Judgment and Decision Making (2024), **Vol. 19**:e11 1–21
doi:10.1017/jdm.2023.46

EMPIRICAL ARTICLE

Factors that promote the repulsion effect in preferential choice

Pronobesh Banerjee[1], William M. Hayes[2], Promothesh Chatterjee[3], Tamara Masters[3], Sanjay Mishra[4], and Douglas H. Wedell[5]

[1]Indian Institute of Management Kozhikode, IIMK Campus Kozhikode, Kerala, India; [2]Department of Psychological and Brain Sciences, Indiana University, Bloomington, IN, USA; [3]David Eccles School of Business, University of Utah, Salt Lake City, UT, USA; [4]School of Business, University of Kansas, Lawrence, KS, USA and [5]Department of Psychology, University of South Carolina, Columbia, SC, USA

Corresponding author: William M. Hayes; Email: whayes2@binghamton.edu

Received: 9 November 2022; **Revised:** 2 October 2023; **Accepted:** 15 November 2023

Keywords: decoy effects; preferential choice; tainting hypothesis; similarity; extreme values; repulsion effect

Abstract
Inclusion of a decoy alternative dominated by a target option, but not its competitor, typically leads to increased choice for the target over the competitor, known as the attraction effect. However, the reverse sometimes occurs, known as the repulsion effect. This research tested factors that moderate the repulsion effect in preferential choice scenarios with numerical attributes. Experiment 1 used a between-subjects design with a small set of consumer products and demonstrated robust repulsion effects that did not depend on the relative similarity of the decoy and target. Experiments 2 and 4 used a more powerful within-subjects design along with an expanded set of products and showed that repulsion effects were generally enhanced when the decoy and target had more similar attributes; however, the moderating effect of decoy–target similarity appeared to be fragile and sensitive to stimulus presentation factors. These findings provided mixed support for the hypothesis that the target is tainted by its proximity to the decoy. Experiments 3 and 5 tested whether the extremity of values on the attribute favoring the target moderates the repulsion effect. The results demonstrated that repulsion is more likely when all the alternatives have extremely high values on the target's better attribute. Extremity of attribute values on the dimension favoring the target may result in a categorical assessment along that dimension and shift focus to the attribute favoring the competitor as one way to foster the repulsion effect.

1. Introduction

The attraction effect occurs when a target alternative asymmetrically dominates a decoy alternative, resulting in an increased choice of the target over the competitor. Several replications of the attraction effect show the effect to be relatively robust but dependent on stimulus characteristics and task factors (Cataldo & Cohen, 2019; Pettibone, 2012; Trueblood et al., 2013; 2014; Wedell et al., 2022). For example, the attraction effect is frequently observed when numerical attribute values are used but is typically weakened when less stylized representations are used, such as a pictorial representation. In addition, sometimes the opposite result is observed in which preference for the competitor is enhanced by the inclusion of an attraction decoy, referred to as the repulsion effect (RE) (Frederick et al., 2014).

William Hayes is now an Assistant Professor in the Department of Psychology at Binghamton University. Correspondence to this article may be addressed to Pronobesh Banerjee (pbanerjee@iimk.ac.in) or William Hayes (whayes2@binghamton.edu).

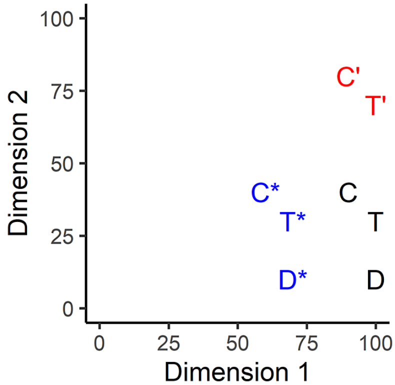

Figure 1. *Various positions for the target (T), competitor (C), and decoy (D) alternatives in two-dimensional attribute space. A comparison of choice sets {T, C, D} and {T', C', D} illustrates the concept of decoy–target similarity: D is more similar to T than it is to T', and thus, the tainting hypothesis would predict a stronger repulsion effect for the {T, C, D} choice set. A comparison of choice sets {T, C, D} and {T*, C*, D*} illustrates the concept of extremity. In the former case, all three options have extremely high values on Dimension 1 and so choice is assumed to be based more on Dimension 2, which favors C. In the latter case, the alternatives have more moderate values and there should be less of an inclination to reduce the choice problem to a single dimension. It should be noted that most studies of the attraction effect have used choice sets with moderate values.*

Though several theories have tried to explain the attraction effect using an array of mechanisms (e.g., Bushong et al., 2021; Roe et al., 2001; Trueblood et al., 2014; Tversky & Simonson, 1993; Usher & McClelland, 2004; for a review, see Wollschlaeger & Diederich, 2020), it is still not clear when the introduction of an asymmetrically dominated decoy should increase the choice share of the competitor rather than the target, as in the RE.

The RE has been primarily documented in studies of perceptual choice (e.g., judging the sizes of rectangles: Evans et al., 2021; Spektor et al., 2018), and it has recently been shown to occur in preferential choice as well (Liao et al., 2021; Spektor et al., 2022; see also Hadar et al., 2018). The results from these studies suggest that the RE is more likely to occur when attributes are presented in a non-numerical format (Frederick et al., 2014) and that it may depend on the pattern of eye movements during the sampling of attribute information, with alternative-wise transitions potentially facilitating the effect (Spektor et al., 2022). Further, there is some evidence that the RE is sensitive to the spatial arrangement of stimuli on screen, making it difficult to generalize across studies that use different choice tasks (Evans et al., 2021; Spektor et al., 2018).

One explanation of the RE is the tainting hypothesis (Simonson, 2014), which posits that the decoy taints the attribute space surrounding it (see also Kreps, 1990). In other words, if the target performs poorly on a particular attribute and the decoy also has a poor value on the same attribute, that particular target attribute gets tainted and makes the competitor's relative strength on this attribute stand out. This tainting process may be somewhat categorical in nature. As an example, consider choosing between two oranges and an apple, with the decoy alternative being an orange with mold on it, the target being the orange with no mold and the competitor being the apple. Clearly, the target orange dominates the moldy orange, but it may be tainted by the focus on the idea that oranges can go moldy (Frederick et al., 2014; Simonson, 2014). This implies repulsion should be more likely the more similar the target is to the decoy in attribute space. Indeed, according to Spektor et al. (2018), 'the tainting hypothesis, as we see it, predicts that tainting should be a decreasing function of distance in the attribute space' (p. 1318). For example, in Figure 1, the RE should be stronger for choice set {T, C, D} than for choice set {T', C', D}.

Research in both perceptual and preferential choice has shown that the RE does indeed vary with the distance between the decoy and target in the two-dimensional attribute space. In perceptual choice, the RE was shown to diminish and eventually flip to an attraction effect as the distance between the decoy and target increased, consistent with the tainting hypothesis (Spektor et al., 2018). Liao et al. (2021) found a RE for small and large distances that flipped to an attraction effect for intermediate distances in perceptual choice (i.e., repulsion–attraction–repulsion). In preferential choice, they found the opposite pattern (i.e., attraction–repulsion–attraction). Importantly, the attributes in Liao et al.'s preferential choice tasks were presented in a numerical format (e.g., prices and quality ratings). In contrast to this, Spektor et al. (2022) found that the RE weakened with increasing distance between the decoy and target using a preferential choice task that presented attributes in a graphical format (i.e., filled bars). They noted that the discrepancy between their results and Liao et al.'s results likely stemmed from the different presentation formats. Other studies using numerical attributes have demonstrated a strengthening of the attraction effect as the decoy moves further away from the target in two-dimensional attribute space (Dumbalska et al., 2020; Soltani et al., 2012). Given the opposing relationship between the attraction effect and RE, this finding can be interpreted as consistent with the tainting hypothesis and the idea that repulsion should be most prominent when the decoy and target have similar attributes (see Figure 1).

In the current study, we sought to further test the influence of decoy–target similarity on the RE in preferential choice tasks with numerical attributes. In addition, we investigated the degree to which RE may occur when the target, competitor, and decoy alternatives have extremely high values on one of the two dimensions. To understand why this may be important, consider a choice between two alternatives T and C, where the target alternative (T) has dimension values (100, 30) and the competitor alternative (C) has values (90, 40) (Figure 1). Further, suppose that decision makers are aware that 100 is the highest possible value on both dimensions. What would happen if an asymmetrically dominated decoy (D) with values (100, 10) were added to the choice set? According to the standard attraction effect, T should benefit from comparisons to D more than C does and so the relative choice share for T should increase. However, given that Dimension 1 has very high values for all three alternatives, one may decide to focus more on Dimension 2 with the clear winner being C. Similar to the lexicographic semi-order rule (Payne et al., 1993; Tversky, 1969), adding the decoy may cause individuals to perceive the differences among the three high dimension values as negligible and unimportant (as they are all extremely high), and hence decide based on the other dimension. In other words, when one of the attributes is highly favorable for all three alternatives, we propose that individuals will edit out the high values from further consideration and shift focus to the other attribute to simplify the choice problem (Kahneman & Tversky, 1979; Payne et al., 1993). Attention to the second attribute is brought into focus primarily with the introduction of the decoy, as the extremity of the high dimension values becomes more apparent with three points in the attribute space compared to two. This process should lead people to choose the competitor, as it has the best value on the second attribute. When values are more moderate on the target's better dimension, it is less likely that decision makers will edit out that dimension and so repulsion should decrease (compare choice set {T, C, D} to {T*, C*, D*} in Figure 1).

The current study tests the tainting hypothesis and the extremity hypothesis across multiple experiments. Key to testing the tainting hypothesis is to vary the relative similarity of the target to the decoy, with the hypothesis that higher similarity will lead to greater RE. To test the extremity hypothesis, we manipulate the extremity of the values on the target's advantageous dimension, with the hypothesis that greater extremity will lead to greater RE.

We present five experiments that tested these predictions using hypothetical consumer choice tasks. Experiment 1 used a small number of consumer products and a completely between-subjects design. The results provided preliminary evidence that RE occur when the alternatives have extremely high values on the target's better dimension. However, no consistent relationship with decoy–target similarity was found. In the remaining experiments, we expanded the set of consumer products to test the generality of the effects and used a more powerful within-subjects design. Experiments 2 and 4 manipulated decoy–target similarity, while Experiments 3 and 5 manipulated the extremity of values

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

on the high-value dimension. Our overarching hypotheses are that RE should be greater when all three alternatives have extremely high values on the target's better attribute, based on the editing process described for the extremity hypothesis, and when the decoy is more similar to the target, based on the similarity mechanism driving the tainting hypothesis.

2. Experiment 1

In Experiment 1, participants encountered a single choice between one of three types of consumer products: backpacks, grills, or MP3 players. The choice set consisted of either two or three alternatives, depending on whether the decoy was present. Each alternative was described by two numerical attribute dimensions that ranged from 1 to 100. The values on the first dimension for Target (T), Competitor (C), and Decoy (D) alternatives were always T = 100, C = 90, and D = 100. Thus, all three alternatives had extremely high values on the first dimension. The decoy's value on the second dimension was held constant at 10, while the values for the focal alternatives varied depending on the choice set to which participants were assigned: (T = 30, C = 40), (T = 40, C = 50), (T = 50, C = 60), (T = 60, C = 70), or (T = 70, C = 80). Note that as the values on Dimension 2 increase, the similarity of D to T decreases while the variance on that dimension increases. Thus, the Dimension 2 manipulation tests for moderating effects of either decoy–target similarity or dimensional variance. The tainting hypothesis implies that RE should strengthen as D becomes more similar to T, as in the low-value sets. Alternatively, attribute weighting has been shown to increase with greater dimensional variance (Mellers & Biagini, 1994; Wedell, 1998) and so a variance hypothesis predicts repulsion should be greatest for the highest variance (lowest similarity) sets. As all conditions had extreme values on the target's advantageous dimension, the extremity hypothesis predicts RE for all similarity levels.

3. Method

3.1. Participants

Participants were 1,643 workers on Amazon Mechanical Turk (MTurk) who completed the experiment online and were paid ($8 hourly rate) for their time (712 women, 914 men, 17 nonbinary/another gender; M_{age} = 36.25, SD_{age} = 11.62). The median time taken to complete the experiment was just over 2 min. All aspects of the study were approved by the institutional review board (IRB) at the authors' university.

3.2. Design

Participants were randomly assigned to one of 30 different conditions based on a factorial combination of three factors: Product (backpacks, grills, or MP3 players), Decoy (present or absent), and Low Dimension (30-40, 40-50, 50-60, 60-70, or 70-80). Each product was described by two attributes: Backpacks were described by storage space and durability, grills by cooking space and cooking speed, and MP3 players by features and ease of use. Attribute values were presented as integers on a 100-point scale, with higher values implying better quality. The values for the three alternatives were T = (100, _), C = (90, _), and D = (100, 10), with the values on the second dimension for T and C depending on the Low Dimension condition to which participants were assigned (30-40, 40-50, 50-60, 60-70, or 70-80). Thus, T and C always had equal summed dimension values and D was asymmetrically dominated by T. The similarity between T and D was highest in the 30-40 condition and lowest in the 70-80 condition.

3.3. Procedure

Participants were instructed that they would see two or three different alternatives from a particular product category and that their task was to choose the one they preferred from the given set. They were told that the descriptions of the alternatives came from a recent edition of *Consumer Reports* and that

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

the brands would be labeled x, y, and z. Following the instructions, participants encountered a single choice between two or three backpacks, grills, or MP3 players, depending on the condition to which they were assigned. The name of the product category appeared at the top of the screen. The alternatives and their attributes were presented in a table with rows equal to the number of alternatives and columns equal to the number of attributes. The target, labeled 'Brand x', always appeared in the first row and the competitor, labeled 'Brand y', always appeared in the second row. If present, the decoy appeared in the third row and was labeled 'Brand z'. The high-value dimension always appeared in the first column (backpacks: storage space, grills: cooking space, MP3 players: features), and the low-value dimension always appeared in the second column (backpacks: durability, grills: cooking speed, MP3 players: ease of use). The column headers indicated that both attributes were rated on a scale from 1 to 100. Below the table, participants could indicate their preferred alternative by clicking a radio button for Brand x, y, or z.

4. Results

Table 1 shows choice frequencies for the target, competitor, and decoy alternatives across the various experimental conditions. Collapsing across product categories, the presence of the decoy increased the competitor's choice share by 9%, 5%, 18%, 7%, and 18% in the 30-40, 40-50, 50-60, 60-70, and 70-80 conditions, respectively. Thus, we observed choice patterns that were consistent with repulsion in all five cases, but the magnitude of the effect did not change monotonically with the values of the low dimension.

We used logistic regression to model the log odds of choosing the competitor as a function of Decoy (present or absent), Low Dimension (30-40, 40-50, 50-60, 60-70, 70-80), and Product (backpacks, grills, MP3 players), as well as the two- and three-way interactions between these predictors.[1] Trials on which the decoy was chosen (n = 19) were excluded (1.2% of trials). The estimated intercept ($\widehat{\beta}$ = 0.38, SE = 0.05) was significantly greater than zero, z = 7.19, p < .001, due to the overall preference for the competitor averaged across conditions. The estimated Decoy coefficient ($\widehat{\beta}$ = 0.24, SE = 0.05) was positive and significant, z = 4.47, p < .001, reflecting the increased choice share for the competitor in the presence of the decoy, controlling for the other predictors. The only other effects that were significant at the .05 level involved Product or the interaction between Low Dimension and Product. In particular, the choice share for the competitor was lower overall for MP3 players compared to backpacks and grills (Table 1). The coefficients for the interaction between Decoy and Low Dimension were all nonsignificant (ps > .15), indicating that the magnitude of the RE did not depend significantly on the degree of similarity between the decoy and target alternative.

5. Discussion

Experiment 1 provides preliminary support for the proposed extremity mechanism for producing repulsion. The choice sets had extremely positive values for all alternatives on the dimension favoring the target and produced fairly consistent RE regardless of the similarity between the decoy and target along the other dimension. While supporting the extremity hypothesis, these results did not provide support for a similarity-mediated tainting hypothesis. However, the question of the generalizability of this effect arises. There was no counterbalancing of alternative and attribute locations on the screen. Prior work suggests order in the display may be a moderating factor (Spektor et al., 2018). Also, similarity was manipulated between subjects, which provides less power to detect a relationship. Further, the extremity condition had no corresponding moderate condition for comparison. The remaining experiments addressed these limitations.

[1]Logistic regression was performed using the glm() function in R. The model was coded as chose_C ~ Decoy * LowDim * Product, with sum-to-zero contrasts used for the predictors. The outcome variable chose_C was defined as 0 if the target was chosen, 1 if the competitor was chosen.

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

Table 1. *Choice frequencies in experiment 1.*

		No decoy		Decoy		
Low dimension	Product	T	C	T	C	D
30-40	Backpacks	19	37	18	42	0
	Grills	25	33	16	42	2
	MP3 players	31	31	23	26	2
	Totals	**75**	**101**	**57**	**110**	**4**
	C/(T+C)		**.57**		**.66**	
40-50	Backpacks	19	37	18	29	1
	Grills	22	32	18	36	3
	MP3 players	30	24	25	33	1
	Totals	**71**	**93**	**61**	**98**	**5**
	C/(T+C)		**.57**		**.62**	
50-60	Backpacks	13	26	11	57	1
	Grills	27	31	14	39	0
	MP3 players	35	16	34	26	2
	Totals	**75**	**73**	**59**	**122**	**3**
	C/(T+C)		**.49**		**.67**	
60-70	Backpacks	21	34	21	35	0
	Grills	31	25	18	31	3
	MP3 players	22	27	24	32	0
	Totals	**74**	**86**	**63**	**98**	**3**
	C/(T+C)		**.54**		**.61**	
70-80	Backpacks	23	38	12	29	2
	Grills	26	27	12	38	1
	MP3 players	41	21	20	21	1
	Totals	**90**	**86**	**44**	**88**	**4**
	C/(T+C)		**.49**		**.67**	

Note: The value for the decoy alternative on the low dimension was held constant at 10. Abbreviations: C, competitor, D, decoy; C/(T+C), relative choice share for the competitor; T, target.

6. Experiment 2

The aim of Experiment 2 was to test the robustness of the results from the first experiment, sampling a larger array of consumer products and utilizing a more powerful within-subjects manipulation of decoy–target similarity. As in Experiment 1, the attribute values on one dimension were always extremely high: T = 100, C = 90, and D = 100. We called this the high-value dimension. The values on the second, low-value dimension varied depending on the level of decoy–target similarity. In one condition, the values on the low dimension were T = 30, C = 40, and D = 10 (high similarity), while in the other condition, the values were T = 70, C = 80, and D = 10 (low similarity). The tainting hypothesis implies that repulsion should be stronger in the 30-40-10 condition.

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

7. Method

7.1. Participants

Participants were 329 paid MTurk workers who completed the experiment online and were paid $1.00 for their time. After excluding data for $n = 118$ participants who failed multiple attention checks (see Design), the final sample included $n = 211$ participants (81 women, 126 men; 4 nonbinary/another gender; $M_{\text{age}} = 36.07$, $SD_{age} = 10.82$). The median time taken to complete the experiment was just under 7 min. All aspects of the study were IRB-approved.

7.2. Design

Participants were randomly assigned to one of four different conditions based on the factorial combination of Decoy (present or absent) and Configuration (high-value dimension presented in the first or second column of the choice display). Note that Configuration was included as a counterbalancing factor and we did not make any predictions about what effect, if any, it would have. On each trial, participants encountered a choice among two (decoy absent) or three (decoy present) different alternatives belonging to a particular product category. There were 12 product categories, each described by two attributes (Table 2). Attribute values were presented as integers from 1 = worst to 100 = best.

Participants made two choices for each product category, one for each level of the Low Dimension factor. In the 30-40-10 condition, the dimension values for the three alternatives were T = (100, 30), C = (90, 40), and D = (100, 10), so that the decoy was similar to the target. In the 70-80-10 condition, the values were T = (100, 70), C = (90, 80), D = (100, 10), so that the decoy was less similar to the target. Note that T and C always had equal summed dimension values and D was always asymmetrically dominated by T. For each participant, the high dimension values (90 and 100) were either presented in the first or second column of the choice display.

In summary, the between-subjects factors were Decoy and Configuration, and the within-subjects factor was Low Dimension. Participants made 24 choices (12 products × 2 choice scenarios for each product). In addition, there were four attention checks in which participants were presented with a choice between two or three dishwashers with attributes capacity and energy savings, where one of the alternatives was clearly superior to the others on both attributes, e.g., X = (100, 90), Y = (20, 10), Z = (30, 20). Participants were excluded from the analysis if they chose an inferior option on more than one of the attention check trials.

Table 2. *Consumer products used in experiments 2–5.*

Product	First attribute	Second attribute
Cable services	Number of channels	DVR storage
Cameras	Resolution	Zoom range
Cars	Gas mileage	Safety features
Cell phones	Battery life	Camera resolution
Coffee makers	Brew speed	Features
Job offers	Paid sick days	Paid vacation days
Laptops	Processing speed	Memory (RAM)
Microwave ovens	Warranty	Cooking power
Refrigerators	Storage capacity	Average lifespan
Restaurants	Location	Quality
Televisions	Screen size	Average lifespan
Washing machines	Average lifespan	Energy savings

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

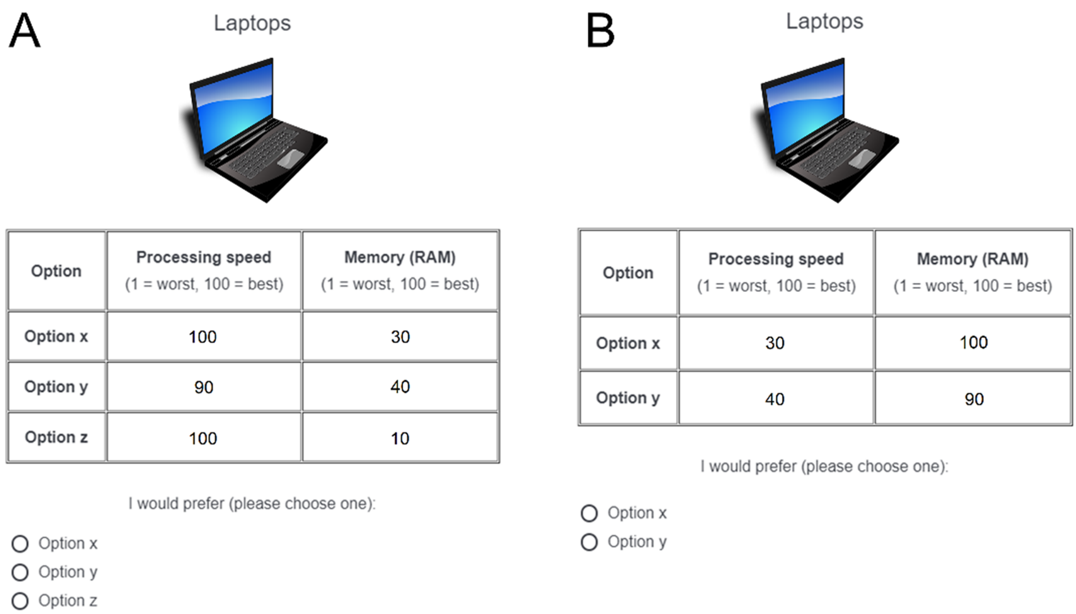

Figure 2. *An example of the choice display. (a) Three-alternative choice with the high-value dimension in the first column. (b) Two-alternative choice with the high-value dimension in the second column.*

7.3. Procedure

Participants were instructed that on each trial they would be choosing between two or three different consumer products, appliances, or services. They were told that each option was rated on two different attributes and that the ratings range from 1 (worst) to 100 (best). An example of the choice display is shown in Figure 2. Panel A shows an example of a three-alternative choice with the high-value dimension in the first column, and Panel B shows an example of a two-alternative choice with the high-value dimension in the second column. Note that the first attribute for each product always appeared in the first column header and the second attribute always appeared in the second column header (see Table 2); however, whether the attribute values in each column were high or low depended on the configuration condition to which participants were assigned. The options were always labeled x, y, and z moving from top to bottom of the choice display, but the underlying alternatives (T, C, and D) were presented an equal number of times in each of the rows. Participants indicated their preferred alternative by clicking a radio button for option x, y, or z. The trials were presented in a random order for each participant and were entirely self-paced.

8. Results

Table 3 shows choice frequencies for T, C, and D across experimental conditions. In the 30-40-10 condition (high decoy–target similarity), the presence of the decoy increased the competitor's choice share by 9%, collapsing across products and choice display configurations. In the 70-80-10 condition (low decoy–target similarity), the decoy increased the competitor's choice share by only 3%. Thus, the RE appeared to be more prominent when the decoy was more similar to the target.

We used mixed-effects logistic regression to model the log odds of choosing the competitor as a function of Decoy (0 = absent, 1 = present), Low Dimension (0 = 30-40-10, 1 = 70-80-10), and the interaction between Decoy and Low Dimension. The model included by-subject and by-item random

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

Table 3. *Choice frequencies in Experiment 2.*

	Low dimension: 30-40-10					Low dimension: 70-80-10				
	No decoy		Decoy			No decoy		Decoy		
Product	T	C	T	C	D	T	C	T	C	D
Cable services	49	61	30	61	10	50	60	28	62	11
Cameras	43	67	23	63	15	52	58	28	59	14
Cars	38	72	42	50	9	38	72	45	42	14
Cell phones	49	61	40	58	3	57	53	47	47	7
Coffee makers	36	74	24	66	11	45	65	29	60	12
Job offers	63	47	38	60	3	59	51	40	55	6
Laptops	44	66	31	66	4	48	62	35	56	10
Microwave ovens	52	58	39	46	16	55	55	43	42	16
Refrigerators	50	60	29	57	15	53	57	46	45	10
Restaurants	52	58	28	68	5	54	56	42	54	5
Televisions	43	67	33	59	9	43	67	44	46	11
Washing machines	43	67	18	70	13	40	70	27	61	13
Totals	**562**	**758**	**375**	**724**	**113**	**594**	**726**	**454**	**629**	**129**
C/(T+C)		**.57**		**.66**			**.55**		**.58**	

Abbreviations: C, competitor; D, decoy; C/(T+C), relative choice share for the competitor; T, target.

Table 4. *Mixed-effects logistic regression parameter estimates in experiment 2.*

Fixed effects ($\widehat{\beta}$)	Estimate	*SE*	*z*	*p*
Intercept	0.41	0.15	2.69	.007
Decoy	0.36	0.20	1.87	.06
Low Dimension	−0.13	0.09	−1.44	.15
Decoy × Low Dimension	−0.30	0.13	−2.26	.024
By-Subject Random Effects				
$\widehat{\sigma}_{\text{Int}}$	1.22			
By-Item Random Effects				
$\widehat{\sigma}_{\text{Int}}$	0.25			

Note: Decoy was coded as 0 = absent, 1 = present. Low Dimension was coded as 0 = 30-40-10, 1 = 70-80-10. $\widehat{\sigma}_{\text{Int}}$ = random intercept standard deviation.

intercepts, where ‘items’ refer to the different products (Baayen et al., 2008).[2] Using the syntax for the glmer() function in the *lme4* R package (Bates et al., 2015), the model can be written as follows:

$$\text{chose\_C} \sim 1 + \text{Decoy}^{*}\text{LowDim} + (1 \mid \text{Subj}) + (1 \mid \text{Item})\,.$$

We excluded trials on which the decoy was chosen from the analysis (n = 242; 4.8% of trials). The estimated coefficients are shown in Table 4.

[2]We could not include by-subject random slopes for the effect of Low Dimension because it resulted in a singular fit (the estimated correlation between by-subject random intercepts and slopes was 1.00).

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

The estimated intercept (0.41) was significantly greater than zero, reflecting the overall preference for the competitor when there was no decoy and the values of the target and competitor on the low dimension were 30 and 40, respectively. The slope for Decoy (0.36), though nonsignificant (p = .06), was positive due to the 9% increase in the competitor's choice share with the introduction of the decoy in the 30-40-10 condition. Critically, the slope for the Decoy × Low Dimension interaction (−0.30) was significant and negative, indicating that the RE was reduced in the 70-80-10 condition (low decoy–target similarity). Further analysis indicated that the effect of Decoy was nonsignificant in the 70-80-10 condition ($\widehat{\beta} = 0.06$, $z = 0.33$, $p = .74$).[3]

A second model that included Configuration and its interactions with the other predictors revealed a significant three-way interaction (Supplementary Table 1). The RE was significant in the 30-40-10 condition when the high dimension values, which favored the target option, were in the second column; however, it was significantly reduced in the 70-80-10 condition when the high values were in the first column.

9. Discussion

Like Experiment 1, Experiment 2 showed that in preferential choice scenarios, the addition of a dominated decoy to a choice set can sometimes boost the attractiveness of the competitor option, rather than the dominating target option. Unlike Experiment 1, but similar to past research (Liao et al., 2021; Spektor et al., 2022), the RE was significantly moderated by decoy–target similarity. We found a larger (though nonsignificant, p = .06) RE when the decoy and target were more similar, as predicted by the tainting hypothesis. However, there was some evidence that the effect may depend on the arrangement of attribute values in the choice display. Presenting the competitor's better attribute in the first column of the display may promote the RE.

10. Experiment 3

The first two experiments established fairly robust RE in choice sets where the alternatives all have extremely high values on the target's better attribute. Experiment 3 was aimed at manipulating the extremity of values on the target's better attribute to directly test the extremity hypothesis. The values on the low dimension were held constant at T = 30, C = 40, and D = 10. In the high extremity condition, the values on the target's better dimension were T = 100, C = 90, and D = 100, while in the low extremity condition, the values were T = 70, C = 60, and D = 70. Given that participants are explicitly informed that the attribute values range from 1 (worst) to 100 (best), they may consider the difference between 90 and 100 to be inconsequential in the high extremity condition (i.e., since both values are 'very good') and thus focus their attention on comparing the alternatives on the low-value dimension to simplify the choice problem. This would benefit the competitor, which always has the highest value on the low dimension. Since this choice editing process is more likely to occur in the high extremity condition than in the low extremity condition, we predict that RE will be stronger in the high extremity condition.

[3]We obtained similar results in a separate experiment (n = 186) with different attribute values. In that experiment, the values for T, C, and D on the low-value dimension were 30-40-25 (high decoy-target similarity) or 40-50-10 (low decoy-target similarity). The values on the high-value dimension were 100-90-100. The presence of the decoy increased the choice share of the competitor by 11% in the high-similarity condition and by 7% in the low-similarity condition. The logistic regression coefficient for the Decoy × Low Dimension interaction was significant and negative ($\widehat{\beta} = -0.35$, $z = -2.34$, $p = .019$), indicating a reduction in the magnitude of the repulsion effect when the decoy and target were located further apart in attribute space.

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

11. Method

11.1. Participants

Participants were 221 MTurk workers who completed the experiment online and were paid $1.00 for their time. After excluding data for n = 49 participants who failed multiple attention checks, the final sample included n = 172 participants (69 women, 103 men; M_{age} = 37.91, SD_{age} = 10.65). The median time taken to complete the experiment was about 7.5 min. All aspects of the study were IRB-approved.

11.2. Design

The design was the same as in Experiment 2, with the exception that the values on the high dimension were manipulated instead of the values on the low dimension. The manipulation was done within subjects. In the high extremity condition, the dimension values for the three alternatives were T = (100, 30), C = (90, 40), and D = (100, 10), so that all three alternatives had extremely positive values on the target's better dimension. In the low extremity condition, the values were T = (70, 30), C = (60, 40), D = (70, 10), so that the values on that same dimension were more moderate. Note that decoy–target similarity was held constant across the two extremity conditions. The high dimension values (90 and 100, or 60 and 70) were either presented in the first or second column of the choice display, depending on the configuration condition to which participants were assigned.

11.3. Procedure

The procedures were the same as in Experiment 2.

12. Results

Table 5 shows choice frequencies for T, C, and D across experimental conditions. In the low extremity condition, the presence of the decoy had no effect on the competitor's choice share when collapsing across product categories and choice display configurations. In the high extremity condition, on the other hand, the decoy increased the competitor's choice share by 7%. Thus, the extremity manipulation seemed to moderate the magnitude of the RE as predicted.

We used mixed-effects logistic regression to model the log odds of choosing the competitor as a function of Decoy (0 = absent, 1 = present), High Dimension (0 = 70-60-70, 1 = 100-90-100), and the interaction between these factors. Trials on which the decoy was chosen were excluded (n = 81; 2% of trials). The model included by-subject and by-item random intercepts, as well as by-subject random slopes to account for variability in the effect of High Dimension across participants. The estimated coefficients are shown in Table 6.

The estimated intercept (−0.04) was close to zero, indicating near indifference between the target and competitor in the no-decoy, low extremity condition. The slope for Decoy (0.02) was also close to zero, due to the introduction of the decoy having essentially no effect on the competitor's choice share in the low extremity condition. There was a positive effect of High Dimension (0.21) driven by more frequent selections of the competitor in the no-decoy, high extremity condition compared to the no-decoy, low extremity condition. However, this effect failed to reach significance (p = .08). Importantly, the significant Decoy × High Dimension interaction (0.35) indicates that the decoy increased the competitor's choice share to a greater extent in the high extremity condition than in the low extremity condition. However, the effect of Decoy did not reach significance in the high extremity condition ($\widehat{\beta}$ = 0.37, z = 1.53, p = .13).

As in the previous experiment, we fit a second model that included Configuration and its interactions with the other predictors. This time, however, the three-way interaction was nonsignificant (Supplementary Table 2).

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

Table 5. *Choice frequencies in experiment 3.*

	High dimension: 70-60-70					High dimension: 100-90-100				
	No decoy		Decoy			No decoy		Decoy		
Product	T	C	T	C	D	T	C	T	C	D
Cable services	36	45	36	51	4	36	45	25	61	5
Cameras	41	40	33	56	2	34	47	30	59	2
Cars	43	38	52	37	2	31	50	32	53	6
Cell phones	41	40	41	50	0	45	36	33	54	4
Coffee makers	42	39	44	44	3	38	43	41	44	6
Job offers	40	41	46	41	4	45	36	34	52	5
Laptops	40	41	36	53	2	35	46	27	63	1
Microwave ovens	44	37	60	29	2	41	40	50	39	2
Refrigerators	43	38	46	38	7	35	46	38	50	3
Restaurants	50	31	49	42	0	45	36	38	49	4
Televisions	33	48	45	42	4	33	48	30	54	7
Washing machines	35	46	42	45	4	33	48	33	56	2
Totals	**488**	**484**	**530**	**528**	**34**	**451**	**521**	**411**	**634**	**47**
C/(T+C)		**.50**		**.50**			**.54**		**.61**	

Abbreviations: C, competitor; D, decoy; C/(T+C), relative choice share for the competitor; T, target.

Table 6. *Mixed-effects logistic regression parameter estimates in experiment 3.*

Fixed effects ($\widehat{\beta}$)	Estimate	*SE*	*z*	*p*
Intercept	−0.04	0.18	−0.23	.82
Decoy	0.02	0.22	0.08	.93
High Dimension	0.21	0.12	1.77	.08
Decoy × High Dimension	0.35	0.16	2.17	.030
By-Subject Random Effects				
$\widehat{\sigma}_{\text{Int}}$	1.28			
$\widehat{\sigma}_{\text{HighDim}}$	0.45			
$\widehat{\rho}_{\text{Int,HighDim}}$	0.15			
By-Item Random Effects				
$\widehat{\sigma}_{\text{Int}}$	0.26			

Note: Decoy was coded as 0 = absent, 1 = present. High Dimension was coded as 0 = 70-60-70, 1 = 100-90-100. $\widehat{\sigma}_{Int}$ = random intercept standard deviation. $\widehat{\sigma}_{HighDim}$ = random slope standard deviation for the effect of High Dimension. $\widehat{\rho}_{Int,HighDim}$ = correlation between random effects.

13. Discussion

In Experiment 3, the extremity hypothesis was directly tested. The RE was found to be stronger in the high extremity condition than in the low extremity condition. This finding, combined with the results of the first two experiments, supports the idea that one way to produce a RE is to make the values on the dimension favoring the target extremely high for all three alternatives. This may result in a tendency

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

to place the high dimension values into the same category so that one's focus is shifted to the other dimension that favors the competitor.

14. Experiment 4

The aim of Experiment 4 was to provide a stronger test of the tainting hypothesis, which predicts greater repulsion the closer the decoy is to the target in attribute space. The results of the previous experiments were mixed: Experiment 1 used five levels of decoy–target similarity in a between-subjects design and provided no support for the tainting hypothesis, as the magnitude of repulsion was inconsistent across the different similarity conditions. Experiment 2 used a more powerful within-subjects design and demonstrated a decrease in the RE when the attribute values of the decoy and target were further apart. These results support the tainting hypothesis; however, because only two levels of decoy–target similarity were used, we could only assess linear changes in the magnitude of the RE. It is possible that the relationship between decoy–target similarity and repulsion is nonlinear (Liao et al., 2021), but this requires testing more than two levels of similarity. Thus, in Experiment 4, we tested four levels of decoy–target similarity using a within-subjects design. We hypothesized that the RE would be greater when the decoy is closer to the target in attribute space but did not make any specific predictions about the functional form of this relationship. We conducted this experiment after an initial round of peer review and preregistered the method and analyses on AsPredicted.org (#126431).

15. Method

15.1. Participants

Participants were 289 MTurk workers who completed the experiment online and were paid $1.00 for their time. Based on our preregistered exclusion criteria, data for n = 158 participants were excluded because they failed more than 25% of the attention checks. This left n = 131 participants (67 women, 64 men; M_{age} = 33.72, SD_{age} = 10.27) in the final sample. The median time taken to complete the experiment was about 12.5 min. All aspects of the study were IRB-approved.

15.2. Design

Participants were randomly assigned to one of four different conditions based on the factorial combination of Decoy (present or absent) and Configuration (high-value dimension presented in the first or second column of the choice display). The same product categories and attributes were used as in the previous experiments (Table 2).

Decoy–target similarity was manipulated within subjects. Participants made four choices for each product category, one for each level of the Low Dimension factor. On each trial, the values on one dimension were always extremely high: T = 100, C = 90, D = 100. The values on the second, low-value dimension varied: T = 30, C = 40, D = 10 (30-40-10 condition); T = 40, C = 50, D = 10 (40-50-10 condition); T = 50, C = 60, D = 10 (50-60-10 condition); or T = 60, C = 70, D = 10 (60-70-10 condition). Decoy–target similarity was highest in the 30-40-10 condition and lowest in the 60-70-10 condition. Note that T and C always had equal summed dimension values and D was always asymmetrically dominated by T. For each participant, the high dimension values were either presented in the first or second column of the choice display.

Participants completed 48 test trials (12 products × 4 levels of decoy–target similarity) and 24 attention check trials in which one of the three options clearly dominated the other two. Participants were excluded from the analysis if they failed to choose the dominating option on more than 25% of the attention checks.

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

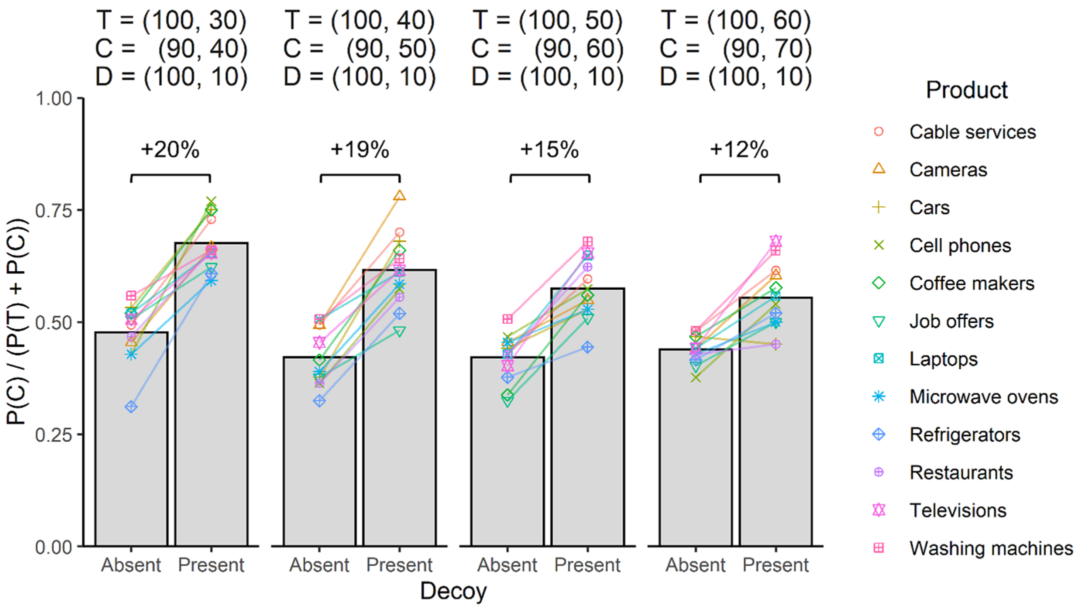

Figure 3. *Experiment 4 results. This plot shows the relative choice share of the competitor as a function of decoy (absent or present) and the locations of the target (T), competitor (C), and decoy (D) in attribute space. Decoy selections were excluded. The relative choice shares for each product category are shown, along with the averages across products (bars). The data are collapsed across individuals. The percentages show the change in the competitor's choice share with the introduction of the decoy. Positive numbers indicate a RE.*

15.3. Procedure

The procedures were the same as in the previous experiments.

16. Results

Figure 3 shows the relative choice share of the competitor over the target as a function of the decoy (absent or present) and the values of the three options on the low dimension (30-40-10, 40-50-10, 50-60-10, or 60-70-10). The data for each product category are shown along with the averages across products. A RE occurs when the competitor's choice share is greater in the presence of the decoy than in its absence, which was observed in every low dimension condition. However, the size of the effect was largest in the 30-40-10 condition, where the decoy and target were most similar, and smallest in the 60-70-10 condition, where the decoy and target were least similar. This pattern is qualitatively consistent with the tainting hypothesis.

We used mixed-effects logistic regression to model the log odds of choosing the competitor as a function of Decoy, Low Dimension, and the interaction. Trials on which the decoy was chosen were excluded ($n = 96$; 1.5% of trials). We used sum-to-zero coding for Decoy (absent = −1, present = 1) and polynomial contrasts for Low Dimension (linear, quadratic, and cubic). The model included random intercepts for subjects and items. By-subject random slopes for the effect of Low Dimension were not included due to convergence issues. The estimated coefficients are shown in Table 7.

There was a significant positive effect of Decoy, indicating an overall RE. However, the interaction between Decoy and Low Dimension is the primary test of the tainting hypothesis. This interaction was significant according to a Type III Wald chi-square test, $\chi^2(3) = 10.33$, $p = .016$. We next examined the

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

Table 7. *Mixed-effects logistic regression parameter estimates in experiment 4.*

Fixed Effects ($\widehat{\beta}$)	Estimate	*SE*	*z*	*p*
Intercept	0.09	0.18	0.50	.62
Decoy	0.50	0.16	3.11	.002
Low Dimension: linear	−0.36	0.06	−5.58	< .001
Low Dimension: quad.	0.17	0.06	2.69	.007
Low Dimension: cubic	−0.03	0.06	−0.53	.60
Decoy × Low Dimension: linear	−0.20	0.06	−3.02	.003
Decoy × Low Dimension: quad.	−0.07	0.06	−1.02	.31
Decoy × Low Dimension: cubic	0.02	0.06	0.25	.80
By-Subject Random Effects				
$\widehat{\sigma}_{Int}$	1.77			
By-Item Random Effects				
$\widehat{\sigma}_{Int}$	0.24			

Note: Decoy was coded as −1 = absent, 1 = present. Low Dimension (4 levels: 30-40-10, 40-50-10, 50-60-10, 60-70-10) was coded using linear, quadratic, and cubic polynomial contrasts. $\widehat{\sigma}_{\mathtt{Int}}$ = random intercept standard deviation.

component interactions between Decoy and the polynomial contrasts for Low Dimension. As shown in Table 7, the interaction between Decoy and the linear component of Low Dimension was significant and negative, indicating a linear decrease in the magnitude of the RE with greater attribute distance between the decoy and target (i.e., lower similarity). The interactions between Decoy and the quadratic and cubic components were not significant.

As an exploratory analysis, we fit a second model that included Configuration and its interactions with the other predictors, but none of the effects that involved this factor were significant (Supplementary Table 3). Thus, the RE and its interaction with decoy–target similarity did not depend on whether the high dimension values were in the first or second column of the choice display.

17. Discussion

The pattern of results in Experiment 4 was consistent with the tainting hypothesis. A strong RE occurred when the target and decoy were most similar, and the effect weakened as the similarity between the target and decoy decreased. Moreover, the weakening of the RE with decreasing similarity was linear rather than nonlinear. There is a caveat, however: In another version of the same experiment in which the value of the decoy on the low dimension was fixed at 25 instead of 10, no RE were observed at any level of decoy–target similarity (Supplementary Figure 1). This result is at odds with the tainting hypothesis. We conclude that while the RE might be moderated to some extent by the similarity between the decoy and target along the target's poor dimension, this interaction is somewhat fragile and appears to be susceptible to minor changes in the choice presentation.

18. Experiment 5

The purpose of Experiment 5 was to provide a stronger test of the extremity hypothesis. This hypothesis predicts greater repulsion as the values on the dimension that favors the target move closer to the upper end of the scale, such that all the options are 'extremely good' on that dimension. The results of Experiment 3 supported this prediction; however, only two levels of extremity were used, and thus, we could only assess linear changes in the magnitude of the RE. The present experiment tested four levels

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

of extremity in a within-subjects design. We hypothesized that the RE would be strongest when all options have extremely high values on the target's better dimension, but we did not make any specific predictions about the functional form of this relationship. We conducted this experiment after an initial round of peer review and preregistered the method and analyses on AsPredicted.org (#124437).

19. Method

19.1. Participants

Participants were 297 MTurk workers who completed the experiment online and were paid $1.00 for their time. Based on our preregistered exclusion criteria, data for n = 176 participants were excluded because they failed more than 25% of the attention checks. This left n = 121 participants (49 women, 71 men, 1 nonbinary/another gender; $M_{\text{age}} = 34.62$, $SD_{age} = 9.14$) in the final sample. The median time taken to complete the experiment was about 11 min. All aspects of the study were IRB-approved.

19.2. Design

As in the previous experiments, the between-subjects factors were Decoy (present or absent) and Configuration (high-value dimension presented in the first or second column of the choice display). Extremity was manipulated within subjects. Participants made four choices for each product category, one for each level of the High Dimension factor. On each trial, the values on the low-value dimension were T = 30, C = 40, and D = 25. The values on the second, high-value dimension varied: T = 70, C = 60, D = 70 (70-60-70 condition); T = 80, C = 70, D = 80 (80-70-80 condition); T = 90, C = 80, D = 90 (90-80-90 condition); or T = 100, C = 90, D = 100 (100-90-100 condition). Extremity was lowest in the 70-60-70 condition and highest in the 100-90-100 condition.

Participants completed 48 test trials (12 products × 4 levels of extremity) and 24 attention check trials in which one of the three options clearly dominated the other two. Participants were excluded from the analysis if they failed to choose the dominating option on more than 25% of the attention checks.

19.3. Procedure

The procedures were the same as in the previous experiments.

20. Results

Figure 4 shows the relative choice share of the competitor over the target as a function of the decoy (absent or present) and the values of the three options on the high dimension (70-60-70, 80-70-80, 90-80-90, or 100-90-100). The data for each product category are shown along with the averages across products. Qualitative RE were observed in every high dimension condition. However, the size of the effect was larger in the conditions where the high values were more extreme. This pattern is qualitatively consistent with the extremity hypothesis.

Mixed-effects logistic regression was used to model the log odds of choosing the competitor as a function of Decoy, High Dimension, and the interaction. Trials on which the decoy was chosen were excluded ($n = 215$; 3.7% of trials). We used sum-to-zero coding for Decoy (absent = −1, present = 1) and polynomial contrasts for High Dimension (linear, quadratic, and cubic). The model included random intercepts for subjects. By-item random intercepts and by-subject random slopes for the effect of High Dimension were not included due to convergence issues. The estimated coefficients are shown in Table 8.

The coefficient for Decoy was significant and positive, indicating an overall RE. However, the critical test for the extremity hypothesis is the interaction between Decoy and High Dimension, which was significant according to a Type III Wald chi-square test, $\chi^2(3) = 17.07$, $p < .001$. As shown in

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

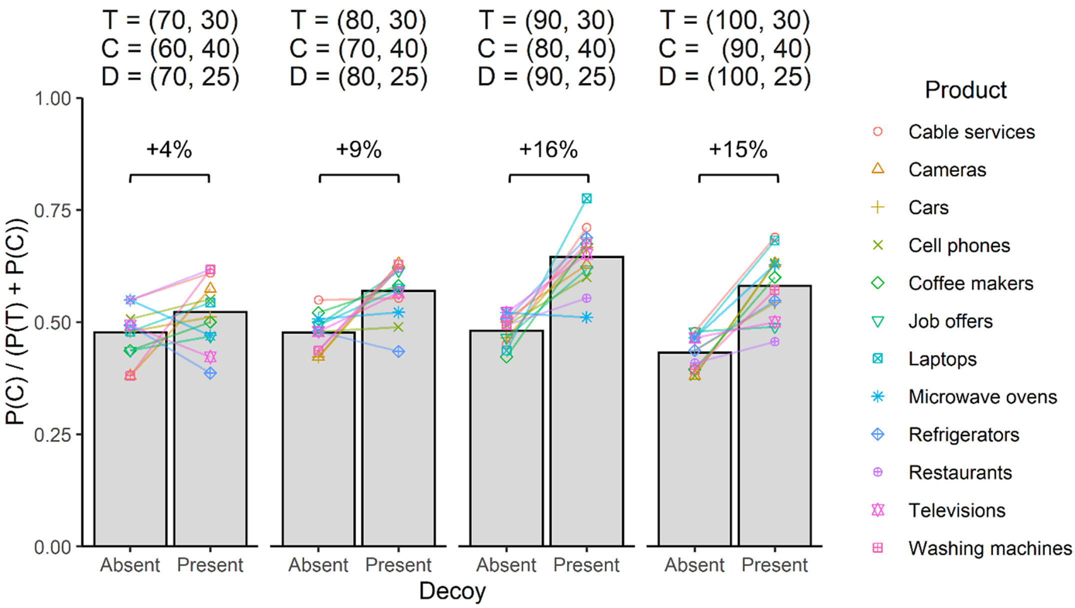

Figure 4. *Experiment 5 results. This plot shows the relative choice share of the competitor as a function of decoy (absent or present) and the locations of the target (T), competitor (C), and decoy (D) in attribute space. Decoy selections were excluded. The relative choice shares for each product category are shown, along with the averages across products (bars). The data are collapsed across individuals. The percentages show the change in the competitor's choice share with the introduction of the decoy. Positive numbers indicate a RE.*

Table 8. *Mixed-effects logistic regression parameter estimates in experiment 5.*

Fixed effects ($\widehat{\beta}$)	Estimate	*SE*	*z*	*p*
Intercept	0.11	0.14	0.79	.43
Decoy	0.29	0.14	2.09	.037
High Dimension: linear	0.08	0.07	1.25	.21
High Dimension: quad.	−0.22	0.07	−3.35	<.001
High Dimension: cubic	−0.15	0.07	−2.30	.022
Decoy × High Dimension: linear	0.24	0.07	3.73	<.001
Decoy × High Dimension: quad.	−0.09	0.07	−1.35	.18
Decoy × High Dimension: cubic	−0.08	0.07	−1.18	.24
By-Subject Random Effects				
$\widehat{\sigma}_{Int}$	1.48			

Note: Decoy was coded as −1 = absent, 1 = present. High Dimension (4 levels: 70-60-70, 80-70-80, 90-80-90, 100-90-100) was coded using linear, quadratic, and cubic polynomial contrasts. $\widehat{\sigma}_{Int}$ = random intercept standard deviation.

Table 8, the interaction between Decoy and the linear component of High Dimension was significant and positive, indicating a linear increase in the magnitude of the RE with greater value extremity on the dimension favoring the target. The interactions between Decoy and the quadratic and cubic components were not significant.

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

As an exploratory analysis, we fit a second model that included Configuration and its interactions with the other predictors, but none of the interaction terms that involved Configuration and Decoy were significant (Supplementary Table 4). Thus, the RE did not depend on whether the high dimension values were in the first or second column of the choice display.

21. Discussion

The pattern of results in Experiment 5 was consistent with the extremity hypothesis. The RE was stronger when the values of all options were extremely high on the target's better dimension. The increase in the magnitude of repulsion with increasing extremity was linear rather than nonlinear. These results corroborate the results of Experiment 3 and support the idea that RE are more likely to occur when the values on the dimension favoring the target are extremely high for all three alternatives. We theorize that this type of setup encourages participants to edit the high values out of the deliberation process and focus attention on the dimension with lower values, which in this case favors the competitor.

22. General discussion

The attraction effect was first developed as a demonstration that contextual manipulations of multi-attribute choice stimuli could lead to violation of choice axioms, such as regularity and independence from irrelevant alternatives (Huber et al., 1982). This work built on earlier work by Tversky (1969, 1972) demonstrating the effects of similarity unaccounted for by traditional models. In the lexicographic semi-order (LEX-SEMI) heuristic, Tversky showed how grouping together options with similar values on a primary attribute could lead to choices being determined by differences on a secondary attribute, producing predictable violations of transitivity in pairwise choice. Likewise, his elimination by aspects model demonstrated how adding a third option that is similar to a target option but not to a competitor can lead to disproportionally reduced choices of the target relative to the competitor and a violation of the independence from irrelevant alternatives axiom in ternary choice. The early demonstrations of the attraction effect were then designed to show the opposite effect of similarity when adding an option similar to the target but also dominated by the target (Huber et al., 1982). The RE, like the similarity effect, hurts the target it is similar to Frederick et al. (2014) and Simonson (2014). These two effects differ, however, in that the similarity decoy achieves this by taking substantial choice share away from the target, whereas repulsion achieves this even though the share of choices for the decoy is typically minimal, since it is a dominated option. Notably, the decoys were rarely chosen in the present study, allowing us to rule out the similarity effect in favor of the RE.

The mechanisms producing the RE have remained unclear, but how repulsion depends on similarity relations has been one key avenue of investigation. According to the tainting hypothesis, the similarity of the decoy and target on the target's poorer dimension should enhance focus on the undesirable value of the target, leading to increased choice of the competitor. Thus, the tainting hypothesis predicts repulsion is more likely as the similarity of target and decoy increases. Results of Experiments 2 and 4 support this prediction, which is also consistent with research on perceptual choice and preferential choice tasks that use graphical attributes (Spektor et al., 2018, 2022). Our findings extend this relationship to preferential choice options with numerical attributes. However, there is some evidence that the association between decoy–target similarity and repulsion is nonlinear rather than linear (Liao et al., 2021). We tested this in Experiment 4 by including four levels of similarity in a within-subjects design. In contrast to Liao et al. (2021), the results suggested that the RE decreases in a linear fashion as the target moves away from the decoy in attribute space.

We did not find a consistent relationship between the magnitude of repulsion and target–decoy similarity in Experiment 1. Unlike the other experiments, Experiment 1 used a between-subjects design in which each participant made only one choice and thus encountered only one set of attribute

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

values. A within-subjects design helps participants better assess target–decoy similarity because they experience a wider range of values, making it a potentially better test for the tainting hypothesis. Yet, our conclusions about the effects of target–decoy similarity must also be tempered by the null results we found in a preliminary version of Experiment 4, which tested four levels of target–decoy similarity in a within-subjects design. In that experiment, we set the lower decoy value to 25 instead of 10 to further increase target–decoy similarity, and no significant RE were observed. Thus, while Experiments 2 and 4 were consistent with the tainting hypothesis, it seems that the predicted similarity-driven effects are subject to variations in the value of decoy, the distribution of attribute values of the target–competitor pair, and how the attribute values are presented. Overall, in our experiments we found only weak support for the type of similarity-driven repulsion predicted by the tainting hypothesis.

Our studies introduce an additional factor in predicting repulsion, namely, the extremity of values along one of the attribute dimensions. In a process akin to the LEX-SEMI heuristic (Payne et al., 1993; Tversky, 1969), the decision maker may evaluate whether attribute values along one dimension are sufficiently different to consider in the choice process. Similar, extremely high values on the target's better dimension may be classified into the same category (i.e., 'very good') and hence lead to greater focus on the dimension favoring the competitor. As discussed earlier, the extremity of an attribute can be judged more easily with three points in the attribute space, which is made possible with the introduction of the decoy. This line of thinking supports past research, which shows that important salient attributes automatically form a category (Ha et al., 2009). In our research, the distribution of attribute values provides a basis for category formation—extreme values versus nonextreme values.

In addition, formation of categories based on salient features is an intuitive process (Hogarth, 2001), which is likely to occur without much effort, regardless of the choice goal (Kahneman & Frederick, 2002). Such categorical processing of information helps in editing the choice problem, as editing is an integral part of the choice process and may be considered throughout decision making until one finds a simplified structure that aids choice (Payne et al., 1993). Thus, our extremity manipulation may be seen as one possible facilitator of the RE by focusing attention on the target's poorer attribute. In other words, the extreme values on one attribute help consumers to edit out that attribute from further consideration and shift focus on the target's poorer attribute. This in turn simplifies the choice process, allowing comparisons on a single attribute rather than two, resulting in the increased choice of the competitor that has the highest value on the nonextreme attribute. Indeed, past research shows that attribute trade-offs are emotionally draining (Janis & Mann, 1977; Luce, 1998) and given the option, consumers tend to avoid such trade-offs (Hedgcock & Rao, 2009). Thus, our extremity manipulation provides an avenue to focus on one attribute in making a choice, resulting in the higher preference of the competitor, which leads to the RE. Further, Experiment 5 showed that the RE increased linearly as the value of the higher dimension became more extreme.

One additional avenue for better understanding the RE may derive from considering how it is related to effortful processing strategies. There is evidence that the attraction effect is likely the result of default automatic choice processes. In support of this idea, the effect is enhanced under ego depletion conditions (Masicampo & Baumeister, 2008; Pocheptsova et al., 2009), unaffected or enhanced by a cognitive load task (Tsuzuki et al., 2019; Wedell et al., 2022), and found in nonhuman primates (Parrish et al., 2015), assuming limited control processes guiding choice in the species being studied. If RE are reduced under cognitive load, then they may well result from deliberate strategies that override the automatic processing guiding the attraction effect. Mishra et al. (1993) found no direct effect of involvement in the choice task, but a negative indirect effect on the attraction effect (p. 339), suggesting that the anomalies are diminished as task involvement increases. Other methodological approaches, such as eye-tracking, may provide insights as to how participants are processing attribute information in our extremity paradigm. Based on our theorizing, we would expect RE to be enhanced with dimension-wise transitions and greater time spent on the target's poorer attribute value (Mishra et al., 1993). This prediction is based on a LEX-SEMI editing process induced by the extremity manipulation and would not be expected when less extreme values are used, in which case alternative-wise processing has been shown to be predictive of repulsion (Spektor et al., 2022).

https://doi.org/10.1017/jdm.2023.46 Published online by Cambridge University Press

23. Limitations and future research

While we have consistently demonstrated the RE across five experiments, 12 products, and thousands of decisions, our results must be viewed under the following caveats. Order effects in the presentation of the options moderated the effects in one of the experiments (Experiment 2). Better control and understanding of this factor should be considered to help clarify the results and develop a better understanding of the RE phenomenon. While the products are regular consumer products, we do not have other control measures like product class involvement and familiarity, information relevance, or task involvement to better classify these decisions and partial out the possible impacts of contaminating variables. Future research should consider investigating whether factors such as the distribution of products in the market (do most have high values on an attribute?), individual characteristics such as involvement and familiarity with the products (Mishra et al., 1993), the importance of the decision, and the interactions between the individual and product-level factors impact the transition point from attraction to repulsion. Future studies should consider controlling for these individual-level variables when studying choice anomalies.

The attribute values in our experiments were presented as quality ratings on a common scale. While this makes it easier to judge the extremity of the attributes by comparing them to the endpoints of the scale (1 = worst, 100 = best), it is an open question whether our results would generalize to attributes on different scales. Indeed, there is some evidence that the attraction effect is more likely to occur with incommensurable attributes (e.g., CPU speed in GHz and RAM size in GB) than commensurable attributes (e.g., quality ratings expressed on a common scale) (Hayes et al., 2023). Thus, the use of quality ratings in the present study may account for why we generally observed repulsion or null effects but never attraction effects. Future studies should continue to test moderators of the RE with different attribute formats.

In the current research, we did not measure respondent-reported similarity but assumed that the options are viewed 'similar as presented'. Given that choice is context dependent, it is prudent to assume that the similarity perception could vary with options presented, product categories used, and individual differences like product class knowledge, task involvement, information relevance, etc. Future research should consider capturing self-reported similarities between the target and decoy and the competitor and decoy, so it can be modeled to better assess the impact of similarity on choices and identify the repulsion and attraction effect regions.

Supplementary Materials. The supplementary material for this article can be found at http://doi.org/10.1017/jdm.2023.46.

Data availability statement. The data and code associated with this article can be accessed from https://osf.io/qtb57/.

References

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390–412.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*, 1–48.

Bushong, B., Rabin, M., & Schwartzstein, J. (2021). A model of relative thinking. *Review of Economic Studies*, *88*, 162–191.

Cataldo, A. M., & Cohen, A. L. (2019). The comparison process as an account of variation in the attraction, compromise, and similarity effects. *Psychonomic Bulletin & Review*, *26*, 934–942. https://doi.org/10.3758/s13423-018-1531-9

Dumbalska, T., Li, V., Tsetsos, K., & Summerfield, C. (2020). A map of decoy influence in human multialternative choice. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(40), 25169–25178.

Evans, N. J., Holmes, W. R., Dasari, A., & Trueblood, J. S. (2021). The impact of presentation order on attraction and repulsion effects in decision-making. *Decision*, *8*(1), 36–54.

Frederick, S., Lee, L., & Baskin, E. (2014). The limits of attraction. *Journal of Marketing Research*, *51*(4), 487–507.

Ha, Y. W., Park, S., & Ahn, H. K. (2009). The influence of categorical attributes on choice context effects. *Journal of Consumer Research*, *36*(3), 463–477.

Hadar, L., Danziger, S., & Hertwig, R. (2018). The attraction effect in experience-based decisions. *Journal of Behavioral Decision Making*, *31*(3), 461–468.

Hayes, W. M., Holmes, W. R., & Trueblood, J. S. (2023). Attribute comparability and context effects in preferential choice. PsyArXiv. https://doi.org/10.31234/osf.io/cq79y.

Hedgcock, W., & Rao, A. R. (2009). Trade-off aversion as an explanation for the attraction effect: A functional magnetic resonance imaging study. *Journal of Marketing Research*, *46*(1), 1–13.

Hogarth, R. M. (2001). *Educating intuition*. University of Chicago Press.

Huber, J., Payne, J. W., & Puto, C. (1982). Adding asymmetrically dominated alternatives: Violations of regularity and the similarity hypothesis. *Journal of Consumer Research*, *9*, 90–98.

Janis, I. L., & Mann, L. (1977). *Decision making: A psychological analysis of conflict, choice, and commitment*. Free Press.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 49–81). Cambridge University Press.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–292.

Kreps, D. M. (1990). *A course in microeconomic theory*. Princeton University Press.

Liao, J., Chen, Y., Lin, W., & Mo, L. (2021). The influence of distance between decoy and target on context effect: Attraction or repulsion? *Journal of Behavioral Decision Making*, *34*(3), 432–447.

Luce, M. F. (1998). Choosing to avoid: Coping with negatively emotion-laden consumer decisions. *Journal of Consumer Research*, *24*(4), 409–433.

Masicampo, E. J., & Baumeister, R. F. (2008). Toward a physiology of dual-process reasoning and judgment: Lemonade, willpower, and expensive rule-based analysis. *Psychological Science*, *19*, 255–260.

Mellers, B. A., & Biagini, K. (1994). Similarity and choice. *Psychological Review*, *101*, 505–518.

Mishra, S., Umesh, U. N., & Stem, D. E. (1993). Antecedents of the attraction effect: An information-processing approach. *Journal of Marketing Research*, *30*(3), 331–349.

Parrish, A. E., Evans, T. A., & Beran, M. J. (2015). Rhesus macaques (Macaca mulatta) exhibit the decoy effect in a perceptual discrimination task. *Attention, Perception, & Psychophysics*, *77*(5), 1715–1725.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge University Press.

Pettibone, J. C. (2012). Testing the effect of time pressure on asymmetric dominance and compromise decoys in choice. *Judgment and Decision Making*, *7*, 513–523.

Pocheptsova, A., Amir, O., Dhar, R., & Baumeister, R. F. (2009). Deciding without resources: Resource depletion and choice in context. *Journal of Marketing Research*, *46*, 344–355.

Roe, R. M., Busemeyer, J. R., & Townsend, J. T. (2001). Multialternative decision field theory: A dynamic connectionist model of decision making. *Psychological Review*, *108*, 370–392. https://doi.org/10.1037/0033-295X.108.2.370.

Simonson, I. (2014). Vices and virtues of misguided replications: The case of asymmetric dominance. *Journal of Marketing Research*, *51*(4), 514–519.

Soltani, A., De Martino, B., & Camerer, C. (2012). A range-normalization model of context-dependent choice: A new model and evidence. *PLoS Computational Biology*, *8*(7), e1002607.

Spektor, M. S., Kellen, D., & Hotaling, J. M. (2018). When the good looks bad: An experimental exploration of the repulsion effect. *Psychological Science*, *29*(8), 1309–1320.

Spektor, M. S., Kellen, D., & Klauer, K. C. (2022). The repulsion effect in preferential choice and its relation to perceptual choice. *Cognition*, *225*, 105164.

Trueblood, J. S., Brown, S. D., & Heathcote, A. (2014). The multiattribute linear ballistic accumulator model of context effects in multialternative choice. *Psychological Review*, *121*, 179–205.

Trueblood, J. S., Brown, S. D., Heathcote, A., & Busemeyer, J. R. (2013). Not just for consumers: Context effects are fundamental to decision making. *Psychological Science*, *24*, 901–908.

Tsuzuki, T., Takeda, Y., & Chiba, I. (2019). Effortful processing reduces the attraction effect in multi-alternative decision-making: An electrophysiological study using a task-irrelevant probe technique. *Frontiers in Psychology*, *10*, 896. https://doi.org/10.3389/fpsyg.2019.00896.

Tversky, A. (1969). Intransitivity of preferences. *Psychological Review*, *76*, 31–48.

Tversky, A. (1972). Elimination by aspects: A theory of choice. *Psychological Review*, *79*, 281–299.

Tversky, A., & Simonson, I. (1993). Context dependent preferences. *Management Science*, *39*, 1179–1189. https://doi.org/10.1287/mnsc.39.10.1179.

Usher, M., & McClelland, J. L. (2004). Loss aversion and inhibition in dynamical models of multialternative choice. *Psychological Review*, *111*, 757–769. https://doi.org/10.1037/0033-295X.111.3.757.

Wedell, D. H. (1998). Testing models of tradeoff contrast in pairwise choice. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 49–65.

Wedell, D. H., Hayes, W. M., & Verma, M. (2022). Context effects on choice under cognitive load. *Psychonomic Bulletin & Review*, *29*, 1986–1996. https://doi.org/10.3758/s13423-022-02113-0

Wollschlaeger, L. M., & Diederich, A. (2020). Similarity, attraction, and compromise effects: Original findings, recent empirical observations, and computational cognitive process models. *American Journal of Psychology*, *133*, 1 –30.

Cite this article: Banerjee, P., Hayes, W. M., Chatterjee, P., Masters, T., Mishra, S., and Wedell, D. H. (2024). Factors that promote the repulsion effect in preferential choice. *Judgment and Decision Making*, e11. https://doi.org/10.1017/jdm.2023.46