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This research reports on a cognitive neuroscientific examination of whether trade-off aversion explains the attraction effect. The principal study involves the neuroimaging of participants engaging in choice tasks while their cerebral activity is recorded. The authors examine whether the presence of a third (normatively irrelevant) alternative yields relatively less activation in areas of the brain associated with negative emotion than the activation during choice tasks involving two equally (un)attractive options. The results support the claim that trade-off choice sets are associated with relatively greater negative emotion. The authors discuss the implications of the research for marketing theory and methodology, as well as for managerial practice in the corporate and public policy arenas.

Keywords: fMRI, cognitive neuroscience, trade-off aversion, decoy effect, attraction effect

Trade-Off Aversion as an Explanation for the Attraction Effect: A Functional Magnetic Resonance Imaging Study

People are frequently faced with a choice between two or more options that are equally attractive or unattractive, but for different reasons. For example, a consumer might be faced with a choice between two automobiles, one that offers excellent gas mileage but is low on power and one that has superior power and acceleration but poor gas mileage. A voter might be faced with two candidates, one who has an attractive economic program but a relatively unattractive position on immigration and one who is appealing on the immigration dimension but has an unattractive economic program. A patient might be presented with two treatment alternatives, one that has several undesirable side effects but offers the prospect of a quick cure and one that has few, mild side effects but takes a long time to cure the ailment. A sports fan may be confronted with the choice between a beer that tastes great and one that is less filling.

A robust and enduring finding in the marketing literature, as well as the literature in related fields, is that when people are confronted with such trade-off-type choices, the introduction of a third (normatively irrelevant) option can affect preferences. In general, the introduction of a third, dominated option increases the share of the original option that dominates it. Thus, the introduction of a car that is fairly good on the gas mileage attribute but just as poor on power will increase the choice share of the original high-gas-mileage/low-power option. Apparently, the introduction of the dominated and, therefore, irrelevant option (often called a "decoy") into the choice set makes one of the original options (the "target") more attractive. This effect has been termed the "attraction effect" (Huber and Puto 1983).

The literature provides several explanations for why the choice share of the target increases when a decoy is introduced into the choice set. For example, one line of reasoning suggests that the weight associated with the attribute on which multiple options perform relatively well increases,

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thus yielding increased share for the option that dominates on that attribute (Hedgcock, Rao, and Chen 2009; Wedell and Pettibone 1996). A second perspective suggests that the perceived values associated with the original options change when a decoy is introduced (Huber, Payne, and Puto 1982). A third, related explanation draws on prospect theory and loss aversion to suggest that the presence of a decoy changes the reference point against which options are evaluated, as a consequence of which the loss associated with the target decreases, making it relatively attractive (Pettibone and Wedell 2000). Yet a fourth perspective suggests that the presence of the decoy enables people to justify their choices (Simonson 1989).

A recent comprehensive examination of trade-off decisions posits that trade-off-type choices are emotionally taxing (Luce, Bettman, and Payne 2001). Consequently, humans find trade-offs to be difficult and are likely to be inherently averse to them. We draw from this perspective to propose that the introduction of a decoy into a trade-off-type choice set reduces the decision maker's experienced trade-off difficulty. That is, the introduction of a third, tie-breaking option provides the decision maker with an opportunity to employ a simple heuristic (pick the car that does better on gas mileage) or decision rule rather than engaging in an elaborate and emotionally taxing evaluation of two equally (un)attractive options (Luce 1998). As a consequence, any negative emotion generated during trade-off-type decisions should be attenuated. We examine this general issue of experienced emotions during choices that involve trade-offs versus choices that include a decoy in addition to the trade-off options. Specifically, we employ a cognitive neuroscientific approach that assesses the cerebral activation of participants while they are engaged in choice tasks.

The contributions of this research can be assessed in several ways. First, we provide insight into the role of emotions during trade-off-type decisions. In particular, our argument draws on Luce, Bettman, and Payne's (2001) premise of trade-off aversion; we identify differences in emotional activation due to the nature of the choice problem confronting the decision maker and document that the attraction effect is a manifestation of trade-off aversion. Second, we employ the relatively new technique of functional magnetic resonance imaging (fMRI) to examine physiological processes that reflect the postulated underlying mechanism (for a recent application of fMRI in consumer behavior, see Yoon et al. 2006). This technique allows for the concurrent measurement of cerebral activation, instead of a retrospective account. Finally, from a practitioner standpoint, our substantive findings regarding the role of decoys in reducing negative emotion are likely to be of considerable value across various settings. Although firms may profit from employing such an emotion-reducing strategy, public policy makers may want to monitor the use of such a strategy, particularly for vulnerable segments, such as emotionally volatile consumers, or for emotion-laden products.

We organize the remainder of this article as follows: We turn to a brief review of the literature on the emotional dimensions of trade-off-based choices, the attraction effect as a manifestation of trade-off aversion, and the cognitive neuroscientific basis for our inquiry. From this review, we develop a series of predictions regarding areas of the brain that should be differentially implicated, depending on the nature of the choice task—namely, two-item trade-off choices versus three-item choices that include a decoy. We then describe two studies that are designed to address our predictions. The first employs a standard behavioral experiment that is designed to elicit choice and to ensure that the stimuli we employ in the second study generate an attraction effect in the laboratory. The second study employs fMRI to assess differences in cerebral activation due to choice condition. We conclude with a discussion of the theoretical, methodological, and substantive implications of our research.

REVIEW OF LITERATURE

Perhaps the most common form of a trade-off in most marketplace settings is that between price and quality. There is a rich empirical tradition in the marketing literature that documents the positive relationship between price and quality perceptions (Rao and Monroe 1988, 1989); price and quality tend to be viewed as a trade-off that requires giving up something (money) to get something else (a desirable attribute). In other words, the consumer must compensate for a loss on one attribute with gains on the other. Higher prices are aversive, but in general, they are necessary to receive higher quality, regardless of whether a person is purchasing an automobile or hiring an employee. Other illustrations of such negatively correlated attributes, which are essential for trade-off-type choices, include taste versus nutritional value in food, effort (which is aversive) versus the payoff of physical exercise, risk versus return in financial investments, fuel consumption versus acceleration in automobiles, and probability of payout versus magnitude of payout (Glimcher and Rustichini 2004; Smith et al. 2002).

Our essential premise in this article is that such trade-off-type choices generate negative emotion, and the introduction of a decoy into a choice set comprising trade-off options reduces negative emotion. The introduction of the third option provides the decision maker with another, simpler decision-making strategy, and the enhanced decision-making ease that follows likely explains the attraction effect. To the extent that trade-offs are emotionally taxing and choice sets with decoys are not, we should observe differences in cerebral activation that are consistent with differences in decision-making strategies. Therefore, our review of the literature encompasses three research streams. The first is the general area of trade-off decisions and the factors that make them more or less aversive. The second briefly examines the attraction effect, an effect that is well known in the marketing literature, and how this effect might be a consequence of trade-off aversion. Finally, the third stream examines the decision neuroscience literature, an examination that enables us to make predictions about particular patterns of cerebral activation that should occur if trade-off aversion explains the attraction effect.

Trade-Off Difficulty

In their seminal review of the topic, Luce, Bettman, and Payne (2001) provide an in-depth examination of the negative emotion associated with trade-off-type choices. They relate emotions to goal attainment (Lazarus 1991; see also

Pham 2007). Negative emotion is a consequence of perceived threats to goal attainment, while positive emotion is a consequence of progress toward goal attainment. Because trade-offs represent difficult choices, they are a threat to the goal of selecting an option that presumably has positive utility, and therefore trade-offs generate negative emotion. In particular, the source of the negative emotion in trade-off choices is task related and is not related to a person's ambient mood or postdecision outcomes (either regret or satisfaction) (Luce, Bettman, and Payne 2001).

Luce, Bettman, and Payne (2001) further observe that the identities of the attributes and the attribute values on which the options are perceived are important elements of the trade-off problem and affect the degree to which negative emotion is generated. Automobile safety is likely a more important and emotionally relevant attribute than color, and as a consequence, if safety and price were traded off, there might be greater negative emotion aroused than if color and price (or color and safety) were traded off. Furthermore, the perceived negative correlation between two attributes will determine the "exchange rate," or the amount a person must give up of one to acquire more of the other, and this exchange rate will affect the resultant conflict and negative emotion.

Because of the difficulty associated with making trade-off-type choices, Luce, Bettman, and Payne (2001, p. 32, emphasis added) observe that "emotion-focused coping motivations … manifest themselves in a desire to *avoid explicit decision trade-offs*." In other words, consumers will prefer making comparisons between options that do not represent trade-offs. The presence of a decoy provides them such an opportunity, and therefore trade-off avoidance may be an important driver of the attraction effect.

The Attraction Effect

A well-established phenomenon in the marketing and consumer behavior literature streams (e.g., Huber and Puto 1983; Simonson 1989), the attraction effect is the observation that the introduction of an alternative into a two-item choice set can increase the share of one of the original items. For example, consider a group of participants who are confronted with the choice set for apartment rentals displayed in Table 1. Initially, they evaluate only two options, which are deemed to be equivalent. One has a higher crime rate, and the other is more expensive. After the introduction of a third option (Option 3), which has a relatively high crime rate and is also more expensive than the existing high-crime option (Option 2)—making it inferior to Option 2 and, thus, normatively irrelevant—the choice share of Option 2 increases.

Table 1
ILLUSTRATION OF THE ATTRACTION EFFECT

Option	*Attribute A (Crime Statistics)*	*Attribute B (Price)*	*Initial Choice Share*	*Choice Share After the Introduction of Option 3*
1	7 per 1000 residents	$700	50%	40%
2	15 per 1000 residents	$620	50%	60%
3	15 per 1000 residents	$650	N.A.	0%

Notes: N.A. = not available.

Many of the extant explanations (e.g., a change in the weight of attributes, a change in perceptions of the value of options, the ease with which a choice may be justified) for why the attraction effect occurs appear to argue for a cognitively based decision process. However, drawing from the trade-off avoidance literature, we suggest that the negative emotion associated with conflict from the trade-off task makes the three-item decoy-based choice problem more emotionally palatable than the two-item trade-off choice. Choosing among options that are relatively well sorted in a structure in which at least one dominates the others likely generates the least negative emotion of the various comparisons facing the decision maker when evaluating a three-item choice set that includes a decoy. Therefore, a reason for the observed shift in weight and value, or a consumer's ability to justify his or her choice when the choice set includes a decoy, is that in the decoy-enriched choice set, the decision maker might not experience the task-induced negative emotion that he or she would experience in the impoverished trade-off choice set. That is, it is possible that underlying the process explanations that are current in the literature is the negative emotion associated with making difficult choices and the associated preference for easy choices. To understand how such a possibility might be investigated, we now turn to the cognitive neuroscience literature, which allows for specific predictions about cerebral activation due to negative emotions aroused during decision making.

Cerebral Activation During Choice Processes

The literature in cognitive neuroscience has correlated neural activity in certain areas of the brain with specific cognitive and emotional processes. Although a host of emotional processes are controlled by the brain (e.g., homeostasis, the process that regulates the body's physiological machinery, such as blood pressure, temperature, and glycaemic level [Damasio et al. 2000]), the processes of interest here are the organism's emotional responses to stimuli. These emotions include fear, disgust, and reward. For example, the amygdala has been implicated in the manifestation of fear and negative emotion (LeDoux 2000), and disgust has been associated with enhanced activation of the anterior insular cortex (Phillips et al. 1997; Wicker et al. 2003). The dopaminergic system, including areas such as the medial prefrontal cortex (MPFC) and striatum, is associated with aspects of reward. For example, Knutson and colleagues (2001) demonstrate increased activation in the ventral striatum in response to reward anticipation and increased activation in the ventromedial prefrontal cortex in response to rewarding outcomes. Activity in more superior regions of the MPFC (Brodmann areas [BA] 10/32) has been associated with self-referential processes, including judgments about the self versus others (Kelley et al. 2002), the viewing of autobiographical versus nonautobiographical photographs (Cabeza et al. 2004), and evaluative judgments of own preferences (Zysset et al. 2002). This last result is particularly germane to our inquiry.

A host of cognitive processes, such as visual object recognition (Grill-Spector, Kourtzi, and Kanwisher 2001), number processing, and cognitive control, have also been associated with specific areas of the brain. Several areas in the parietal lobe have been implicated in various aspects of number processing, including mental calculation (addition, subtraction, multiplication) in the horizontal intraparietal sulcus and the processing of numerical magnitude in the inferior parietal lobule (Tang et al. 2006). Another cognitive process is the recollection of nonemotional, factual aspects of memories (in contrast to feelings), which has been associated with activation in the right mid–dorsolateral prefrontal cortex (right mid-DLPFC) (BAs 9 and 46) (Gilboa 2004).

Studies investigating cognitive control have found specific structures that are correlated with overcoming prepotent (i.e., initial) responses. For example, the Stroop task is an exercise in which respondents are asked to identify colors associated with words displayed on a computer screen. However, the words themselves may conflict with their semantic content. For example, the word "blue" may be displayed in green or red typeface. When the word and color are congruent ("blue" in blue typeface), responses are faster and accuracy is higher than when the word and color are incongruent ("blue" in green typeface). Performance of this task requires participants to retain the rules associated with the task in working memory and, during incongruent trials, to recognize response conflict so that they may provide the correct task-specific response. Response conflict occurs when two cognitive processes differ over which option is the correct option. Thus, during the Stroop task in which participants are asked to identify the color of a word and are presented with incongruent information ("blue" written in green typeface), the prepotent response (to say "blue") is overcome by the correct response (to say "green"), but not without conflict between two processes. The conflict the participant experiences during the Stroop task is similar to the conflict a participant may experience during a trade-off choice task, in which the prepotent response is to employ one choice procedure (e.g., a heuristic, such as "Choose the dominated option"), while on cogitation, the participant might contemplate an alternative choice procedure (e.g., weighing the attributes associated with both options).

Two types of conflict may occur during the decision process. The first type can be termed "indifference." This occurs when a participant evaluates the alternatives and has no strong preference for one option over the other and therefore is unable to decide which response to provide to the question posed. The second type of conflict can be termed "response conflict." This occurs when two mental processes lead to conflicting decisions (i.e., the participant is "of two minds"). The Stroop task generates response conflict because participants reading "blue" in green typeface can employ two processes to identify the color. The quicker, more automatic response is "blue." The more effortful response is "green." Importantly, although the Stroop task generates response conflict, the participants are not indifferent between the two response tendencies. "Green" is clearly the preferred response.

Response conflict during the performance of the Stroop task has been associated with activation in the anterior cingulate cortex (ACC; BAs 24/32) (Kerns et al. 2004; MacDonald et al. 2000). In addition, other research has demonstrated increased activation in the ACC even when participants were unaware of the conflict (Berns, Cohen, and Mintun 1997), suggesting that conflict monitoring can occur independent of conscious awareness. Performing the Stroop task has also been associated with increased activity in the DLPFC (BA 9), which suggests that "[T]he DLPFC provides top-down support of task-appropriate behaviors" (MacDonald et al. 2000, p. 1837). Subsequent research has demonstrated increased activity in the posterior DLPFC (BA 9) when experimental stimuli provided information for rule-based decisions (Huettel and Misiurek 2004). Consistent with these findings and those of Curtis and D'Esposito (2003, p. 420), we posit that parts of the DLPFC are "involved in the rule-based selection of responses."

Summary

In line with this review, for our purposes, differences in cerebral activation associated with choosing among two options in a trade-off-type choice set relative to a choice set that is enriched with a decoy option should be observed as follows:

- Decision strategies that yield differences in negative emotion should result in differences in activation in the amygdala;
- To the extent that larger set sizes yield increased computation, there should be increased activation in parietal lobe areas implicated in number processing, such as the inferior parietal lobule;
- Decreases in self-referential evaluation of own preferences due to the use of heuristics in decoy-enriched choice sets should be reflected in decreases in activation of the MPFC (BAs 10/32);
- The employment of decision rules should be reflected in changes in activation of the posterior DLPFC (BA 9); and
- To the extent that emotional and cognitive processes conflict when they lead to incongruent choices, differences in activation of the ACC (BAs 24/32) should be observed.

PREDICTIONS

Our core prediction is based on the argument that the choice problem associated with options in a two-item trade-off choice set generates negative emotion, while the choice problem associated with options in a decoy-enriched three-item choice set generates less negative emotion. Therefore, negative emotion associated with the decision task should be higher in the trade-off choice set. Specifically,

H_1: In a trade-off setting, a decision involving a choice set enriched with a decoy should be associated with less activation in the amygdala than a decision involving a choice set comprising two options.

In addition, the presence of the decoy provides the opportunity to employ a strategy that does not require making a trade-off decision. Decision makers avoid the negative emotion caused by trade-offs by using a "noncompensatory" decision heuristic that does not involve a calculation of how much of one attribute to give up in exchange for the benefits associated with the other attribute. This implies that the availability of a decoy in the choice set will (1) increase rule- or heuristic-based selection processes that will be reflected in increased activation in the DLPFC and (2) decrease self-referential evaluation of preferences, thus decreasing activation in the MPFC. Specifically,

H_2: In a trade-off setting, a decision involving a choice set enriched with a decoy should have more activation in the DLPFC (BA 9) and less activation in the MPFC (BAs

10/32) than a decision involving a choice set comprising two options.

Because decisions with a choice set enriched with a decoy offer the decision maker the opportunity to use a heuristic that compares the target and the decoy or to engage in elaborate self-referential processing, a potential for response conflict exists between the employment of the two processes. This response conflict is less likely to arise when the decision maker is faced with a two-item choice set. The increased response conflict under a three-item choice set will be reflected in increased activation in the ACC. Thus:

H_3: In a trade-off setting, a decision involving a choice set enriched with a decoy should be associated with increased activation in the ACC (BAs 24/32) compared with a decision involving a choice set comprising two options.

Finally, although we do not develop a formal prediction, it is plausible that a choice set enriched with a decoy is associated with enhanced activation in areas of the parietal lobe, such as the inferior parietal lobule, because of enhanced processing of numerical information associated with all the options. We now turn to a description of our empirical approach to assess support for our predictions.

EMPIRICAL PROCEDURES, ANALYSES, AND RESULTS

Overview

Participants were recruited from the population at a major U.S. university and its surrounding metropolitan community, following review and approval of the study protocol by the university's Institutional Review Board, which waived the need to obtain written consent from the participants in the first study. We conducted two studies to assess support for our predictions. Both studies used similar stimuli and experimental designs. The first, a pilot study, involved participants performing choice tasks in a manner largely similar to those reported in attraction effect studies available in the literature (Huber, Payne, and Puto 1982). The second, the main study, required participants to perform choice tasks while their brains were being scanned for cerebral activation. Participants in the second study provided written consent before participation.

We conducted the pilot study to ensure that the attraction effect indeed manifested itself for the stimuli that we intended to use for the second study. We also wanted to calibrate aspects of the design, such as the time of stimulus exposure, to develop the design for the main study. Furthermore, we reasoned that if our main study replicated the choice results of our pilot study, the results of the second (cerebral activation) study would likely be less subject to the criticism of artificiality associated with the scanning procedure.

Pilot Study

We conducted the pilot study in two phases. In the first phase, undergraduate student participants (n = 48) responded to a preliminary questionnaire that was designed to elicit attribute values that would make them indifferent between two choices. We employed this procedure to generate customized stimuli for the second phase. (In prior attraction effect studies, the stimulus comprising the trade-off options was developed on the basis of pretests. Aggregate levels of preference that were close to 50% market share were used as proxies for indifference. In our case, given our relatively small sample size, we chose to employ this customized stimulus approach to enhance precision.)

Participants responded to a paper-and-pencil questionnaire (see Web Appendix A at http://www.marketingpower.com/jmrfeb09) that was designed to elicit approximate indifference levels toward the options in a two-item choice set. The stimulus provided participants with two attribute values for one of two options and one of two attribute values for the other. Participants were asked to indicate the value of the second attribute for the second option that would make them indifferent between the two options. For example, one housing option was described on price ($620) and quality (safety based on crime statistics of 15 moderate to severe criminal acts per 1000 residents of the neighborhood). Participants were then exposed to a second housing option for which the crime statistics were lower (i.e., safety based on crime statistics of 7 moderate to severe criminal acts per 1000 residents of the neighborhood). They were then asked to provide a price that would equalize the two options. We anticipated that in this instance, participants would provide a dollar figure greater than $620. Participants provided these points of indifference for 32 stimuli and on several different attributes (price and quality related) to generate the two-item trade-off choice set that we would employ in the second phase.

Following the first phase, participants returned to the laboratory one to three weeks later and participated in the second phase, in which they responded to a series of choice problems comprising two-item (trade-off) and three-item (decoy enriched) choice sets, designed to assess the attraction effect (for a complete list of stimuli in the order in which participants saw them, see Web Appendix B at http://www.marketingpower.com/jmrfeb09). The attribute values in these choice problems were customized for each participant according to his or her responses in the first phase. The choice task was performed using E-Prime in a computer lab.[1] Participants received course credit as compensation for participation.

Procedures. We presented stimuli as follows: Participants first performed a practice task comprising two scenarios that they had not encountered in the first phase. They then responded to choice problems that were based on the stimuli and attribute value that they had encountered and provided in the first phase.

A description of the attributes and the choice problem was displayed on the computer screen. Participants proceeded from this screen to the next by depressing the space bar. On the next screen, they were presented with the choice problem itself, comprising either two or three options, described on two attributes. Participants made a selection by depressing either "1," "2," or "3" on the keyboard's numerical keypad (each key represented a choice of one of the options). After depressing a key, they were presented with a new choice problem description. This procedure was repeated for 32 different experimental scenarios.

[1]E-Prime is a PC-based software program that allows for response time tracking. The software measures both the choice and the time participants spent engaged in the choice task.

Participants responded to eight choice problems, took a short break, and then began the next set of eight problems. We refer to each set of eight choice problems as a block. After participants completed the task, they were thanked, debriefed, and dismissed.

Experimental design and manipulations. The design comprised three conditions: the trade-off condition (two-item choice set) and two decoy-enriched conditions (three-item choice sets). The first decoy condition included an asymmetrically dominated decoy, which performed as well as the target on one attribute (on which it was inferior to the competitor) but was inferior to the target on the other attribute (but it dominated the competitor on that second attribute). In the second decoy-enriched choice set, the decoy was an inferior decoy. That is, the decoy was slightly better than the target on one attribute but significantly worse on the other attribute. Although the inferior decoy was not strictly dominated by either the target or the competitor, the procedure of eliciting indifference values in Phase 1 enabled us to customize attribute values so that the inferior decoy could be placed in a position that made it subjectively inferior to the target. Figure 1 illustrates the three conditions.

In addition, we varied the element of the two-item choice set that was decoyed. That is, we systematically manipulated whether the item that performed well on Attribute 1 (crime rate) or Attribute 2 (price) was the target, to assess whether making Option 1 the target would yield enhanced share for Option 1 and making Option 2 the target would yield enhanced share for Option 2, all else being equal.

Analyses and results. To assess whether the attraction effect occurred, we examined choice shares of the decoyed option in all three-item choice sets that varied only on whether one or the other element was the target. That is, in any three-item choice set, we define the options as ABA′ (where A is one option, B is another, and A′ is a decoy located close to A) or ABB′ (where A is one option, B is another, and B′ is a decoy located close to B). The two choice sets did not vary in any other manner. If the share of A is relatively high in the choice set comprising ABA′ and the share of B is relatively high in the choice set comprising ABB′, such evidence would be supportive of an attraction effect. This approach—that is, assessing the attraction effect by comparing two three-item choice sets—is consistent with the procedure adopted by Wedell and Pettibone (1996) and Pettibone and Wedell (2000).[2]

The omnibus mixed logit analysis that accounts for the repeated measures factor (participants' exposure to multiple stimuli) yielded the following result (italicized coefficients are significant at $p < .05$):

$$\text{LOGIT(SHARE)} = \mathit{.35} + \mathit{1.02\ DECOY} - \mathit{.36\ TASK} - .15\ \text{TASK} \times \text{DECOY},$$

where SHARE is the choice share of a particular option, DECOY indicates whether that option was decoyed (i.e., was the target) or the other option was decoyed, and TASK indicates whether the decoy was asymmetrically dominated or inferior.

The results indicate a main effect due to an option serving as the target and a main effect due to whether the decoy was asymmetrically dominated by or inferior to the target. An examination of choice shares between conditions indicates that decoying an option increases its share by approximately 20% on average.

Summary. Recall that the purposes of the pilot study were to (1) ensure that the attraction effect manifested itself for stimuli that we intended to use for the main study and (2) develop an estimate of the time participants spent on various elements of the task so that the stimuli for the main study could be designed appropriately. We were successful

[2]However, this approach is a departure from that adopted by others, including Huber, Payne, and Puto (1982), who assess the share of the target when it is a member of a three-item choice set compared with when it is a member of a two-item choice set. Although our two-item choice sets were not identical to the three-item choice sets in terms of attributes and attribute values, because we wanted to pretest stimuli for our main study (for a complete list of stimuli in the order in which participants saw them, see Web Appendix A at http://www.marketingpower.com/jmrfeb09), we tested to determine whether the choice shares of the target in the three-item choice sets differed from those in the two-item choice sets. Because several choice share values exceeded 70%, we performed an arcsine transformation on each participant's choice share data. For both asymmetric ($p < .0001$) and inferior ($p < .0001$) decoy conditions, we observed the attraction effect; choice shares for the target were significantly higher in the three-item choice set than either of the two options in the two-item choice set.

Figure 1

DESIGN FOR PILOT STUDY

	Crime Rate	Cost
1)	7 per 1000	$700
2)	15 per 1000	$620
3)	15 per 1000	$634

Press "1," "2," or "3"

Asymmetric Decoy

	Crime Rate	Cost
1)	7 per 1000	$700
2)	15 per 1000	$620
3)	N.A.	N.A.

Press "1," "2," or "3"

No Decoy

	Crime Rate	Cost
1)	7 per 1000	$700
2)	15 per 1000	$620
3)	25 per 1000	$605

Press "1," "2," or "3"

Inferior Decoy

Notes: N.A. = not applicable.

in both endeavors. We observed the attraction effect for our stimuli in a behavioral laboratory setting, so its replication in an fMRI scanner cannot be attributed to the artificiality of that method. Furthermore, in the interest of ecological validity, choice data collected in the scanner can be compared with choice data collected in the lab. To the extent that they are similar, observed cerebral activation in the scanner likely reflects cerebral activation in the behavioral lab setting. Finally, the data on time spent on each screen enabled us to design our stimuli for the scanner-based study not only so that screen transitions would be automatic but also so that participants would have sufficient time to read and process information necessary for decision making.

Main Study

This study also employed a two-phase procedure. In the first phase, as in the pilot study, participants ($n = 18$) responded to a preliminary questionnaire that was designed to elicit attribute values that would make them indifferent between two choices. They provided these points of indifference for 72 stimuli and on several different attributes (price and quality related) to generate the two-item trade-off choice sets that would be employed in the second phase. Following the first phase, participants returned to a central facility over a period of several weeks to participate in the imaging phase of the study. In that second phase, participants were exposed to 72 customized stimuli that included 24 versions each of trade-off-type choices and choice sets that were enriched with either an inferior decoy or an asymmetrically dominated decoy. Their brains were scanned as they examined these choice sets and made their choices.

Participants and experimental procedures. Eighteen right-handed participants who had been screened for safety so that they could participate in an fMRI study and had no prior history of psychological illness participated in this study. We did not include the functional scans for two participants in the final analysis. Computer problems interrupted the experiment during one participant's scan, and another participant's functional data could not be aligned to a standardized space. Therefore, we analyzed behavioral and brain imaging data for the remaining 16 participants (6 were female). Participants received $20 as compensation.

Participants responded to the stimuli while lying on their backs in the scanner. Stimuli were projected onto a screen located outside the scanner. Participants could see the stimulus in a mirror located directly in front of their eyes. They provided responses by depressing one of three keys on a keypad located in close proximity to their right hand. The total time participants spent on this procedure, including scanner preparation, receiving instructions, and task time, was 75 minutes.

As in the pilot study, participants first responded to two practice scenarios before encountering the experimental stimuli. Then, they read a description of the attributes and the choice problem displayed for 15 seconds (see Figure 2). Next, participants were presented with the choice problem itself, comprising either two or three options, described on two attributes. Participants had up to 28 seconds to choose an option. (Participants successfully selected a preferred option in less than 28 seconds in all but two cases.) When participants selected an option in less than 28 seconds, they saw a gray screen for the remaining amount of time. They then saw a fixation cross ("+") for 2 seconds to alert them to the imminent appearance of the next choice problem description. This procedure was repeated for the 72 different experimental scenarios.

As in the pilot study, the stimuli were arranged in blocks. A total of six blocks, each comprising 12 stimuli, were created. Participants took a short break between blocks. The choice problems featured a variety of stimuli, including cars, hotels, home maintenance, cruises, car repair, apartments, day care, retirement investments, houses, health plans, education policy, and careers (for a complete list of stimuli in the order in which participants saw them, see Web Appendix C at http://www.marketingpower.com/jmrfeb09). We employed different attributes and attribute values as manipulations, as a result of which participants answered similar, but never identical, questions in the different blocks.

In all the decoy conditions, in a departure from the procedure we employed in the pilot study, the same option was decoyed. This simplified the design and was deemed to be appropriate because decoying one or the other option yielded the attraction effect in the pilot study.

Results. To assess whether the attraction effect occurred, we conducted the following analysis: Recall that all participants provided attribute values that would make them indifferent between two focal options. We assessed the choice share of these two options depending on whether one of them was decoyed (by either an inferior or an asymmetric decoy). We reasoned that any deviation from indifference (a 50% share) would be indicative of an attraction effect.

When the target was decoyed by an asymmetrically dominated decoy, its share relative to the competitor was 64.7%, a figure that is substantially and significantly higher than 50% (Pearson $\chi^2 = 31.7$, d.f. = 1, $p < .001$).[3] When the target was decoyed by an inferior decoy, its share relative to the competitor was 56.8%, a figure that is also significantly higher than 50% (Pearson $\chi^2 = 6.224$, d.f. = 1, $p < .013$).[4] A t-test of the arcsine transformed proportions data yielded similar, statistically significant conclusions (all ps < .05). Prior literature has found the same pattern of results. Inferior decoys typically generate a smaller attraction effect than asymmetric decoys (Pettibone and Wedell 2000).[5]

Hemodynamic response results. We observed no differences in brain activation between the asymmetric decoy and the inferior decoy conditions (p[bonf] < 1.0). This suggests that decision making with an inferior and asymmetric decoy is qualitatively similar regardless of the location of the decoy. Prior research has also indicated that the same cognitive process might explain both inferior and asymmetric decoys (Pettibone and Wedell 2000). Therefore, in the following analyses, we combine both decoy conditions.

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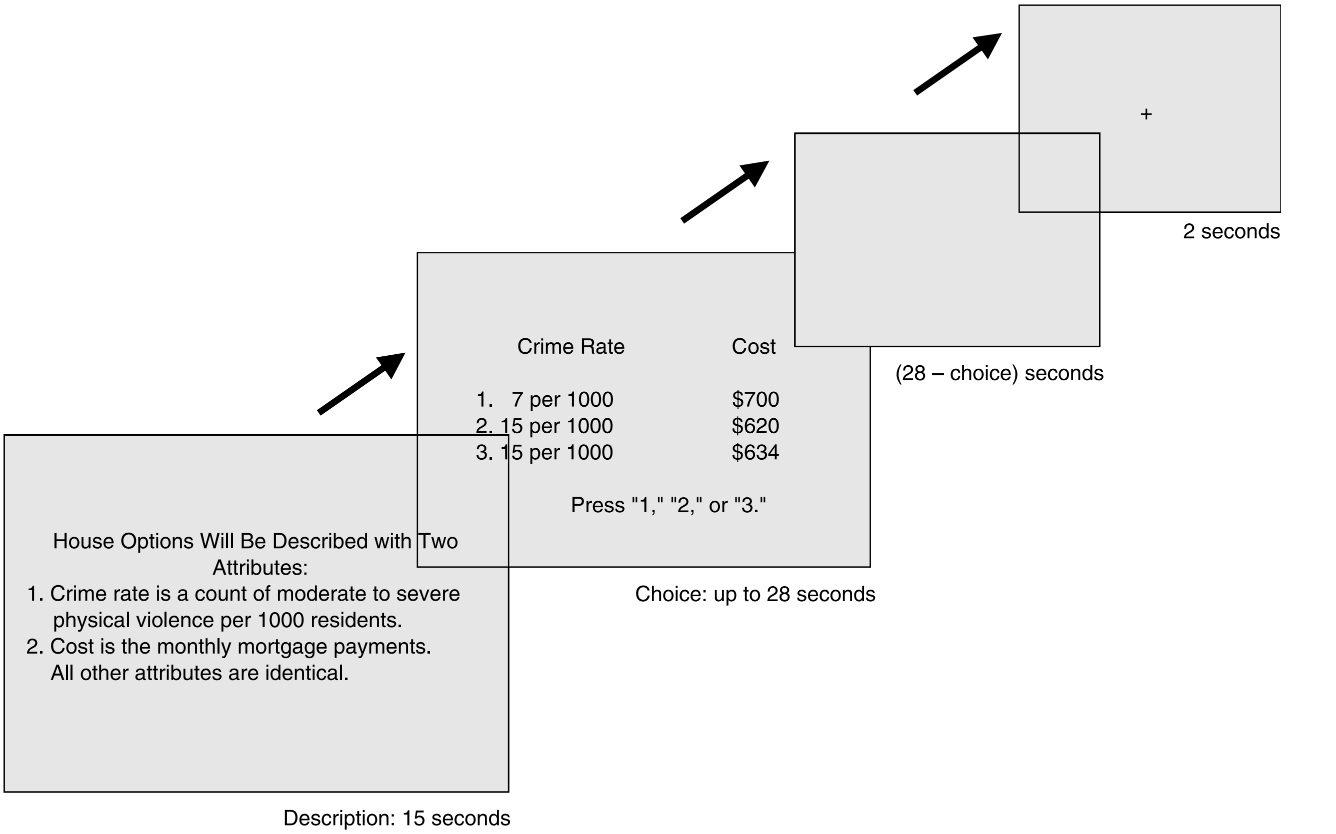
[3]The decoy was selected 4% of the time (16 of the 384 decisions).

[4]The decoy was selected 12% of the time (44 of the 384 decisions).

[5]We constructed the two- and three-item choice sets to differ on number of items, attributes, and attribute values to minimize the possibility that participants would become fatigued from repeatedly responding to nearly identical stimulus values in this within-subjects design. Nevertheless, we conducted an additional analysis that compared choice shares in the three- and two-item choice sets to assess whether the attraction effect occurred. We performed a t-test on the arcsine transformation of the observed proportions. For the asymmetrically dominated decoy conditions, we observed an attraction effect ($p < .05$), but the effect was weak for the inferior decoy condition ($p < .10$, one-tailed).

Figure 2
STUDY 1: STIMULI EXPOSURE PROCEDURE



A comparison of cerebral activation under trade-off versus decoy conditions revealed several significant differences. In light of our hypotheses, we focused on activation differences in (1) the amygdala, (2) the MPFC, (3) the DLPFC, (4) the ACC, and (5) parts of the parietal cortex. Relative to choice sets with no decoy, choice sets enriched with a decoy showed a statistically significant

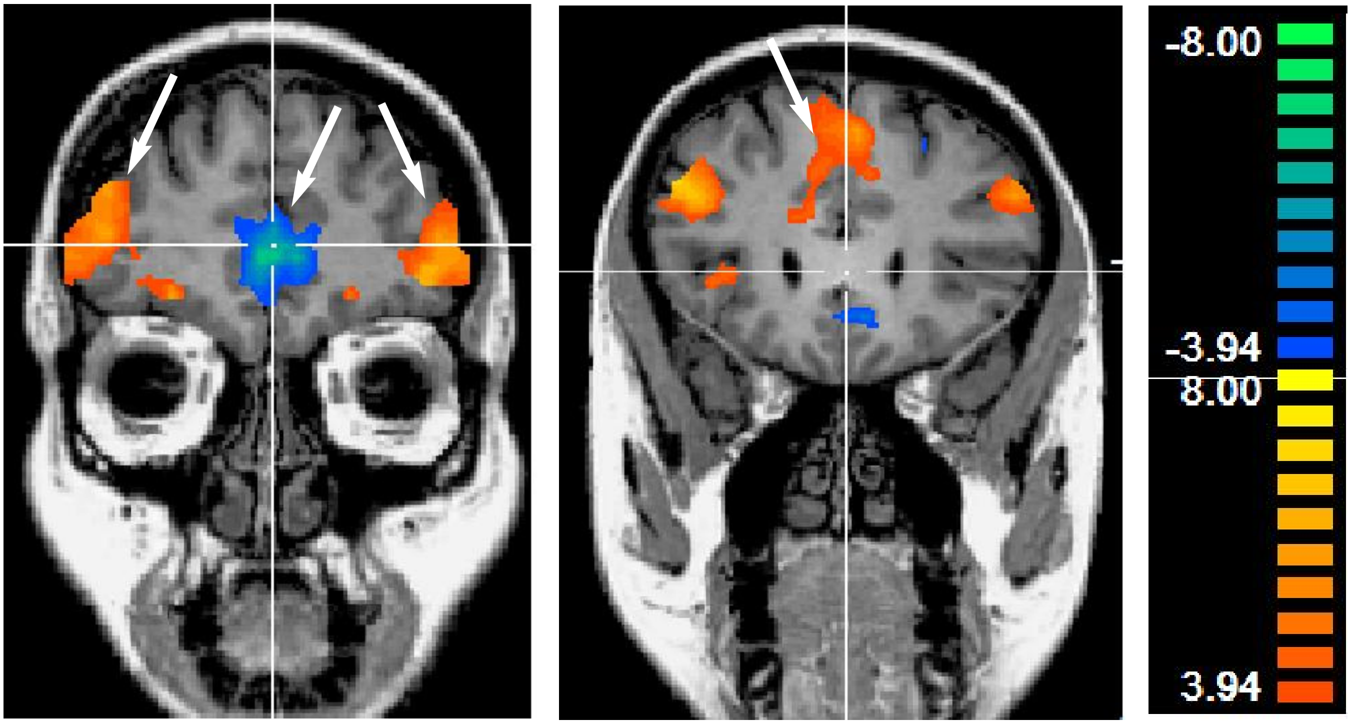
- Decrease in activation in the amygdala, an area of the brain associated with negative emotion;
- Decrease in activation in the MPFC (BAs 10/32), an area of the brain associated with self-referential evaluation of preferences;
- Increase in activation in the DLPFC (BA 9), an area of the brain associated with the use of decision rules;
- Increase in activation in the ACC (BAs 24/32), an area of the brain associated with monitoring conflict; and
- Decrease in activation in the right inferior parietal lobule, an area of the brain associated with processing numerical magnitude.

These results appear in Figures 3 and 4. A list of the previously described activation differences appears in Table 2. The technical details associated with our equipment, procedures, and analyses appear in Web Appendix D (see http://www.marketingpower.com/jmrfeb09).

These findings support H_1–H_3. Seemingly, two-item choice sets activate the amygdala more than choice sets enhanced with a decoy, reflecting an increased role for negative emotion in decisions when a decoy was not present.[6] Reduced activation in the DLPFC and ACC during decisions involving two-item choice sets suggests reduced use of rules or heuristics and reduced conflict regarding the use of appropriate decision rules when confronted with two-item choice sets. Increased activation of the MPFC reflects enhanced use of an area that is associated with emotion in decision making while examining a two-item choice set. The particular BAs implicated suggest a reduction in evaluative judgments of own preferences when a decoy is present (Zysset et al. 2002). Finally, increased activation in the right inferior parietal lobule suggests enhanced numerical magnitude processing, which could be a consequence of the numerical nature of our stimuli.

[6]Relative to a baseline condition (the fixation cross), the signs of the parameters associated with amygdala activation were negative. In the decoy condition, the average t-values were as follows: Right amygdala = –8.105, and left amygdala = –8.657. In the no-decoy condition, the average t-values were as follows: Right amygdala = –4.377, and left amygdala = –5.533. These negatively signed values indicate that there is less activation in the amygdala than in the baseline condition. However, focusing on or anticipating a fixation point may not be emotionally neutral from a cerebral activation standpoint. It might produce anxiety. It might startle the participant when it is first encountered. Therefore, our conservative claim is that the *relative* activation under two- and three-item choice sets differs.

Figure 3
RESULTS: CONTRAST DECOY VERSUS NO DECOY: MPFC, DLPFC, AND ACC ACTIVATION



Notes: The MPFC (in blue/green) is less active when decision sets include a decoy alternative, and the DLPFC (in orange/yellow) is more active when decision sets include a decoy alternative. The ACC (center screen in orange/yellow) is more active when decision sets include a decoy alternative.

These results support our premise regarding trade-off aversion and the negative emotion generated during the evaluation of trade-offs. In evaluating choice sets that do not represent a trade-off (i.e., the structure of the choice set enables a dominant option to be identified), the relative decrease in activity in areas associated with negative emotion suggests that one compelling explanation for the attraction effect is trade-off aversion and the avoidance of negative emotion. That is, the manifestation of the attraction effect under asymmetric and inferior decoys is accompanied by the relative decrease in negative emotion. In general, the negative emotion associated with trade-off decisions is lower in decisions when the choice set is enriched with a decoy.

Rival explanation. There is a plausible rival explanation for a fraction of our results. Increased activation in the DLPFC and ACC could be the consequence of participants processing more information in the three-item choice set than in the two-item choice set. That is, more information must be stored in working memory when three options are evaluated than when two options are evaluated, and this task complexity might explain the increased activation in the DLPFC and the ACC. Therefore, in our next analysis, we examine relative activation when three-item choice sets are evaluated by participants who display the attraction effect to a greater or lesser degree.

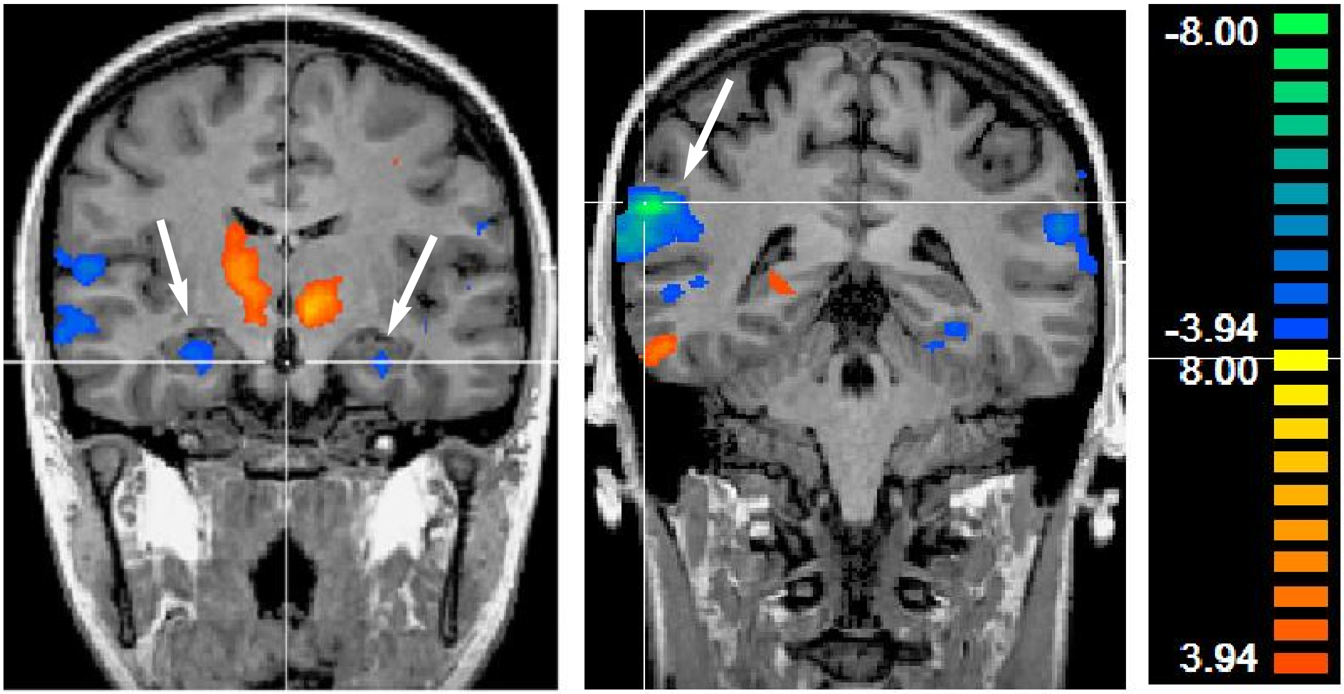
Recall that participants responded to 48 stimuli that included a decoy. We split our data, classifying participants who selected the target more than 50% of the time as "high heuristic processors," because they likely used a heuristic to select the target, and those who selected the target 50% or less of the time as "low heuristic processors." We then assessed brain activation differences between these two groups. This contrast holds the stimuli constant across the two conditions and thus eliminates any stimulus-based confounds in the analysis. Therefore, any differences in brain activation between conditions can be attributed only to differences in the degree to which the target was selected.

We reason that participants who are high in heuristic processing are likely to experience relatively less negative emotion when examining decoy enriched choice sets because they likely employ a decision rule that results in their selection of the target more frequently than those who are low in heuristic processing. As a consequence, they should display less activation in the amygdala and MPFC and more activation in the DLPFC and ACC than participants who likely do not employ heuristics to the same degree because they selected the target less frequently.

A comparison of cerebral activation for high heuristic processors versus low heuristic processors revealed several effects. Compared with low heuristic processors, high heuristic processors displayed reduced activation in the amygdala, reduced activation in the MPFC (BAs 10/32), increased activation in the DLPFC (BA 9), increased activation in the ACC (BAs 24/32), and reduced activation in the right inferior parietal lobule (all *p*s $< .05$). These findings

Figure 4

RESULTS: CONTRAST DECOY VERSUS NO DECOY: AMYGDALA AND RIGHT INFERIOR PARIETAL LOBULE ACTIVATION



Notes: The amygdala (in blue/green) is less active when decision sets include a decoy alternative. The right inferior parietal lobule (in blue/green) is less active when decision sets include a decoy alternative.

Table 2

REGIONS OF INTEREST SHOWING SIGNIFICANT DIFFERENCES IN BOLD ACTIVATION FOR THE CONTRAST OF DECOY VERSUS NO DECOY IN THE CHOICE TASK

A: Regions with Significant Increases							
Location	*Hemisphere*	*BA*	*x*	*y*	*z*	*Significant Voxels*	*Average t-Statistic*
Anterior cingulate/medial frontal gyrus		24/6/32	1.9	13	44	12,792	5.08
DLPFC: middle/inferior frontal gyrus	Right	9/46	40	18	20	23,817	4.77
DLPFC: inferior/middle frontal gyrus	Left	10/46	–40	43	6.8	3625	4.7
DLPFC: precentral gyrus/middle frontal gyrus	Left	6/9	–42	5.9	31	6577	4.37
B: Regions with Significant Decreases							
Location	*Hemisphere*	*BA*	*x*	*y*	*z*	*Significant Voxels*	*Average t-Statistic*
Amygdala	Left		–20	–7.8	–16	51	–4.11
Amygdala	Right		24	–8.3	–16	1894	–4.22
MPFC/rostral anterior cingulate	Right/left	10/25/32	–.69	30	–.05	14,339	–4.55
Inferior parietal lobule/superior temporal gyrus	Right	40/22	56	–36	20	7377	–4.6

Notes: n = 16; random effect, $p < .00012$, q(FDR) < .001. The x, y, and z coordinates are Talairach coordinates.

confirm our hypotheses, suggesting that, indeed, the tendency to manifest the attraction effect is accompanied by a reduction in negative emotion, an effect that we observe while holding constant the amount of information to which participants are exposed. Emotional trade-off avoidance is a viable explanation for the attraction effect.

DISCUSSION

The research we report in this article examines whether negative emotion accompanies the evaluation of trade-off-type choice sets and whether this emotion might explain why the attraction effect occurs. Drawing on the extant literature on trade-off aversion, the attraction effect, and cognitive neuroscience, we developed predictions about cerebral activation depending on the nature of the choice problem that participants encountered. An initial pilot study provided empirical validation for the stimuli we subsequently employed in an imaging study.

Methodological Issues

The use of physiological techniques in consumer research is not new (for research using electroencephalography to study the response to television commercials, see Rothschild et al. 1988). Yet the use of fMRI to study brain processes in decision making has achieved a level of visibility in both the academic literature and the popular press that is perhaps unparalleled. For example, Tom and colleagues (2007) examine neural correlates of loss aversion in a gambling setting, and McClure and colleagues (2004) examine neural correlates of preference for carbonated soft drinks. Yet, despite the burgeoning sophisticated research corpus, we caution the reader about the difficulties associated with conducting fMRI-based research. Although there are many concerns with the use of this technique, we briefly discuss two broad issues: philosophical concerns and pragmatic concerns.

Philosophical concerns. Paraphrasing Rozenblit and Keil (2002), we caution those enamored of techniques that provide seemingly veridical access to mental events to guard against the "illusion of explanatory depth." As Giere (2006, p. 30, emphasis in original) observes in a different context, "There is no such thing, for example, as *the* way the Milky Way looks. There is only the way it looks to each instrument. Moreover, even if it were physically possible to build an instrument sensitive to the whole electromagnetic spectrum emitted by a distant galaxy, it would still be blind to things such as neutrinos, which we presume, are also emitted. There just is no universal instrument that could record every aspect of any natural object or process." By the same token, the color images displayed through fMRI scans are "false colors produced by computer manipulation of the original data" (Giere 2006, p. 30). The images represent the perspective of the measuring instrument and should not be interpreted as real, in a colloquial sense.

Another philosophical concern is related to the overinterpretation of cerebral activation data. Although it is true that several research studies have successfully implicated different parts of the brain in different processes, the brain is a remarkably plastic organ, and it is likely that several cranial regions interact in information processing and decision making in ways that are difficult to tease apart using crude instruments, such as fMRI, which typically take measurements only once every two seconds.

Pragmatic issues. The physical conduct of fMRI-based research is costly and exceedingly complex. Studies of fMRI require access to equipment (typically available at a major university, Veteran Affairs medical centers, or private medical facility) and trained personnel. The cost per hour for each participant is approximately $500, as a result of which most fMRI-based research employs small sample sizes. The development of stimuli; the conduct of the study; and the collection, processing, and analysis of large amounts of data all add to the complexity of this type of research.

Another concern is the degree of intrusiveness associated with the fMRI procedure. The setting and the task are indeed removed from actual choice tasks.

Theoretical Implications

The presence of decoys can be observed in several marketing settings ranging from the introduction of dominated alternatives in telephone services to the availability of unattractive (i.e., high priced or feature deprived) automobile models. Several mechanisms have been invoked for why such dominated alternatives might generate an attraction effect for a target in the choice set. Many of these explanations are cognitively based, arguing for either enhanced or different computational processes in the judgment and choice task. As we noted previously, our results indicate that emotion may underlie the reasoning that is implicated in the phenomenon. The desire to avoid a choice task that generates negative emotion may yield cognitive processes that emphasize heuristics that are consistent with a change in importance weights of product attributes or the valuation of the options.

That emotion may be implicated in trade-off choices has been hinted at previously (Luce 1998, particularly Experiment 1). However, prior studies have assessed emotions retrospectively, whereas our approach allows for an assessment of emotion online. This is an important theoretical issue because a retrospective elicitation of experienced emotion may reflect regret, which is a consequence of having forgone a desirable alternative, and therefore the negative emotion being reported may be due to the choice that has been exercised. In contrast, an online examination of emotion likely provides a more direct measure of the aversion associated with the decision process itself. Prior research has also assessed emotion as a dependent variable by asking participants how they feel. The very process of thinking about feelings (either through concurrent verbal protocols or through retrospective reconstruction) might elicit feelings, dampen feelings, or interfere with memories of feelings in some unanticipated way. Our procedure protects against these possibilities.

Substantive Implications

Irrelevant alternatives are seemingly routinely encountered in various settings ranging from Web-based travel and vacation markets to the market for political candidates. Our findings suggest that the provision of such irrelevant alternatives is a valuable device to reduce negative emotion. That is, astute merchants may employ irrelevant alternatives to generate enhanced preferences for a targeted option or to eliminate the negative emotion consumers experience when faced with a choice set comprising several equally attractive options.

Although the strategic implications of such an approach have been well documented, the underlying reasons for the effect have remained unclear. To the extent that emotion plays a role in decisions, manipulating the identity of the attributes and their valence in combination with the availability of an irrelevant option should yield desirable outcomes (Luce, Bettman, and Payne 2001). Firms interested in reducing negative affect may choose to introduce decoys, political parties interested in reducing negative affect may strategically foster the entry of decoy candidates, senior managers may want to correct for the effect of a decoy when personnel managers make recommendations about job candidates, and patients (and regulatory agencies) may want to monitor the role of decoys in physician prescribing behavior.

Limitations and Further Research

Consistent with prior research on decision making, a majority of our respondents were students. However, extensive pretesting ensured that our stimuli and procedures were appropriate for this population. In addition, we were sensitive to the possibility that decoy effects could vary depending on the nature of the attribute (Heath and Chatterjee 1995), and thus we included stimuli that were described on two quality-related attributes. To some degree, this approach reduces concerns about generalizability.

Moreover, we have no behavioral evidence for the response conflict that likely drove the ACC activation. Therefore, another plausible explanation might be that more controlled processing resources were being expended in the three-item than the two-item choice set. However, this explanation is not inconsistent with our story; a controlled process could be the employment of a heuristic. In other words, it is possible that the third option generated more controlled processing. However, the explanation regarding the expenditure of controlled processing resources does not account for the differences in amygdala activation, whereas our explanation does.

Finally, although we examined a decision bias that was accompanied by a change in emotional state, the factors that affect the magnitude of the bias are not well understood. That is, although we were able to distinguish empirically between participants who differed in their choices and to observe differences in activation in brain regions associated with emotion, it is unclear which factor drove them to employ different processing strategies. Pocheptsova and colleagues (2009) suggest that the degree to which a person's resources have been depleted likely has an effect on the degree to which he or she displays biases, such as the attraction effect. This issue would be a reasonable next step in studying the cerebral processes that underlie biases in decision making.

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