A Multi-Measure Analysis of Context Effects in Multi-Attribute Decision Making: Examining the Similarity, Attraction, and Compromise Effects

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Abstract

The similarity, attraction, and compromise effects warrant specific investigation in multi-attribute decision making. To examine these effects concurrently, we assigned 145 undergraduates to three context effect conditions. They were requested to solve 20 hypothetical purchase problems that had three alternatives described along two attribute dimensions. We measured their choices, confidence ratings, and response times. We found that adding the third alternative had significant effects for choice proportions and confidence ratings in all three conditions. The attraction effect was more prominent than the other two effects with regard to choice proportions. The compromise effect condition yielded low confidence ratings and long response times, although the choice proportion was high for the third alternative. These results indicate that the mutual relationship among choice proportions, confidence ratings, and reaction times requires theoretical investigation.

Keywords: decision making; choice; context effects; similarity effect; attraction effect; compromise effect

Introduction

Theories of rational decision making suggest that choice is intrinsically determined by the utilities of the individual alternatives and thus unaffected by the relationships among the alternatives in the choice context. However, many studies have found violations of this tenet (Busemeyer, Barkan, & Chaturvedi, 2007; Tsetsos, Usher, & Chater, 2010). Three much-studied findings regarding such context-dependent choice effects warrant specific attention since they constitute violations of axioms fundamental to rational choice. The present paper collectively addresses these effects because they share important commonalities and can be explained using a unified framework. These findings include the attraction, similarity, and compromise effects.

These effects occur with the addition of a third alternative (decoy) to the two-alternative choice set (Roe, Busemeyer, & Townsend, 2001; Tsetsos et al., 2010; Tsuzuki & Guo, 2004; Usher & McClelland, 2004). Consistent with established research, the present paper examines these effects in a two-attribute form (see Figure 1). The alternatives that constitute the core two-alternative set are commonly referred to as the target and the competitor. The target and the competitor form a trade-off—one is better than the other on one attribute, but worse on the other attribute. The third alternative is then added to this core set.

Depending on the relative position of the third alternative with respect to the target, three types of phenomena are likely to occur. Two arise when the third alternative is more similar to the target than it is to the competitor. However, if a trade-off exists between the third alternative and the target, the choice probability of the target decreases relative to that of the competitor. This is called the similarity effect (Brenner, Rottenstreich, & Sood, 1999; Tversky, 1972). In contrast, if the third alternative is inferior to the target on all attributes, the choice probability of the target should increase relative to that of the competitor. This is called the attraction effect (Hedgcock & Rao, 2009; Huber, Payne, & Puto, 1982).

The third phenomenon occurs when the third alternative rests between the target and the competitor, in which case the third alternative, now constituting a compromise between the core items, would be chosen most often. This is called the compromise effect (Mourali, Böckenholt, & Laroche, 2007; Simonson, 1989). All three of these phenomena constitute a violation of the axioms of rational choice.

Numerous explanations have been provided for each of the three kinds of decoy effects (Simonson & Tversky, 1992; Tversky, 1972; Tversky & Simonson, 1993). However, Roe et al. (2001) were the first to explain all three within a single framework that was implemented in a connectionist model derived from a previous stochastic mathematical theory (Busemeyer & Townsend, 1993; Tsuzuki, Kawahara, & Kusumi, 2002). Their model (the multi-alternative decision field theory, MDFT) accounts for these findings specifically with the aid of variable lateral inhibition, which is due to similarity relations among alternatives and the momentary shifting of attention from one attribute to another.

Tsetsos et al. (2010, p. 1280) remarked that "before we start, we note that these effects (the similarity, attraction, and compromise effects) were so far obtained in different studies, so until a study reports all three effects with the same

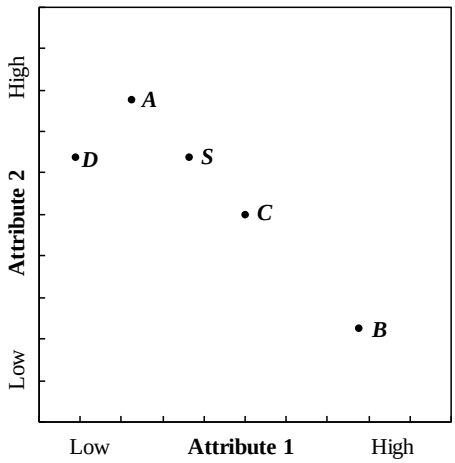

Figure 1: A summary of the phenomena simulated. The letters *S*, *D*, and *C* stand for the third alternatives for the similarity effect, attraction effect, and compromise effect, respectively.

materials, procedures, and subjects, there is the possibility that more freedom exists if parameters (noise) can be modified for various decoy effects." Therefore, empirical studies are needed to test if the three effects can be replicated using the same experimental design and materials.

The present experiment focused on the functioning of all three major context effects in multi-attribute, multi-alternative decision-making processes using the same materials and procedures. This was done using valid choice sets (hypothetical purchase problems) based on preliminary research. In the three-choice session, participants made a selection, gave confidence ratings for the alternatives, and were measured for response times in 20 different choice sets.

Method

Participants and Design

One hundred and forty-five university undergraduates participated in this experiment, for which they received course credit. The basic design variables were (a) the type of the third alternative (corresponding to the similarity, attraction, or compromise effect), which was manipulated between subjects and (b) the type of the alternative (target, competitor, or a third alternative). The participants were randomly assigned to the between-subjects conditions. For the similarity, attraction, and compromise effect condition, 48, 49, and 48 undergraduates were assigned, respectively. The presentation of choice sets was quasi-randomized for each participant in each condition.

Materials and Apparatus

Based on the stimuli of previous studies (Okuda, 2003; Pettibone & Wedell, 2000; Wedell & Pettibone, 1996), we conducted four preliminary surveys and subsequently developed 20 choice sets (see Appendix). Each set contained alternatives from a single type of consumer product or service and consisted of two core alternatives (the target and the competitor) and a third alternative that was described on two dimensions (see Figure 1). Across the 20 choice sets, the average choice proportion for the target vs. the competitor was 51.32 vs. 48.27; these two proportions were not significantly different ($n = 77$, $\chi^2 = 0.16$, $df = 1$).

For the similarity effect condition, the third alternative was created by lowering the value of the target on one of its dimensions by one-fourth of the difference between the target and the competitor and by raising the value of the other dimension of the target by one-fourth of the difference between the target and the competitor. For the attraction effect condition, the third alternative was created by lowering the values of the target on both its dimensions by one-fourth of the difference between the target and the competitor. Finally, for the compromise effect condition, the third alternative was created by lowering the value of the target on one of its dimensions by half of the difference between the target and the competitor and by raising the value of the other dimension of the target by half of the difference between the target and the competitor. All materials and instructions were presented using personal computers.

Figure 2: A screen image of the task used in the experiment with English translation (attraction effect condition).

Procedure

A session with three alternatives. Participants were informed that they would be presented with many sets of three alternatives (the target, the competitor, and the third alternative), and that they would need to indicate their preference for each set. Each choice set was represented by three alternatives, each constructed using two values of differing dimensions (see Figure 2). The arrangement of the alternatives and dimensions on the screen was quasi-randomized in each trial. Choice sets were presented

on the screen and remained on the screen until the preference choice was made. The reaction time between the start of the presentation of the choice set and the choice response was measured using a personal computer. Following this, a confidence rating of the choice was provided based on a 9-point scale.

A session with two alternatives. Participants performed a similar experimental session using two alternatives (the target and the competitor).

Results

Binary Choice Session

In the binary choice session, the average choice proportions for the target vs. the competitor were 51.42 vs. 48.58 in the similarity effect condition, 48.61 vs. 51.39 in the attraction effect condition, and 51.42 vs. 48.58 in the compromise effect condition. The two choice proportions were not significantly different in any of the conditions ($\chi^2 = 0.54$, $df = 1$; $\chi^2 = 0.53$, $df = 1$; $\chi^2 = 0.01$, $df = 1$, in the similarity, attraction, and compromise effect conditions, respectively). These results confirm the equivalence of the binary choice sets in this experiment as the baseline data.

Choice Proportion in the Three-Choice Session

The arcsin transformed choice proportions were analyzed by two-way ANOVA (3 [type of context] × 3 [type of alternative]) with repeated measures (see Figure 3; Greer and Dunlap [1997] demonstrated that ANOVAs are applicable for the ipsative measures). Context type was a between-subjects factor and alternative type was a within-subjects factor.

The main effects of context type, $F(2, 142) = 48.88$, $p < .001$, and alternative type, $F(2, 284) = 55.45$, $p < .001$, and the interaction of the two factors, $F(4, 284) = 80.33$, $p < .001$ were significant. The simple main effects of alternative type were significant in the similarity, attraction, and compromise effect conditions ($F(2, 426) = 5.74$, $p < .01$; $F(2, 426) = 129.20$, $p < .001$; $F(2, 426) = 105.68$, $p < .001$, respectively).

A multiple comparison (Tukey's *WSD* test) was performed on the three conditions of alternative type. In the similarity effect condition, the proportion of the competitor was significantly higher than that of the target and third alternative (both *p*s < .05). In the attraction effect condition, the proportion of the target was significantly higher than those of the competitor and third alternative (both *p*s < .01). Furthermore, the proportion of the competitor choice was significantly higher than that of the third alternative, $p < .01$. In the compromise effect condition, the proportion of the third alternative was significantly higher than that of the competitor, $p < .05$. Overall, these results indicate that the three kinds of decoy effects were replicated in the choice proportions for each of the three context effect conditions.

Confidence Rating in the Three-Choice Session

The confidence rating scores were analyzed using a two-way mixed model ANOVA (3 [type of context] × 3 [type of alternative]) with repeated measures (see Figure 4).The main effects of context type, $F(2, 153.44) = 3.65$, $p < .05$, and alternative type, $F(2, 215.91) = 15.60$, $p < .001$, and the interaction of the two factors, $F(4, 205.99) = 7.63$, $p < .001$, were significant. The simple main effects of alternative type were found to be significant in the similarity, attraction, and compromise effect conditions ($F(2, 2.99) = 15.23$, $p < .001$; $F(2, 29.83) = 4.49$, $p < .05$; $F(2, 61.11) = 26.02$, $p < .001$).

A multiple comparison was performed on the three conditions of alternative type. In the similarity effect condition, the confidence rating for the third alternative was significantly lower than those of the target and the competitor (both *p*s < .001). In the attraction effect condition, the confidence rating of the target was significantly higher than that of the competitor, $p < .05$. In the compromise effect condition, the confidence rating of the third alternative was significantly lower than those of the target and competitor (both *p*s < .001).

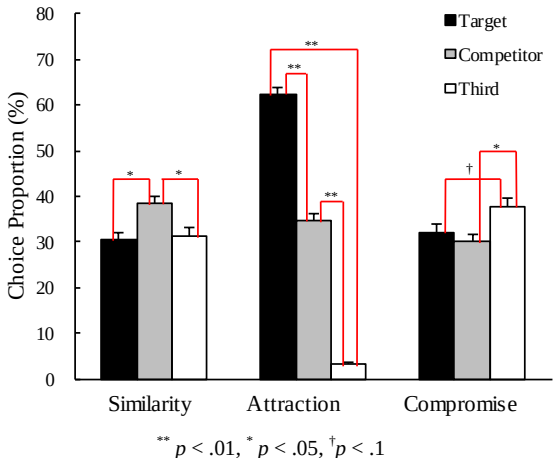

Figure 3: Mean choice proportions (%) of three alternatives in three context conditions. Error bars show standard errors.

In the similarity and attraction effect conditions, the confidence rating scores were largely consistent with the choice proportions. However, in the compromise effect condition, the confidence rating scores were reversed in magnitude relative to the choice proportions.

Reaction Time in the Three-Choice Session

Choice latencies more than 2 *SD* above the mean for each subject were classified as errors and excluded from the RT analysis. The log-transformed choice latencies were analyzed in a one-way repeated-measures ANOVA (three-alternative types) in each of the three context conditions (see Figure 5).

Although the compromise effect condition yielded a

significant main effect, $F(2, 93.87) = 4.58$, $p < .05$, no such significant effects were found for the similarity or attraction conditions, $F(2, 60.42) = 0.25$ and $F(2, 73.88) = 2.17$, respectively. For the compromise effect condition, a multiple comparison performed on the alternative type indicated that the decision time of the third alternative was significantly longer than those of the target and competitor, (both ps $< .05$). These results are consistent with those of the confidence ratings.

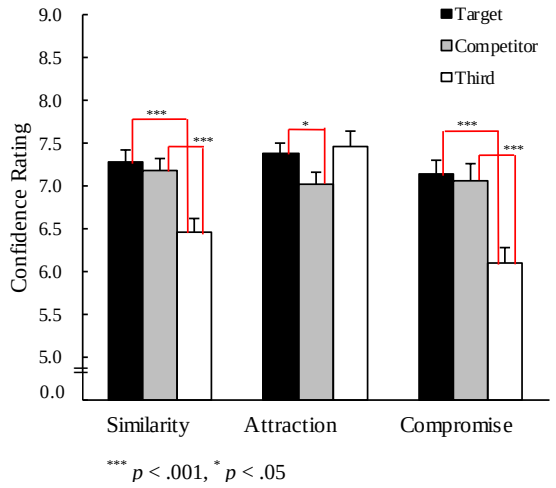

Figure 4: Mean confidence ratings of three alternatives in three context conditions. Error bars show standard errors.

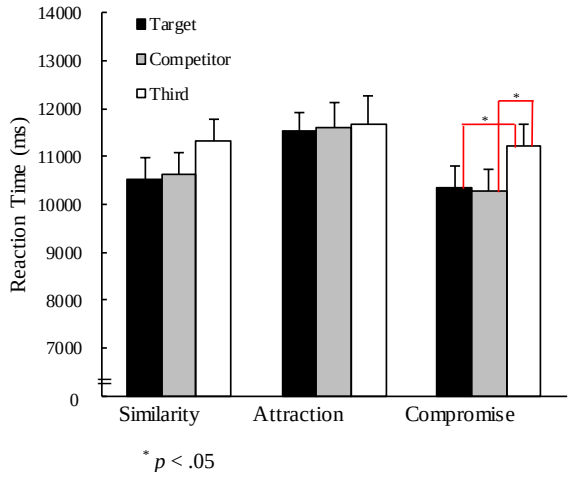

Figure 5: Mean response time (ms) of three alternatives in three context conditions. Error bars show standard errors.

Discussion

Subsequent to the integrated account of three decoy effects by the MDFT model (Roe et al., 2001), Guo and Holyoak (2002) proposed a connectionist model that accounts for the attraction and similarity effects; this model was also based on inter-alternative similarity. According to this model, the decision process is divided into two stages in which the two most similar alternatives (i.e., the target and the third alternative) are compared first, followed by the incorporation of the competitor.

Despite its explanatory simplicity and consistency with some established experimental data, the two-stage model appears to be oversimplified for the purpose of describing human behavior. Studies have demonstrated that in multi-alternative choice tasks similar to those of the similarity, attraction, and compromise effects mentioned above, (1) people momentarily shift their attention across pairwise comparisons and (2) similar pairs are compared more frequently than dissimilar pairs (Russo & Rosen, 1975; Satomura, Nakamura, & Sato, 1997).

Based on the data collected from these studies, Tsuzuki and Guo (2004) proposed a stochastic comparison-grouping model in which all possible types of comparisons are performed momentarily using differential frequencies (Figures 6, 7). In addition, while Guo and Holyoak's model uses a mathematical conversion to estimate choice probabilities from the results of only one simulation, Tsuzuki and Guo's model runs a large number of simulations in order to represent decisions across individuals, thereby directly estimating choice probabilities (Table 1).

In contrast to this research, Usher and McClelland (2004) offered an alternative to previous models that account for the three major context effects simultaneously. Their model, the leaky competing accumulator (LCA), shares many of the same principles of the MDFT model but makes different assumptions about loss aversion and the non-linear activation function (Busemeyer, Townsend, Diederich, & Barkan, 2005).

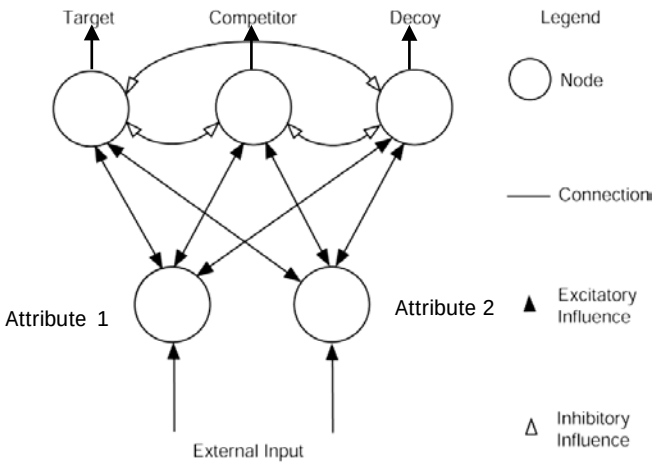

Figure 6: The architecture of the model (Tsuzuki & Guo, 2004). External Input represents the motivational and attentional sources that drive the decision process.

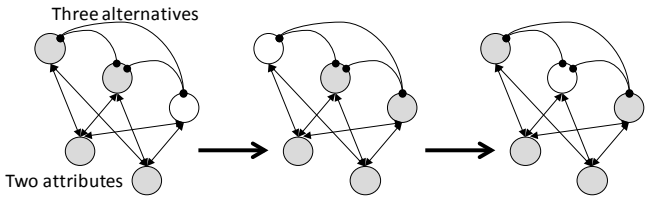

Figure 7: The time-series image of the dynamic fluctuation of the stochastic comparison (Tsuzuki & Guo, 2004). The dark color of the node reflects high node activation.

Table 1: Simulation results as choice probability (estimated from 10,000 simulations; Tsuzuki & Guo, 2004).

Choice scenarios	Choice probability		
	Target	Competitor	Decoy
Binary choice	0.504	0.496	-----
Attraction effect	0.587	0.366	0.048
Similarity effect	0.278	0.397	0.326
Compromise effect	0.213	0.219	0.568

In the present experiment, significant effects of manipulating the third alternative with respect to the similarity, attraction, and compromise effects were found for choice proportions, confidence ratings, and reaction times. Specifically, we found significant effects for choice proportions and confidence ratings in all three of these context-effect conditions, with partially significant effects in response time.

Furthermore, the attraction effect was more prominent than the other two effects with regard to choice proportions. The compromise effect condition yielded low confidence ratings and long response times, although the choice proportion of the third alternative was high. One possibility is that for participants in the compromise effect condition, one kind of selection effect happens for the participant confidence rating for the third alternative in the context of a trade-off or conflict with regard to the evaluation of both attributes. In order to further test this conjecture, we have begun experiments to study the role of eye movements in multi-attribute, multi-alternative processes (Tsuzuki, Shirai, Ohta, Matsui, & Honma, 2008).

Our experimental results support not only our stochastic comparison-grouping model but also the other major models of multi-attribute, multi-alternative choice processes. These results indicate that the relationship between choice proportions and confidence ratings requires theoretical investigation (Pleskac & Busemeyer, 2010), and also suggest that further examination of process-tracing data is needed to determine the mechanisms underlying these three effects (Schulte-Mecklenbeck, Kühberger, & Ranyard, 2011; Willemsen, Böckenholt, & Johnson, 2011).

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Appendix

Binary choice sets used in the experiment: 20 consumer products or services and their two attributes

Consumer product or service	Two attributes
Cell-phone	Number of distinctive functions
	Weight (g)
Electronic dictionary	Types of useful dictionaries
	Weight (g)
MP3 Player	Recording capacity (Number of tunes)
	Weight (g)
Digital watch	Quality of design (1–100)
	Price (thousand ¥)
Notebook computer	Screen size (inch)
	Weight (g)
LCD TV	Screen size (inch)
	Price (thousand ¥)
HDD DVD Recorder	Video recording time (hour)
	Price (thousand ¥)
Digital camera	Image quality (megapixels)
	Weight (g)
Video camcorder	Image quality (megapixels)
	Weight (g)
Component stereo	Sound quality (1–100)
	Price (thousand ¥)
Sport shoes	Quality of design (1–100)
	Price (thousand ¥)
School bag	Quality of design (1–100)
	Weight (g)
Single sofa	Comfort in seating (1–100)
	Price (thousand ¥)
City bike	Quality of design (1–100)
	Price (thousand ¥)
Gas scooter	Quality of design (1–100)
	Gas mileage (km per liter)
Rented apartment	Monthly rent (thousand ¥)
	Walking distance from the station to the apartment (min)
Fitness club	Repletion of equipment (1–100)
	Time taken to reach the fitness club from home (min)
Hair saloon	Magazine's rating of skill (1–100)
	Time taken to reach the saloon from home (min)
Restaurant	Magazine's rating of skill (1–100)
	Time taken to reach the restaurant from school (min)
Part-timer at eating and drinking place	Hourly wage (¥)
	Time taken to reach from home to that place (min)