifiable attribute (Hypothesis 4). For instance, the perceived difference in processing speed between a 2 GHz and 3 GHz computer is likely to seem bigger when the latter is described as 50% faster than the former than when the former is described as 33% slower than the latter. And driving a car is likely to seem riskier if one is 193% more likely to die in a car than murdered than if one is 66% less likely to be murdered than killed in an auto accident (both, in fact, are true[2]). In the case of product evaluations, this may influence the desirability of the product and ultimate purchase decision to the extent to which the attribute is relevant to the desirability of the product. All else equal, compared with a 2 GHz computer, a 3 GHz computer is not only likely to seem faster when it is the target of the comparison than when it is the referent, but also (all else equal) a better value, and as a consequence, more likely to be purchased.

Experiments 1-5 were designed to test these hypotheses. In Experiment 1, participants compared two brands of mopeds. We varied whether the less expensive brand was the referent of comparison (e.g., moped B costs 50% more than moped A) or the more expensive brand was the referent of the comparison (moped A costs 33% less than moped B) to see whether the perceived difference in price, value, and hypothetical purchase would be greater when the less expensive item was the referent of the percent comparison (Hypothesis 1). In Experiment 2 we extended the results of Experiment 1 to a non-hypothetical domain involving financial incentives.

Experiments 3 and 4 were modified versions of Experiment 1 designed to test Hypotheses 2, 3 and 4 while at the same time rule out a competing explanation for the results based on prospect theory (Kahneman & Tversky, 1979). Participants once again evaluated the price, value, and likelihood of purchasing several pairs of products of different prices. In addition to varying the referent of the price comparison, we also varied whether that difference was expressed in absolute or percent terms in order to examine whether the bias we observe can be explained by loss aversion. We also varied the size of the price differences to see whether the size of the framing effect increases as a function of the percent difference in price (Hypothesis 2). In both experiments, we included conditions in which the absolute difference between two products was different, but the percent figure used to describe that difference was identical, to see whether differently priced products could be made to look the same (Hypothesis 3). And in Experiment 4, the products were compared on non-monetary attributes, such as the processing speed of a computer or warranty length of a camera, to see whether the effects observed for price differences would extend to other quantities (Hypothesis 4).

Finally, Experiment 5 was designed to shed light on the source of this bias, while at the same time examine two potential moderators of it. Our explanation is that whole number dominance causes people to reflexively extend whole number rules and procedures (if A is X greater than B then B is X less than B) to numeric representations where they no longer hold (if A is X% greater than B then B is X% less than A). One intriguing implication of this account is that these errors are likely to manifest themselves even among individuals proficient with the mathematics involved but who simply lack the motivation to question their intuitions. In other words, although innumeracy may be sufficient to cause these errors, it may not be necessary. Instead, what may moderate these errors is the motivation to challenge one's intuitions and perform the necessary calculations. We test these possibilities in Study 5 by measuring math skills and manipulating financial incentives for accuracy, respectively.

Experiment 1

Participants in Experiment 1 compared two brands of differently-priced mopeds. In one condition, Moped A was described as 33% less expensive than Moped B, and in another (within-subject) condition, Moped B was described as 50% more expensive than Moped A (see Appendix A). We expected the difference in price to appear greater in the latter condition than in the former condition (Hypothesis 1). As a consequence, we expected participants to see Moped A as cheaper, a better value, and more likely to be purchased when Moped B was described as 50% more expensive than Moped A than when Moped A was described as 33% less expensive than Moped B.

Method

Participants. 103 students (53 women, 47 men, and 3 unidentified) at a large Midwestern university earned $8 in exchange for participating in this and several unrelated experiments.

Procedure. Participants completed a questionnaire in which 8 pairs of consumer products were described. These included a pair of bread makers, down comforters, MP3 players, palmtop computers, stereo speakers, color printers, and mopeds. For each pair, a photograph of the product was provided, as were several details about each brand. In addition, the prices of the two brands were compared on a ratio scale (%). For some pairs, the referent of the comparison was the cheaper of the two brands, and for others, the referent was the more expensive of the two brands. Participants compared each pair of brands in terms of price, value, "deal," and likelihood of future purchase using the scales listed Appendix A.

The key item was the pair of mopeds, which appeared twice in the questionnaire: first near the beginning of the questionnaire, and second at the end of the questionnaire (after the other 7 pairs of consumer products). The only difference between the two presentations other than the order in which they were presented (which was counterbalanced in order to control for possible order effects) was the manner in which the price difference between two mopeds was described. In one version, Moped A was described as 33% less expensive than Moped B, and in the other, Moped B was described as 50% more expensive than Moped A (see Appendix A).

Results

The order in which the two versions of the key item was presented did not influence the results.

Our first prediction was that the difference in price between the two brands of mopeds would appear greater when Moped B was described as 50% more expensive than Moped A than when Moped A was described as 33% less expensive than Moped B, consistent with Hypothesis 1. That is precisely what we found. On average, participants (correctly) reported that Moped A was cheaper than Moped B, but the perceived difference was greater in the former condition than in the latter, *M*s = 3.38 vs. 2.48, $t(95) = 4.17$, $p < .001$.[3]

Our next set of analyses focused on participants' comparisons of the two brands in terms of value, "deal," and anticipated future purchase. Here, too, the perceived difference between the two brands was influenced by the manner in which that difference was described. On average, participants thought that Moped A was a better deal than Moped B, but the perceived difference was once again greater when Moped B was described as 50% more expensive than Moped A than when Moped A was described as 33% less expensive than Moped B, *M*s = 1.75 vs. 1.26, $t(95) = 2.14$, $p = .035$. Participants also reported that they would be more likely to purchase Moped A than Moped B, but that was again particularly true in the former condition, *M*s = 1.70 vs. 0.94, $t(95) = 2.46$, $p = .016$. Counter to our predictions, the framing manipulation had no statistically significant influence on the perceived value dependent measure, *M*s = 0.82 vs. 0.74, respectively, $t(95) < 1$.

Discussion

The results of Experiment 1 provide initial support for our thesis that the perceived difference in price between two products appears greater when the less expensive of the two products is the referent of a percent comparison than when the more expensive of the two products is the referent of the comparison. Participants saw Moped A as cheaper, a better deal, and more likely to be purchased if they were in the market for the product when Moped B was described as 50% more expensive than Moped A than when Moped A was described as 33% less expensive than Moped B.

Experiment 2

One limitation of Experiment 1 is that the purchase decisions were hypothetical. None of the products being compared were actually being considered for purchase, and as such, it is unclear whether the results observed would generalize to real decisions with real consequences.

To overcome this limitation, participants in Experiment 2 made a non-hypothetical choice with financial consequences. Specifically, participants were offered the opportunity to draw from one of two urns containing a mix of red and yellow jelly beans, with participants who drew a yellow jelly bean winning $100. Participants learned that the total number of jelly beans in each urn was 79 and 119 in Urns 1 and 2, respectively, but were not told the specific mix of red and yellow beans. Instead, participants were simply told either that Urn 1 contained 33% fewer yellow jelly beans than Urn 2, or that Urn 2 contained 50% more yellow jelly beans than Urn 1. Because all of the information provided to participants was accurate, this meant that the odds of winning were always slightly better if participants chose Urn 1 than Urn 2, and were of course independent of the framing manipulation.[4]

In keeping with Hypothesis 1, we expected the difference between the numbers of winning beans in each urn to appear greater when they were told that Urn 2 contained 50% more yellow beans than Urn 1 than when they were told that Urn 1 contained 33% fewer yellow beans than Urn 2. As a consequence, we expected participants to be more likely to draw from the objectively inferior Urn 2 in the former condition than in the latter condition.

Method

Participants. 38 students (26 women, 12 men) enrolled in an introductory advertising course at a large Midwestern university participated on a volunteer basis.

Procedure. Participants were recruited in groups of 3-5 for a study of probability. On arrival to the lab, participants were shown two urns. All participants were told (correctly) that Urn 1 contained 79 jelly beans and that Urn 2 contained 119 jelly beans. Half of the participants were then told that Urn 2 contained 50% more yellow jelly beans than Urn 1, and the other half were told that Urn 1 contained 33% fewer yellow jelly beans than Urn 2. Participants' task, they were told, was simply to select the urn from which they would like to draw a jelly bean, and those who drew a yellow jelly bean would win $100.

In addition to making a dichotomous choice between the two urns, participants compared their preference for the two urns on a scale from –5 (*Urn 1 much better*) to 0 (*neither*) to +5 (*Urn 2 much better*). After the experiment participants were thanked, debriefed, and—in one case—paid $100.

Results and Discussion

Twenty-one of the 38 participants (55%) chose to draw from the objectively inferior Urn 2. As predicted, that figure varied by condition, $X^2 = 61.82$, $p < .01$. When Urn 1 was described as having 33% percent fewer yellow beans than Urn 2, most participants (12 out of 19) chose Urn 1, whereas when Urn 2 was described as having 50% more yellow beans than Urn 1, most participants (14 out of 19) chose Urn 2.

An analogous result was observed on the continuous preference measure. Participants preferred Urn 2 more when it was described as having 50% more winning beans than Urn 1 ($M = 1.47$) than when Urn 1 was described as having 33% fewer winning beans than Urn 2 ($M = -0.53$), $t(36) = 2.57$, $p = .015$. The results of Experiment 2 thus complement the results of Experiment 1 in a non-hypothetical domain with real consequences.

Experiment 3

Experiments 3 and 4 employed a modified version of Experiment 1 in order to test Hypotheses 2, 3, and 4. Participants completed a questionnaire in which several popular high-tech products were described. For each type of product, three brands were described: a leading brand and two less expensive competing brands, “Brand A” and “Brand B.” The price of the two competing brands was identical, but the manner in which the price was framed was not. Specifically, both competing brands were compared with the price of the leading brand, but for the Brand A comparison, the more expensive brand was the referent of the comparison (e.g., Brand A costs 33% less than the leading brand), whereas for Brand B, the less expensive brand was the referent of the comparison (e.g., the leading brand costs 50% more than Brand B). As well, for half of the participants, the differences were expressed on a percent scale, and for the other half, on an absolute scale (i.e., in dollars).

Despite the equivalence in price between the two competing brands, we expected this framing manipulation to cause Brand B to seem cheaper, a better value, and more tempting to purchase than Brand A—but only in the percent price comparison condition (Hypothesis 1). We also varied the percent difference in price between the leading and competing brands, in order to see whether the size of the framing effect increases as a function of the percent difference in price (Hypothesis 2).

Finally, we included several additional sets of products in which the price of the two competing brands were in fact different, but the percent price differences used to describe them was the same. For instance, for one product category, the price of the leading brand was $176 and the prices of Brand A and B were $99 and $122, respectively. Thus, in the absolute price comparison condition, Brand A was described "costs $77 less than the leading brand" and Brand B was described "leading brand costs $54 more." In the percent price comparison condition, in contrast, Brand A was described "costs 44% less than leading brand" and Brand B was described "leading brand costs 44% more." Despite the *in*equivalence of the two brands, we expected them to appear the same—but again, only in the percent price comparison condition (Hypothesis 3).

Note that the design of this experiment also enables us to address an alternative interpretation of the previous experiments based on prospect theory (Kahneman & Tversky, 1979), and in particular, loss aversion. One reason the difference between the two mopeds may have seemed greater when, for instance, Moped B was described as 50% more expensive than Moped A then when Moped A was described as 33% less expensive than Moped B is because the former emphasized a loss (focusing on the extra expense) and the latter emphasized a gain (focusing on money saved). Because losses are more psychologically impactful than are equivalent gains, this gain/loss framing, as opposed to any confusion over the magnitude of the percents involved, may have driven this effect (a similar confound was present in Experiment 2). By comparing the results between the absolute and percent price comparison conditions we can address this interpretation.

Method

Participants. 182 students (117 women, 64 men, and 1 unidentified) enrolled in a research methods class at a large Midwestern university participated as part of a course requirement.

Procedure. Participants completed a questionnaire in which 14 sets of high-tech products were described. The products were: a high-definition television (HDTV) set, a mini digital-video camcorder, a DVD player, a portable MP3 player, a digital camera, a palm-top computer, a home theater speaker system, a mini digital pocket camera, a color printer, a flat screen computer monitor, a pair of bookshelf speakers, a home theater system, a portable DVD player, and a desktop computer.

For each set, the questionnaire presented a photograph of the product category as well as a short description of three different brands: a leading brand and two less expensive competing brands, “Brand A” and “Brand B.” Several details about each brand were provided, which were altered slightly so that each brand had slightly different features and specifications. Two examples are provided in Appendix B. In each set, the price of the leading brand was provided, but the prices of the two competing brands were not. Instead, the price of each competing brand was described only in terms of how it differed from the leading brand. Participants’ task was simply to compare Brand A and Brand B along the same scales used in Experiment 1, specifically, price, value, “deal,” and likely purchase. As in Experiment 1, all 4 comparisons were on a scale from -5 to +5, with negative numbers indicating a preference for Brand A and positive numbers indicating a preference for Brand B.

The specific manner in which the price differences were described varied, and constituted the primary independent variables. First, as in the previous experiments, we varied the referent of the price comparison. Specifically, the price of Brand A was described in terms of how it differed from the leading brand (e.g., costs 33% less than leading brand), whereas the price of Brand B was described in terms of how the leading brand differed from it (e.g., the leading brand costs 50% more). Second, we also varied whether the comparison was on an absolute or percent scale. Specifically, for participants in the *percent price comparison condition*, all differences were described on a percent scale (e.g., Brand A costs 33% less than leading brand, leading brand costs 50% more than Brand B), whereas for participants in the *absolute price comparison condition*, all differences were described on an absolute scale (e.g., Brand A costs $133 less than leading brand, leading brand costs $133 more than Brand B).

We also varied the percent price differences between the leading and competing brands. For instance, in the desktop computer set, the price of the leading brand was $1699 and each of the competing brands was $1529. Since the percent difference changes only slightly by varying the referent of comparison (10% when the leading brand is compared with the competing brands versus 11% when the competing brands are compared with the leading brand), we expected a similarly slight framing effect. In contrast, we expected a larger bias in the case of the mini digital-video camcorder set depicted in Appendix B, where the price of the leading brand was $399 and the price of each competing brand was $132 less. There, the percent difference varies considerably depending on which is the referent of comparison (33% vs. 50%), and so should be associated with a similarly larger bias. The percent differences ranged from a low of 10%/11% to a high of 42%/73%. We predicted that the greater the difference, the bigger the framing effect (Hypothesis 2).

Finally, we varied whether the two competing brands were identically or differently priced. In half of fourteen product sets, such as the desktop computer and mini digital-video camcorder described earlier, the price of the two competing brands was the same—with only the percent differences used to describe them different. In the other seven product sets, the price of the two brands was in fact different, but the percent difference used to describe them was the same. For instance, the price of the leading brand of bookshelf stereo speakers described in Appendix B was given as $176. The price of the two competing brands were $99 and $122, respectively. In the absolute price comparison condition, the price of Brand A was framed as "costs $77 less than Brand A" and the price of Brand B was described with "leading brand costs $54 more." In the percent price comparison condition, in contrast, Brand A was framed as "costs 44% less than leading brand" and Brand B was framed as "leading brand costs 44% more." This allowed us to test whether the tendency to treat percent differences as if they are absolute differences can cause not only that which is the same to appear different (Hypothesis 1), but that which is different to appear the same (Hypothesis 3).

Results

Identical competing brands condition. Our first set of analyses focused on the perceived price difference between Brands A and B for the seven product sets in which the two competing brands were the same price. Despite this equality, we expected the framing manipulation to cause Brand B to seem less expensive than Brand A—but only in the percent price comparison condition. As the top half of Table 1 shows, that is precisely what we found. For instance, camcorder Brand B was seen as less expensive than Brand A when the price of the Brand B was framed as "leading brand costs 50% more than Brand B" and the price of Brand A was framed as "Brand A costs 33% less than leading brand." However, the two brands were not perceived to be different when the price of Brand B was framed as "leading brand costs $132 more than Brand B" and the price of Brand A was framed as "Brand A costs $132 less than the leading brand." In fact, if anything, there was a slight tendency for participants to see Brand A as less expensive than Brand B in the absolute price comparison condition, although this tendency was significant for only two of the seven product sets.

Perhaps not surprisingly, these perceived differences led to systematic preferences for Brand B over Brand A in the percent price comparison condition. On average, Brand B was seen as a better value, better deal, and more likely to be purchased than Brand B. In fact, this was true for all three measures and all seven product sets (*M*s = 0.30 to 2.06, all *p*s < .05).

Can this preference for Brand B over Brand A be attributed to some other difference between brands besides the framing manipulation? In a word, no. There was no reliable tendency for participants in the absolute price comparison condition to rate Brand B more favorably than Brand A in terms of value, deal or likely purchase (*M*s = -.63 to 1.09). This result is important because there are other reasons why Brand B might have been seen as superior to Brand A, including order effects (Nisbett & Wilson, 1977) or an unintentional bias in the product descriptions that favored Brand B. Altering the referent of the price comparison may also have altered the comparison of the other product attributes, which might have led to other direction of comparison effects (such as the tendency for people to focus on the unique features of the target of the comparison and underweight features shared by both the target and the referent; Dhar, Nowlis, & Sherman, 1999; Houston & Sherman, 1995; Mantel & Kardes, 1999). Finally, as already mentioned, the differential focus on losses (extra expense) or gains (money saved) may also have influenced the desirability of the various products (Kahneman & Tversky, 1979; see also Viswanathan & Narayanan, 1994). The fact that the bias disappeared when the comparisons were made on an absolute scale rules out these alternative interpretations.

Our next set of analyses focused on the size of the framing effect as a function of the difference in price between the target and referent of comparison (Hypothesis 2). We predicted that the greater the percent difference in price between the leading and competing brands, the greater the size of the framing effect in the percent price comparison condition. A quick glance at Table 1 provides directional support for this prediction. The greatest perceived price difference (M = 2.67) occurred for the item for which there was also the greatest percent difference between the leading and competing brands (42% or 73% depending on the referent of comparison). The weakest perceived price difference (M = 1.00), in contrast, occurred for the product set with the smallest percent difference between the leading and competing brands (10% or 11% depending on the referent of the comparison). This pattern was confirmed by correlating these differences across the seven item sets: As expected, the greater the percent difference in price, the greater the size of the framing effect, $r(5) = .98$. Of key importance, this correlation remained after controlling for the absolute difference in price between the leading and competing brands, $r(4) = .98$, as well as controlling for the price of the leading brand, $r(4) = .79$.

Different competing brands condition. Our final set of analyses focused on the perceived difference in price, value, deal, and anticipated future purchase decision between Brands A and Brand B for the seven product sets where the two competing brands were different prices. As the bottom half of Table 1 reveals, participants had no trouble seeing that Brand B was in fact more expensive than Brand A in the absolute price comparison condition. In the percent price comparison condition, in contrast, Brands A and B were seen as fairly equal. Although here, too, there was a slight tendency for participants to (correctly) rate Brand A as less expensive than Brand B, those differences were either nonsignificant or small. Non-parametric analyses revealed a similar pattern: whereas only 13% to 20% of participants (depending on the specific item) correctly reported that Brand A was in fact less expensive than Brand B, between 74% and 79% believed that the two brands were the same price, and another 6% to 11% thought that Brand A was more expensive than Brand B.

Discussion

The results of Experiment 3 provide strong support for Hypotheses 1, 2, and 3. The perceived difference in price between two high-tech gadgets compared with a more expensive leading brand was greater when the less expensive item was the referent of comparison than when the more expensive item was the referent of the comparison, but only when the comparison was on a percent scale (Hypothesis 1). This was true not only in terms of perceived price, but also perceived value, deal, and anticipated future purchase decision. Consistent with Hypothesis 2, the size of this framing effect depended on the percent difference between the two brands: the greater the difference, the greater the framing effect. Finally, we found that this tendency to treat percent differences as if they are absolute differences could not only cause two identically priced items to appear to have different prices, but two differently priced items to appear the same price (Hypothesis 3).

Experiment 4

Experiments 1 and 3 showed that the perceived difference in price between two products compared on a percent scale depends on the order in which they are compared. The purpose of Experiment 4 was to extend these results to non-monetary attributes (Hypothesis 4). Participants completed a questionnaire similar to that used in Experiment 3, except that this time, instead of comparing the leading and competing brands in terms of price, they were compared on one of a variety of other attributes (warranty length, processing speed, screen size, etc.). Here, too, we expected differences to appear larger when the smaller attribute was the referent of the percent comparison than when the larger attribute was the referent of percent comparison.

Method

Participants. 82 students (58 women, 24 men) enrolled in a research methods class at a large Midwestern university participated as part of a course requirement.

Procedure. Participants completed a questionnaire similar to the one used in Experiment 3, the key differences being that 1) we omitted the absolute price comparison condition (i.e., all comparisons were made on a percent scale), and 2) the brands were compared on a non-monetary attribute (see Table 2). The price of each product was listed in dollars, and was the same for the three brands within a set. Other than these changes, the product descriptions were identical to Experiment 3. In addition to the questions about value, deal, and probable purchase, participants were also asked to compare the two brands in terms of the specific attribute being manipulated (i.e., screen size, visual distortion, and so on).

As in Experiment 3, the competing brands were always superior to the leading brand on the key attribute (in that experiment, price). In the present experiment, this meant that the competing brands sometimes possessed more of the key attribute and sometimes less of the attribute depending on whether the attribute is a positive feature of the product (e.g., screen size, resolution) or negative feature (e.g., harmonic distortion, weight). Also as in Experiment 3, each competing brand was compared with the leading brand, and for one of the brands the leading brand was the referent of the comparison (e.g., Brand A is 33% lighter than the leading brand) and for the other the competing brand was the referent of comparison (e.g., leading brand is 50% heavier than Brand B). In the present experiment, however, this was counterbalanced across participants. That is, for half of the participants, the Brand A was the target of the comparison with the leading brand and Brand B was the referent of the comparison with the leading brand (as in Experiment 3), and for the other half of participants the reverse was true.[5]

Finally, as in Experiment 3 we varied whether the two competing brands were identical or different. For the product sets in the *identical competing brands condition*, the two competing brands were identical in terms of the key attribute—with only the percent differences used to describe them different. For product sets in the *different competing brands condition*, in contrast, the two brands differed on the key attribute, but the percent difference used to describe them did not. For instance, the picture quality of one brand of DVD player was described as "Brand A has 43% less visual distortion than the leading brand," whereas for the other DVD player it was described "the leading brand has 43% more distortion than Brand B." We predicted that the two brands would tend to seem similar to one another in terms of visual distortion despite the fact that the latter has more distortion than the former.

Results & Discussion

Our first set of analyses focused on the perceived difference between pairs of brands identical on the key attribute, such as Brands A and B of the mini digital video camcorder, one of which was described as having a "50% longer warranty than the leading brand" and the other "the leading brand has a 33% shorter warranty." Recall that the descriptions were counterbalanced, such that for half of the participants Brand A was the target in the comparison with the leading brand and Brand B was the referent in the comparison with the leading brand, and for the other half the opposite was true. Thus, the first step was to reverse-score responses from half of the participants so that higher numbers indicated a preference for the brand with higher percent difference (in this case, 50%).[6] As predicted, participants showed a consistent preference for this brand. As the top half of Table 2 shows, this was directionally true for all seven sets of relevant products.

As in Experiment 3, we also examined whether these perceived differences trickled down to judgments of value, deal, and anticipated purchase. Although this was directionally the case for all three measures and all seven product sets, it was significantly so for only 1/3 of them. This may be because attributes such as harmonic distortion and warranty length are less relevant to the desirability of the products than is price.

Our final set of analyses focused on the perceived difference between pairs of brands that differed on the key attribute, but which were described with the same percent figure. Here, too, we reverse-scored the responses of participants in one of the counterbalancing conditions so that higher numbers reflect a preference for the brand that was actually superior on the key attribute. As the bottom half of Table 2 shows, there was no reliable tendency for people to recognize that superiority, consistent with our account. As in Experiment 3, a non-parametric analysis revealed a similar pattern: the majority of participants (74% to 80% depending on the specific product set) believed that the two brands were identical in terms of the key attribute.

Experiment 5

Taken together, the results of Experiments 1-4 provide strong converging evidence that consumers are confused by percent differences. Specifically, people seem to assume that if A is X% greater than B, then B is X% less than A.

What causes this confusion? There are at least two possibilities. First, participants may have been unmotivated to arrive at the correct answer. Although Experiment 2 showed that the bias persisted even with financial incentives for accuracy, note that those financial incentives were relatively weak. Specifically, the expected value associated with the superior urn was only slightly higher than the expected value of the inferior urn, and thus the motivation to select the "correct" urn may have been weak. As well, note that financial incentives were not manipulated. As such, the role of motivation in the bias is unclear.

It may also be that participants were unable to arrive at the correct answer. Although participants in our experiments were drawn from a highly educated sample (namely, college undergraduates at a major university), there is no shortage of studies that attest to the occasional difficulty even well-educated individuals have dealing with mathematical information (Fisher, 1988; Guiler, 1945; Kirsch, Jungeblut, Jenkins, & Kolstad, 2002; Lipkus, Samsa, & Rimer, 2001; Woloshin, Schwartz, Black & Welch, 1999). Thus, it may be a simple case of innumeracy, or the inability to make sense of numerical information, that explains the effect (Paulos, 1988; Peters, Vastfjall, Slovic, Mertz, Mazzocco & Dickert, in press).

Experiment 5 was designed to test both of these explanations. Participants completed a simplified version of Experiment 3, except that this time, we (1) measured participants' math skills and (2) experimentally manipulated incentives for accuracy. This allowed us to simultaneously and orthogonally test the role of innumeracy and motivation, respectively.

Method

Participants. One hundred fifty nine students (87 women and 72 men) enrolled in an introductory advertising course at a large Midwestern university participated in exchange for extra credit.

Procedure. Participants were recruited in groups of up to eight, and were immediately seated before computers running MediaLab experimental software (Jarvis, 2005). All instructions and experimental materials were presented, and dependent measures were collected (along with response times), via MediaLab.

The software presented participants with a simplified version of the questionnaire used in Experiment 3. Participants viewed six sets of products in which the price of two identically-priced competing brands was compared with the price of the leading brand, but the referent of that comparison varied. For Brand A, the more expensive leading brand was the referent of the comparison (e.g., “costs 23% less than the leading brand”) and for Brand B the less expensive competing brand was the referent (“e.g., Leading brand costs 30% more”). The six product sets included trios of flatscreen computer monitors, digital pocket cameras, palmtop computers, high definition television sets, personal computers, and home DVD players. Despite the equivalence of the two brands, we expected Brand B to appear superior to Brand A, which we measured with the same scales used in Experiments 1 & 3.[7]

Our central interest, however, was how this tendency would be influenced by (1) incentives for accuracy and (2) math proficiency. To manipulate incentives for accuracy, prior to completing the experiment all participants were given an overview of the task ahead of them and informed that whereas there were no correct answers to some of the questions (such as which items they would choose to buy) there were correct answers to other questions, such as which of the two competing brands was more expensive. Whereas participants in the no-incentive condition were simply told to respond “with the answer you feel is best given what you know,” participants in the incentive condition were told, “As an incentive for accuracy, you will earn $10 if your responses are among the top 50% in terms of accuracy.”

To measure numeracy, after completing all of the brand evaluations participants were given a 13-item math test with problems conceptually very similar to those posed in the brand evaluation task (e.g., “$100 + 50% =,” “150-33%=,” “1950-23%=”). All responses were solicited in an open-ended format where participants simply typed their answers. In addition, we also asked participants to record their math ACT scores (which for the vast majority of participant was the standardized math aptitude test they completed in High School).

Results and Discussion

As a manipulation check, we compared the amount of time participants spent answering the comparison questions by incentive condition. As expected, participants took more time when they were in the high incentive condition (M = 413s) than when they were in the low incentive condition (M = 320s), $F(1,157) = 15.60$, $p < .001$. This result provides indirect evidence that the incentive manipulation was successful.

Our first substantive question was whether the effects of the previous experiments replicated. They did. Averaging across the 6 product comparisons, we found that overall, participants thought that Brand B cost less than Brand A, M = 1.90, one-sample $t(158) = 11.14$, $p < .001$, despite the fact that the two products were the same price. Also as in the previous experiments, compared with Brand A, participants thought that Brand B was a better value (M = 1.27) and a better deal (M = 1.26), and also indicated that they would be more likely to purchase Brand B if they were in the market for the product (M = 1.31), *t*s >8, ps < .001.

How did the incentive manipulation influence this tendency? On average, participants showed a reduced bias in their price comparisons when they were in the high versus low incentive conditions, *M*s = 1.56 vs. 2.33, respectively, $F(1,157) = 5.20$, p = .024. This was also the case for participants self-reported intentions to buy, albeit to a marginally significant degree, *M*s = 1.07 vs. 1.62, respectively, $F(1,157) = 3.42$, $p = .066$. The “value” and “deal” measures showed a directional reduction, although neither approached significance, *M*s = 1.11 vs. 1.48, respectively, *p*s > .18. Of key importance, however, the bias remained strong even in the high incentive condition. Here, too, participants thought that Brand B was cheaper (*M* = 1.56), a better value (*M* = 1.11), a better deal (*M* = 1.11), and more tempting to purchase (*M* = 1.20), *t*s > 4.8, *p*s < .001, than Brand A.

The above results suggest that one key to the bias is motivation. The more motivated individuals were to make an accurate price comparison, the less they showed the bias. However, the results also show that the results presumably cannot be wholly attributed to motivation. Even in the high motivation condition participants showed a strong and significant tendency to incorrectly see product B as superior to product A.

Our next question concerned the influence of math proficiency on the bias. It stands to reason that one reason people may show the bias is that they simply do not possess the numeracy necessary to be able to correctly determine that the two products are identically priced. We examined this question in two ways. First, we correlated participants self-reported math ACT scores (where applicable) with the bias in price estimates. That correlation was negative, but to only a small and non-significant degree, *r*(103) = -.16, *p* = .106. As well, there was no reliable relationship between ACT scores and any of the other three measures of bias (*r*s = -.04 to +.07, *ns*).

Of course, ACT scores—especially self-reported ones—provide (at best) only an approximation of participants' ability to solve percent calculations. To examine the influence of that ability more directly, we next correlated participants score on the math test involving precisely those operations with the bias in participants' price comparisons. Here, too, there was a slight tendency for participants who scored higher on the math test to show a reduced bias in their price comparisons, *r*(157) = -.10. However, that correlation once again failed to reach significance (*p* = .223) and there was no relationship between participants' score on the math test and the other 3 less direct measures of bias (*r*s = .02 to .07, *ns*). There was also no interaction between scores on the math test and the incentive manipulation for any of the four dependent measures (*r*s = -.11 to + .02, *ns*).

The above results suggest that the tendency of individuals to be influenced by the direction of percent comparisons cannot be attributed to any inability to perform the necessary mathematical operations. Although there was a slight tendency for greater math performance to be associated with less bias, that tendency was small and insignificant. Indeed, a follow-up analysis looking exclusively at the top 10% of test scores revealed that even they showed a strong and reliable tendency to rate B as superior to A, $M_{\text{cost}} = 2.51$, $M_{\text{value}} = 1.89$, $M_{deal} = 1.62$, $M_{\text{buy}} = 2.20$, one-sample ts > 3, ps < .005.

General Discussion

If A is 33% less than B, then B is 50% more than A. The present research investigated the counterintuitiveness of this mathematical tautology, as well as the implications of that counterintuitiveness for consumers. In 5 experiments involving over 500 participants, the perceived difference between two attributes compared on a percent scale varied as a function of which attribute was the referent of the comparison. The difference appeared bigger when the smaller attribute was the referent of comparison than when the larger attribute was the referent of comparison (Hypothesis 1). This was true regardless of whether the quantity being compared was price or some other valued attribute (Hypothesis 4), and was often strong enough to translate into perceptions of value and anticipated purchase decision. Finally, the size of the framing effect depended on the percent difference in price between the two products: the bigger that difference, the bigger the effect (Hypothesis 2).

What accounts for this bias? At first glance the data seem most parsimoniously explained by a simple inability to make sense of all of the relevant numerical information. “Math,” after all, “is hard” (as one none-too politically correct “Talking Barbie” doll is reported to have said). And indeed, there is no shortage of findings that attest to the counterintuitiveness of many mathematical principles (Banks & Hill, 1974; Dewdney, 1993; Gigerenzer & Edwards, 2003; Gilovich, Vallone, & Tversky, 1985; Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000; Kahneman & Tversky, 1973; Kruger, Savitsky, & Gilovich, 1999; Tversky & Kahneman, 1971), percent included (Lembke & Reys, 1994; Parker, 1997; Parker & Leinhardt, 1995; Venezky & Bregar, 1998)

Although doubtless part of the explanation, the results suggest that the bias is a product of more than mere innumeracy. In Experiment 5, for instance, we found that participants’ math ability had little if any influence on their tendency to show the bias. Remarkably, this was true despite the fact that our math measure tapped precisely the same mathematical operations involved in the price comparisons. What *did* moderate the bias, in contrast, was motivation. In Experiment 5 we found that the framing effect was reduced (but not eliminated) with financial incentives for accuracy.

Although other explanations are possible, note that each of these findings are consistent with a whole number dominance explanation of the results. To the extent that people reflexively apply whole number rules and procedures to numeric representations where they no longer hold, then the difference between A and B is likely to seem greater when A is described as 50% more than B than when B is described as 33% less than A—even among individuals who “should know better,” and especially when processing motivation is low.[8]

Indeed, this was precisely the contention of Chen & Rao (in press) in their research on an analogous error in the processing of percent differences. These examined consumer's reaction to "double discounts," that is, discounts expressed as two separate percent discounts (e.g. "save 20% plus an extra 25%") as opposed to a single discount ("save 40%"). Consistent with the work presented here, these researchers found that many consumers treat the percent differences as if they were whole number differences, reasoning that since 20+25 > 40, saving 20% plus an extra 25% must be a better deal than simply saving 40% (in fact, the net savings associated with the two promotions are identical). As in the present work, these researchers found that motivation moderated the effect, consistent with a whole number dominance explanation of the results.

Limitations

Are there any other possible boundary conditions to the effect? Although we found that the size of the framing manipulation increased as a function of the percent differences involved (from a low of 10%/11% to a high of 42%/73%), it is possible, perhaps probable, that the effect might disappear as the percent differences approach or exceed 50%/100%. Whereas whole number dominance might cause people to infer that if A is 73% more than B then B must be 73% less than A, this may seem less plausible if A is 100% than B (because 100% less than A is immediately recognizable as nonsensical, and any number greater than that, impossible). This question is one that must await further research.

A related limitation of the present work concerns the influence—or lack thereof—of the absolute prices involved. Although we did not find any evidence that either the absolute price difference between the leading and competing brands or the price of the leading brand influenced the size of the framing effect, it would be premature (and, we think, incorrect) to conclude that these prices do not matter. Quite the contrary: To the extent that higher prices invoke greater motivation for accuracy, it may be that the effects we have disappeared attenuate or even disappear as the dollar values involved increase. Here too, future work is necessary in order to examine this issue.

Another potential way to debias these errors might be to make them salient, either directly via explicit instruction (i.e., telling consumers that percent differences are not symmetric) or indirectly (such as by prompting the use of rule-based, analytical, thinking as opposed to intuitive, heuristic thinking). Recall that in Experiment 5, for instance, participants took a math test that required them to perform many of the same calculations involved in consumer judgment task. Recall further that this math test was administered after the consumer judgment task. It is possible that simply reversing the order in which participants completed these tasks might have prompted or primed such thinking, causes the errors to disappear.[9]

Implications

Although our focus has been on basic judgment and decision making processes, the results presented here are of obvious practical significance as well. Advertisers frequently compare their products with the products of their competitors (or an earlier version of their own product), often on a ratio scale. One cannot go far in a supermarket, for instance, before coming across a product that is advertised as containing “x% more product than the leading brand,” nor long in a car dealership before learning about how much faster and more fuel efficient the new model is compared with the old. The results presented here suggest that simply varying the referent of such comparisons can inflate or deflate those differences, at least subjectively.

Indeed, some of the stimuli used in the experiments reported here were actual products—with genuine product information—that were on the market on the time of the experiments. For instance, the personal computer used in Experiment 3 was an Apple Macintosh, and the product details were taken directly from an Apple.com advertisement.

What was also taken was the price of the new computer, which was described on Apple.com (and in one condition of our experiment) as being “10% less expensive” than a previous version. Although the percent difference in price between the new and old version was quite small, recall that that difference seemed bigger when the less expensive computer was the referent of the comparison than when it was the target, an effect that translated into anticipated purchase decisions. These data suggest that Apple may have sold more computers had they compared the old computer with the new rather than the new with the old.

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Footnotes

1 Indeed, this was precisely the conclusion of Venezky & Bregar (1998) in their analysis of math errors made by college students, although these researchers did not test their assertion directly (see also Parker, 1994; 1997).

2 The annual frequency of deaths in the United States associated with automobile accidents and homicides are 55,350 and 18,860, respectively (Combs & Slovic, 1979).

3 The ratings in this experiment are reverse-scored for ease of presentation. 5 participants were excluded from this and the following analyses because their responses were over 3 standard deviations from the mean.

4 Specifically, there were 2 winning beans in Urn 1 and 3 winning beans in Urn 2. As such, the odds of winning were exactly 2 in 79 (2.53%) and 3 in 119 (2.52%), respectively. Note, however, that even without this information it can be determined that Urn 1 is superior to Urn 2. For instance, if are were 4 winning beans in Urn 1, then there must be 6 winning beans in Urn 2, making the odds of winning 5.33% and 5.31%, respectively. Similarly, if there are 10 winning beans in Urn 1 there must be 15 winning beans in Urn 2, making the odds of winning 14.49% and 14.42%, respectively. In each case—and in all possible cases—Urn 1 is superior, if only slightly, to Urn 2.

5 Two products were not counterbalanced (the computer monitor and HDTV), and thus for these items the data reported correspond to only one order of counterbalancing.

6 We observed several main effects for counterbalancing condition, but do not report them because they simply reflect the fact that some brands were seen as more desirable than others, independent of the framing manipulation. Note that by collapsing across counterbalancing condition, however, we rule out the possibility that such preferences could be driving our effect.

7 As in Experiment 3, we also varied the percent difference in price between the leading brands from a low of 13%/15% (depending on which whether the leading or competing brand was the referent of the comparison) for the digital pocket camera to a high of 44%/80% for the home DVD player. Unlike Experiment 3, however, these differences were unconfounded with both 1) the absolute price difference between the leading and competing brands and 2) the price of the leading brand. As in Experiment 3, we found that the greater the percent difference in price, the greater the perceived price superiority of Brand B over Brand A, $r(4) = .96$ (Hypothesis 3).

8 The bias we have documented is also analogous to referent neglect in social comparisons. When people compare themselves with others on a relative scale (such as a percentile), their comparative judgments tend to be insufficiently sensitive to the referent of the comparison (Diener & Fugita, 1997; Klar & Giladi, 1997, 1999; Klar, Medding & Sarel, 1996; Kruger, 1999; Kruger & Burrus, in press; Windschitl, Kruger & Simms, 2003; see also Wood, 1986). When comparing one's abilities with those of the average person, for instance, people tend to focus on their own abilities and all but ignore the abilities of the referent of the comparison (the average person). In other words, people treat the comparative judgment as if it were an absolute judgment, and as such, fail to appreciate how the referent of the comparison (in this case, the average person) influences one's relative standing (how one compares with the average person on a percentile scale). In much the same way, people tend to think of a relative difference in price (e.g., 33% less) as if it were an absolute difference (e.g., $33 less), and fail to appreciate how the magnitude of the referent in the former comparison influences the magnitude of the difference.

9 Credit goes to several anonymous reviewers for making these observations.

Table 1.
Perceived price differences between competing brands A & B by price comparison condition, Experiment 3.

		Absolute Price Comparison Condition			Percent Price Comparison Condition		
		Brand A Description	Brand B Description		Brand A Description	Brand B Description	
product	leading brand	*"Brand A is_____ less than leading brand"*	*"leading brand is _____ more than Brand B"*	Perceived price difference between Brand A & B [a]	*"Brand A is_____ less than leading brand"*	*"leading brand is _____ more than Brand B"*	Perceived price difference between Brand A & B [a]
			Identically Priced Competing Brands				
Computer	\$1,699	\$170	\$170	-0.33*	10%	11%	1.00*
Camcorder	\$400	\$132	\$132	-0.16	33%	50%	2.39*
Stereo	\$292	\$100	\$100	-0.23	34%	52%	2.34*
Palmtop	\$143	\$53	\$53	-0.17	37%	59%	2.19*
MP3 player	\$170	\$65	\$65	-0.31*	38%	62%	2.54*
Monitor	\$404	\$158	\$158	-0.01	39%	64%	2.57*
Pocketcam	\$180	\$76	\$76	-0.05	42%	73%	2.67*
			Differently Priced Competing Brands				
HDTV	\$1,699	\$170	\$156	-1.56*	10%	10%	-0.36*
Home DVD	\$167	\$72	\$50	-2.09*	43%	43%	-0.40*
Digital camera	\$190	\$78	\$55	-1.51*	41%	41%	-0.09
Theater spkrs	\$150	\$53	\$39	-1.85*	35%	35%	-0.28*
Printer	\$150	\$54	\$40	-1.43*	36%	36%	-0.16
Bookshelf spkrs	\$176	\$77	\$54	-1.42*	44%	44%	-0.07
Portable DVD	\$355	\$141	\$102	-2.31*	40%	40%	-0.39*

[a] Positive numbers indicate that brand B is seen as less expensive than brand A, negative numbers indicate the opposite.
* $p < .05$ in a one-sample t-test against a null of zero

Table 2.
Perceived price differences between competing brands A & B by price comparison condition, Experiment 3.

		Brand A Description	Brand B Description	
product	key attribute	*"Brand A is_____* more/*less than leading brand"*	*"leading brand is ______ more/less than Brand B"*	Perceived attribute difference between Brand A & B
		Identical Brands[a]		
computer	processing speed	10%	11%	0.55*
camcorder	warranty length	33%	50%	2.22*
stereo	harmonic distortion	34%	52%	1.06*
palmtop	screen size	37%	59%	1.67*
mp3 player	size	38%	62%	1.06*
monitor	screen size	39%	64%	2.12*
pocketcam	memory	42%	73%	2.40*
		Different Brands[b]		
HDTV	screen size	10%	10%	-0.41
Home DVD	visual distortion	43%	43%	-0.04
Digital camera	resolution	41%	41%	-0.17
Theater spkrs	power	35%	35%	-0.07
Printer	speed	36%	36%	-0.13
Bookshelf spkrs	loudness	44%	44%	0.04
Portable DVD	weight	40%	40%	0.52*

Mean perceived attribute differences after reverse-scoring responses from participants in the counterbalanced condition. [a]Positive numbers indicate a preference in the predicted direction. [b]Positive numbers indicate a preference for the superior brand.
* $p < .05$ in a one-sample t-test against a null of zero

Appendix A: Experiment 1 Key Item

Brand A	*Brand B*
Electronic Start	*Electronic Start*
Regular 89 Octane Fuel	*Regular 87 Octane Fuel*
Single Cylinder, Air Cooled Engine	*Engine Displacement 49 cc's*
Telescopic Front Suspension	*Telescopic Front Suspension*
4 speed "clutchless" transmission	*3 speed automatic transmission*
3 gallon gas tank	*5 gallon gas tank*

Experimental Manipulation:

Costs 33% less than Brand B **vs.** ***Costs 50% more than Brand A***

How would you compare the two competition brands in terms of value?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
brand A much better value					no difference					brand B much better value

How would you compare the two brands in terms of price?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
brand A much cheaper					no difference					brand B much cheaper

Which brand would you probably buy if you were in the market for this product?

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
definitely brand A					no preference					definitely brand B

Which brand is the better "deal?"

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
definitely brand A					no difference					definitely brand B

Appendix B: Experiment 3 Sample Items

Mini Digital-Video Camcorder

Leading Brand
10X optical/120X-digital zoom
680k pixel CCD imager
2.5" Precision SwivelScreen LCD
500 Lines of Video Resolution
1 year warranty
Price: $399

Competition Brand A	*Competition Brand B*
10X optical/120X-digital zoom	*8X optical/50Xdigital zoom*
480k pixel CCD imager	*680k pixel CCD imager*
2.5" LCD	*2.5" Precision SwivelScreen LCD*
500 Lines of Video Resolution	*500 Lines of Video Resolution*
2 year warranty	*2 year warranty*

Bookshelf Stereo Speakers

Leading Brand
2-way rear-ported bookshelf speakers
Power rated to 200 Watts
48 to 20,000 Hz frequency response
6-inch woofer
2 1-inch tweeters
Price: $176

Competition Brand A	*Competition Brand B*
3-way rear-ported bookshelf speakers	*3-way bookshelf speakers*
Power rated to 200 Watts	*Power rated to 100 Watts*
Gold-plated biwireable/biampable speaker posts	*80 to 20,000 Hz frequency response*
48 to 20,000 Hz frequency response	*6.7-inch mineral-loaded polymer woofer*
6-inch woofer	*2 1-inch silk-dome tweeters*