



Inferiority, Not Similarity of the Decoy to Target, Is What Drives the Transfer of Attention Underlying the Attraction Effect: Evidence from an Eye-Tracking Study with Real Choices

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1 Inferiority, Not Similarity of the Decoy to Target, Is What Drives the Transfer of Attention
2 Underlying the Attraction Effect: Evidence from an Eye-Tracking Study with Real Choices

3

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18

Abstract

19 Recent studies reported that the attraction effect, whereby inferior decoys cause choice reversals,
20 fails to replicate if the choice options are presented in a pictorial rather than abstract numerical
21 form. We argue that the pictorial setting makes the similarity between decoy and target salient,
22 while the abstract one emphasizes the inferiority relationship between them, crucial for the effect
23 to occur. Thus, we used a novel experimental design in which both similarity and inferiority are
24 equally easy to judge, their relative strength simple to manipulate, and choices incentivized
25 rather than hypothetical. Using eye-tracking, we found that both the transfer of attention towards
26 an undesirable target and choice reversal likelihood increase when the decoy is more strongly
27 inferior but less similar to the target. This suggests that a key mechanism in the attraction effect
28 is that, by virtue of its inferiority, a decoy projects a spotlight of attention towards the target,
29 making it more attractive.

30 **KEYWORDS:** eye-tracking; choice reversal; attraction effect

31

32 One of the most prominent context effects in consumer choice is the attraction effect
33 (Huber, Payne, & Puto, 1982). This occurs when choosing between different options, say A and
34 B, each of which is better than the other in some respects. Adding a third option, C ('decoy'),
35 that is in every respect worse than B ('target'), but still in some respects better than A
36 ('competitor'), makes people more likely to choose B, even if they would have preferred A to B
37 in the absence of C.

38 A number of existing theories, backed by behavioral experiments, have pointed to
39 attention transfers as a key mechanism behind the attraction effect. For instance, Roe,
40 Busemeyer, and Townsend (2001) proposed a 'Multialternative Decision Field Theory', whereby
41 the switching of attention between choice option attributes determines the eventual choice. The
42 theory highlights the fact that, on the one hand, when the decoy is very similar to the target but
43 not clearly inferior, it can reduce the preference for the target via a 'similarity effect'. On the
44 other hand, when the decoy's inferiority is apparent, it can increase the attractiveness of a highly
45 similar target via lateral inhibition, drawing attention towards the attributes where it is superior
46 (see also Ariely & Wallsten, 1995; Bhatia, 2013; Bordalo, Gennaioli, & Shleifer, 2013). The
47 more recently developed 'Multiattribute Linear Ballistic Accumulator Model' (J. S. Trueblood,
48 Brown, & Heathcote, 2014) also assumes an attentional mechanism, whereby the fact that the
49 decoy is closer to the target than to the competitor results in more attention being allocated to the
50 comparison between the difficult to discriminate decoy and target options, ultimately revealing
51 and highlighting the superiority of the target. Finally, Ok, Ortoleva, and Riella (2015) theorized
52 that, in a two-stage process, a decoy first acts as a 'spotlight', narrowing down a person's
53 attention to an 'attraction region', before choosing from within this region at stage two (also see
54 Lleras, Masatlioglu, Nakajima, & Ozbay, 2017 for a related 'limited consideration' model).

55 Despite terms like ‘attention’ or ‘saliency’ featuring prominently in these explanations,
56 and despite eye-tracking being often used to investigate other forms of decision bias (e.g., Król
57 & Król, in press), there has been little attempt to use it to study the visual attention patterns
58 accompanying decoy-induced preference reversals. Such an analysis seems fruitful, because
59 research on value-based choice (in the absence of decoys) demonstrated that attention guides
60 choices in a positive feedback loop, whereby a stronger preference for an option causes more
61 attention to be allocated to it, and vice versa (Ashby, Jekel, Dickert, & Glöckner, 2016; Krajbich,
62 Armel, & Rangel, 2010; Reutskaja, Nagel, Camerer, & Rangel, 2011; Shimojo, Simion,
63 Shimojo, & Scheier, 2003). Nevertheless, we are aware of only a very small number of process-
64 tracing studies of context effects, most of which were based on functional magnetic resonance
65 imaging (W. Hedgcock, Rao, & Chen, 2009; Hu & Yu, 2014; Li, Michael, Balaguer, Hecce
66 Castañón, & Summerfield, 2018; Mohr, Heekeren, & Rieskamp, 2017), and only one of which
67 used eye-tracking. In this study, Noguchi and Stewart (2014) found that, in scenarios that induce
68 context effects, people compare alternatives in pairs, one attribute at a time. However, their
69 otherwise comprehensive design did not allow for an identification of which individual choices
70 were actually affected by decoys (that is, it is impossible to tell if a subject would choose
71 differently from a given competitor-target pair in the absence of a decoy).

72 To address the above problem, similarly to Hedgcock, Rao, and Chen (2016), we used a
73 repeated-measures design, in which subjects face each competitor-target combination both with
74 and without a decoy (separated by other decision trials as well as distractor tasks). However,
75 unlike any existing studies, we combined this type of a repeated-measures design with eye-
76 tracking. To illustrate the purpose of this setup, consider the two-attribute choice problem
77 depicted in Figure 1. Suppose that we have established that a given participant prefers option ‘c’

78 to 't' in the absence of any other choice options. The question we ask in this study is: if we then
79 present the participant with the same choice, but with a decoy that is slightly inferior but very
80 similar to the target ('d₁') would it result in a greater transfer of visual attention from the
81 competitor ('c') to the target ('t') than if we instead used a decoy that is highly inferior but not
82 very similar to the target ('d₂')?

83 [Figure 1 about here]

84 The above question is all the more important given that it can be linked to the recent
85 debate about the robustness of the attraction effect. In particular, the authors of two extensive
86 replication projects have argued that the effect is only reproduced if the choice options are
87 presented as combinations of abstract numerical attributes, but fails to occur under a more
88 realistic, pictorial representation (Frederick, Lee, & Baskin, 2014; Yang & Lynn, 2014). We
89 believe that the reason for the discrepancy is that the numerical representation makes the
90 inferiority relationship between the decoy and the target salient, as it is easy for subjects to notice
91 that one is worse than the other in terms of, for example, both the quality index and the price. In
92 contrast, displaying options as pictures typically emphasizes the similarity between decoy and
93 target – in most stimuli examples presented in the two replication studies it is immediately clear
94 that two of the three options may be perceived as a group, e.g. one gets to choose between two
95 very similarly packaged varieties of the same brand of popcorn and one visually distinct product
96 of another brand. At the same time, as noted by Simonson (2014), this makes it very hard for
97 subjects to tell which option in the pictorial replication studies is the dominated, inferior one,
98 whereas, according to Huber, Payne, and Puto (2014) 'attraction depends on the ability to
99 identify the dominance relationship quickly and unambiguously'. Even in those pictorial
100 replications in which inferiority is clear (e.g. displaying pictures of an orange, a fresh apple, and

101 a spoiled apple), the problem might, in turn, be that undesirable options are known to attenuate
102 the attraction effect (Malkoc, Hedgcock, & Hoeffler, 2013).

103 A separate problem, raised by Lichters, Sarstedt, and Vogt (2015) in their extensive
104 literature review, is that over 98% of studies of the attraction effect, whether pictorial or abstract,
105 are based on hypothetical choices, typically using MTurk and similar online surveys. Thus, the
106 results are potentially affected by subjects' lack of attention, motivation, and automatic response
107 patterns (Lichters, Bengart, Sarstedt, & Vogt, 2017; Smith, Roster, Golden, & Albaum, 2016).

108 With this in mind, we sought to investigate the role of similarity vs. inferiority in the
109 attraction effect via a design in which: a) both relationships are equally easy for the subject to
110 observe, i.e. equally salient; b) the extent to which options are inferior or similar to one another
111 is precisely measured and manipulated; and c) subjects receive whatever they select, i.e. choices
112 are non-hypothetical. In particular, the first objective (a) is achieved by presenting the choice
113 options in a spatial grid, i.e. as in Figure 1.

114 Based on the discussed abstract vs. pictorial discrepancy reported by recent studies, we
115 hypothesized that introducing a decoy inferior to an option one did not choose in decoy's
116 absence will transfer attention (measured by eye fixation duration) to the target from the
117 competitor (that is, a greater proportion of the fixation time will be allocated to an unattractive
118 target if a decoy dominated by that target is added to the choice set). However, this effect will be
119 weaker if the decoy is more similar but less inferior to the target ('d₁' in Figure 1, as opposed to
120 'd₂'). If confirmed, such a result would indicate that the attentional spotlight cast on the target by
121 virtue of its superiority rather than similarity to the decoy is strong enough to offset the natural
122 tendency to perceive spatially close/similar objects as a group and divert more attention towards
123 them (Kimchi, Yeshurun, Spehar, & Pirkner, 2016).

124 Finally, to demonstrate the potential real-world applications of our findings, we explored
125 the possibility of predicting, based on attention to choice options in the presence of a decoy,
126 whether the decoy actually influenced the subject's preferences, i.e. whether or not the choice
127 would have been different if the decoy were absent. In particular, we expected that increased
128 attention to both the decoy and the competitor despite choosing the target might indicate a
129 'genuine' preference for the competitor that has been altered by the decoy. We discussed how
130 such an approach might be useful in the evaluation of real-world marketing strategies.

131

132 **Method**

133 **Subjects**

134 The experiment was carried out at a large private university, where a total of 68
135 undergraduate and postgraduate student subjects were recruited. Their average age was 21.88
136 (SD = 3.18), 39 of them were female, and all had normal or corrected to normal eyesight.

137 **Stimuli and Design**

138 Subjects repeatedly chose (without time limit) one out of two or one out of three bundles
139 of two types of goods: (1) shopping vouchers redeemable at any store of a big supermarket
140 chain, including a store located in the vicinity of the experiment location; (2) food and drink
141 vouchers redeemable at the local university canteen. All monetary values stated below are in the
142 local currency, a unit of which is worth approximately 0.3 USD. For instance, in a given choice
143 trial a subject might be asked to choose one of the following two bundles: (1) a supermarket
144 voucher worth 4 and a canteen voucher worth 16; or (2) a supermarket voucher worth 14 and a
145 canteen voucher worth 8.

146 An example of how the choice was presented to subjects is illustrated in Figure 2. The
147 setting was partly inspired by a typical retailer's taxonomical shelf design, where products that
148 are more similar are located closer together, but where it is equally simple to locate products that
149 are inferior in quality or price (e.g. basic, low-quality products are placed in the bottom shelves).
150 This is known to facilitate the consumers' evaluation of the products and increases their
151 satisfaction (Meier & Robinson, 2004; Mogilner, Rudnick, & Iyengar, 2008).

152 Accordingly, in our case, the subjects' assessment of both similarity and inferiority was
153 facilitated by presenting the voucher bundles on a spatial grid, where each 'disk' corresponds to
154 a single bundle. In the example in Figure 2, its X-axis position (or the number in the left half of
155 the disk) represents the value of the supermarket voucher included in the bundle, and the Y-axis
156 position is the value of the included canteen voucher. Thus, one bundle was inferior to another if
157 positioned to the bottom left of it, while similarity was simple to judge based on proximity.

158 As explained in the 'Payoffs' section, our subjects were motivated to reveal their true
159 preferences. As such, they were unlikely to be biased by the visual presentation of the choice
160 options, with the grid only there to support their assessment of the relationships between them
161 (as shown by existing research, visual decision support tools can help people during multi-
162 attribute choice, see e.g. Samek, Hur, Kim, & Yi, 2016).

163 Nevertheless, to counterbalance potential artefacts associated with the relative positioning
164 of the choice options, for half of the subjects the canteen and supermarket voucher values were
165 instead indicated by the X and Y axis respectively (as expected, we found no difference between
166 the two groups of subjects). Furthermore, as detailed later, the relative positioning of the choice
167 options was included as an independent variable in the regression model (rather than held
168 constant across trials) allowing us to control and investigate its effect on attention and choices.

169 [Figure 2 about here]

170 After every trial, subjects carried out a distractor task (Figure 3), i.e. needed to say if a
171 random math inequality is true (e.g. ‘ $16 - 4 > 3 + 11$ ’), and were reminded which number in a
172 disk representing each bundle corresponds to which type of voucher (this was done via an
173 example bundle, randomly generated in each instance of the task to additionally obstruct any
174 attempts at memorizing the previous choice options). The purpose of the distractor task was to
175 avoid carryover memory/learning effects and psychological reactivity (Ahn, Kim, & Ha, 2015;
176 Hutchinson, Kamakura, & Lynch, 2000), by removing the primary task (choice-related)
177 information from short-term memory (Bjork & Whitten, 1974).

178 [Figure 3 about here]

179 **Choice Trial Specification**

180 In each of the first 30 trials of the experiment, each subject would choose one of two
181 bundles. The composition of each pair of bundles was drawn randomly subject to a number of
182 constraints. That is, we considered all pairs of bundles such that: a) one bundle in each pair
183 included a higher-value canteen voucher than the other, which in turn included a higher value
184 supermarket voucher; b) the value of each type of voucher included in each bundle was at least 4
185 (to allow for an inferior bundle to be added later – see below) but at most 18, and was a
186 multitude of 2 (consistent with the resolution of the grid, and to allow for enough distance
187 between the areas of interest). We drew the pairs of bundles randomly from this set,
188 independently for each subject and without replacement (ensuring that no choice sets were
189 duplicate within subjects). We treated the first three trials obtained in this way as training,
190 familiarizing subjects with the problem.

191 For each of the following 27 trials (trials 4 to 30), we constructed an additional, ‘matching’ trial,
192 by adding a third, decoy bundle to the original two. The decoy was set randomly on each
193 occasion, but always inferior to one (and only one) of the other two bundles (target). That is, the
194 decoy was drawn from the set of bundles which: a) contained strictly less of one type of voucher
195 and no more of the other type of voucher than one of the existing two bundles (the target), but
196 strictly more of one type of voucher (and strictly less of the other type) than the competitor; b)
197 contained at least 2 but at most 16 of each type of voucher (a multitude of 2). In the example
198 shown in Figure 2, the matching trial would include a decoy located either north of bundle 2 but
199 to the south-west of bundle 1, or east of bundle 1 and to the south-west of bundle 2.

200 The 27 matching trials were scheduled after the initial trials, in a randomized order. The
201 reason for this relative timing of the two blocks was that, in the first instance, we wished to elicit
202 each subject’s genuine preference between the competitor and the target without any current or
203 past exposure to decoys. At the same time, in the ‘Results’ section we report that the distractor
204 tasks were apparently successful in eliminating the influence of subjects’ potential recollections
205 of the initial trials on their behavior and attention patterns in the matching trials, i.e. the ordering
206 of the blocks was unlikely to interfere with our study of choice reversals in the matching trials.

207 **Payoffs**

208 Subjects were told that, upon completion, they would receive a single voucher bundle,
209 drawn randomly from the set of the bundles they selected throughout all trials. This kind of
210 random lottery payoff mechanism is often used, as it is effective in preventing portfolio building
211 strategies and ensuring the independence of actions across trials, while allowing for ‘real-world
212 consequences’ of choices (Cubitt, Starmer, & Sugden, 1998). On average, subjects received an

213 equivalent of 7 USD in vouchers, and the whole study took 25 minutes to complete (including
214 the reading of instructions, eye-tracking calibration, and the distractor tasks).

215 **Results**

216 **Measurements and data pre-processing**

217 For each subject and each of the trials numbered 4 to 57 (i.e. skipping the training trials),
218 we identified the eye fixations that occurred between displaying the choice screen and the subject
219 submitting the choice (a fixation is a pause of eye movement on any part of the visual field,
220 representing the subject's gaze being fixed on a specific point on the screen; see the appendix for
221 details of the fixation detection procedure). We computed the total duration (in milliseconds) of
222 all fixations directed at each of the disks representing the available choices. Henceforth, by
223 ‘attention to option X’ we mean the total duration of fixations directed at the disk representing X.
224 For each pair of matched trials (the initial trial and its later matching trial including a decoy), we
225 identified the bundle that was chosen (preferred) in the initial trial – let ‘P’ denote this bundle, and
226 let ‘NP’ denote the other bundle, the one that was not chosen (preferred) in the initial trial.
227 Accordingly, we calculated the value of a variable we term ‘attention reversal’ (between the two
228 trials), defined as follows:

$$229 \quad \log \left[\frac{\text{attention to NP in the matching trial} / \text{attention to P in the matching trial}}{\text{attention to NP in the initial trial} / \text{attention to P in the initial trial}} \right]$$

230 Thus, attention reversal is positive when more attention is allocated to NP relative to P in
231 the matching trial compared with the initial trial, and negative if the opposite occurs (the log-
232 ratio transformation is used to normalize the comparison outcome). In other words, the greater
233 the shift of attention between the initial and matching trial – away from the option chosen in the

234 initial trial and towards the option not chosen in that trial – the greater the attention reversal.
235 Henceforth, we will at times for brevity refer to the option not chosen in the initial trial (NP) as
236 the ‘less preferred’ option, and to P as the ‘more preferred’ option.

237 To determine the potential role of the decoy in attention reversal, for each pair of
238 matched trials we also specified the following two variables:

239 (1) ‘target-preferred’, a binary variable, taking a value 1 if the target option in the matching trial
240 was P, i.e. if the decoy was set inferior to the more preferred option; if this was not the case, the
241 variable took a value 0

242 (2) ‘proximity-to-target’, a continuous variable, equal to the difference between the Euclidean
243 distance between the decoy and the competitor and a similar distance between the decoy and the
244 target (using a log-ratio of the two distances instead does not cause a qualitative change of the
245 results; also note that the reason why the two distances are not considered as separate variables is
246 because it is impossible to change one without changing the other, and due to their strong
247 negative correlation including both in a regression model would cause multicollinearity).

248 Lastly, an alternative dependent variable that we used in a separate model was ‘choice
249 reversal’ (between the matching and initial trial). This was a binary variable taking a value 1 if in
250 the matching trial the subject chose the bundle she did not choose in the initial trial (otherwise, it
251 took a value 0). Such choice reversals occurred in 19% of matched trial-pairs.

252 **Checking for memory carryover effects**

253 To begin with, we wanted to check if our distractor task was successful in removing any
254 carryover memory effects, i.e. if the subjects’ behavior in the matching trials was not influenced
255 by their previous exposure to the corresponding initial trials. To this end, we estimated a mixed-
256 effects binary logistic regression model in which each pair of matched trials by a given subject

257 constituted a single observation, with random intercept and slope effects clustered by subject to
258 allow for correlated errors. The dependent variable was ‘choice reversal’, and the sole
259 independent variable was the number of trials separating the initial trial from its matching trial.
260 We found no significant effect between the two variables ($\beta = -0.004$, $t = -0.522$, $p = .602$)
261 suggesting that a reduced time difference between the two matched trials did not significantly
262 increase the likelihood that a subject's choice would be the same in both of them. In fact, the
263 same was true for the relationship between the time difference and attention reversal ($\beta = 0.002$,
264 $t = 0.829$, $p = .407$).

265 **The influence of inferiority vs. similarity on attention reversal**

266 Following this initial check, we proceeded to the main focus of our investigation, namely
267 the effect of ‘target-preferred’ and ‘proximity-to-target’ on attention reversal. As a prelude to the
268 main analysis, Table 1 shows the average attention reversal depending on the values of the two
269 independent variables in question. In general, attention reversal tends to be positive on average,
270 possibly due to the presence of the decoy distorting the attentional bias towards the preferred
271 option in the initial trial. However, it appears that the difference between the attention transfer
272 when target-preferred = 1, compared with target-preferred = 0, increases with proximity-to-
273 target. This would suggest that the attention transfer to the less preferred option brought about by
274 targeting it, rather than the more preferred option, with an inferior decoy, is greater when the
275 decoy is more strongly inferior but less similar to the target (in fact, for high proximity-to-target,
276 we observe a ‘repulsion effect’ of the decoy instead of attraction).

277 To evaluate the statistical significance of the above effects of the way in which the decoy
278 is set, we estimated a mixed-effects linear regression model, again with each pair of matched

279 trials constituting a single observation and random intercept and slope effects clustered by
280 subject to allow for correlated errors. The dependent variable was now ‘attention reversal’, and
281 the independent variables were the ‘target-preferred’ and ‘proximity-to-target’ variables
282 described above (as well as their interaction). We dropped those pairs of matched trials in which
283 either: a) the subject selected the decoy bundle in the matching trial (2% of trial pairs); b)
284 fixations were not recorded in at least one of the two matched trials due to a technical
285 malfunction, looking away from the screen, blinking etc. (a further 9% of trial pairs); or c) the
286 subject only looked at one of the available options in either of the matched trials, making it
287 impossible to calculate the value of attention reversal (10% of trial pairs; clipping the log-ratio
288 values instead of dropping these trial pairs does not cause a qualitative change of the results).
289 The fixed effects estimation results (based on robust covariances) are presented in Table 2.

290 [Table 2 about here]

291 The fact that the model intercept is significantly positive ($\beta=0.702$, $p<.001$) indicates that, when
292 the decoy is inferior to the ‘less preferred’ option (not chosen in the initial trial) and equally
293 distant from the target and the competitor (target-preferred = proximity-to-target = 0), then in the
294 matching trial subjects allocate more attention to the less preferred option (relative to the more
295 preferred one) compared with the initial trial. In other words, a decoy equally similar to both
296 options, but inferior to the less preferred one, causes a transfer of attention towards it.

297 The significantly negative coefficient estimate of ‘target-preferred’ ($\beta=-0.724$, $p<0.001$)
298 means that making the decoy inferior to the more preferred option (instead of the less preferred
299 one), but keeping its distance from the (new) target similar to the distance from the competitor
300 (low proximity-to-target), results in a greater proportion of attention being allocated to the more

301 preferred option. In fact, when proximity-to-target = 0 and target-preferred = 1, the estimated
302 attention-reversal towards the less preferred option becomes (slightly) negative. This suggests
303 that, given a low proximity-to-target, attention only transfers towards the less preferred option if
304 the decoy is inferior to it rather than to the more preferred option.

305 Most importantly, the significantly negative estimate of ‘proximity-to-target’ ($\beta=-0.082$,
306 $p=0.002$) indicates that, when the decoy is inferior to the less preferred option (target-preferred =
307 0), then the smaller the extent to which it is inferior (and hence the more similar / closer to the
308 target it is relative to competitor), the smaller the transfer of attention towards the (less preferred)
309 target option. Accordingly, the significantly positive estimate of the ‘target-preferred*proximity-
310 to-target’ interaction term ($\beta=0.135$, $p=.006$) indicates that the attention transfer to the less
311 preferred option brought about by targeting it, rather than the more preferred option, with an
312 inferior decoy, is greater when the decoy is more strongly inferior but less similar to the target.
313 This tendency can also be seen in Figure 4, illustrating the regression results, with the highest
314 estimated transfer of attention towards the less preferred option (left panel, warm colours)
315 obtained for decoys that are strongly inferior but not very similar/close to that option.

316 [Figure 4 about here]

317 **The influence of inferiority vs. similarity on choice reversal**

318 To verify if the decoy-induced reversals of attention between the options translated into
319 choice reversals, we estimated a separate mixed model (this time, a binary logit one), with the
320 same fixed and random effects but with ‘choice reversal’ as the dependent variable. The fixed
321 effects estimation results (based on robust covariances) are presented in Table 4, preceded by the
322 raw frequencies of choice reversal (depending on the two independent variables) shown in Table
323 3.

324 [Table 3 about here]

325 [Table 4 about here]

326 In analogy with attention reversal, it seems from Table 3 that the frequency of choice
327 reversal decreases with proximity-to-target when target-preferred = 0 but (in almost all cases)
328 increases with proximity-to-target when target-preferred = 1. Consequently, the difference
329 between the frequency of choice reversal when target-preferred = 1 vs. when target-preferred = 0
330 increases with proximity-to-target. This would suggest that the increase in the likelihood of
331 choosing the less preferred option brought about by targeting it, rather than the more preferred
332 option, with an inferior decoy, is greater when the decoy is more strongly inferior but less similar
333 to the target.

334 Similarly, the regression coefficient estimates shown in Table 4 are all significant and
335 (apart from the intercept) have the same signs as those in Table 2¹. Specifically, we find that,
336 when the decoy is set inferior to the less preferred option (target-preferred = 0), then the smaller
337 the extent to which it is inferior (and hence the larger ‘proximity-to-target’), the smaller the
338 chance of a choice reversal ($\beta=-0.396$, $p<.001$). Additionally, the significantly positive estimate
339 of the ‘target-preferred*proximity-to-target’ interaction ($\beta=0.636$, $p<.001$) indicates that the
340 increase in choice reversal likelihood brought about by targeting it, rather than the more

¹ Note that the fact that the intercept is not significantly different from zero simply means that the probability of choice reversal when target-preferred = proximity-to-target = 0 is not significantly different from ½. As the link function is different in each case and ‘zero’ has a different interpretation, this (null) result does not mean that the current relationship is not consistent with the one estimated in Table 2.

341 preferred option, with an inferior decoy, is greater when the decoy is more strongly inferior but
342 less similar to the target.

343 Given the apparent link between the properties of the decoy on one hand and both
344 attention and choices on the other, it seems natural to consider a model in which both attention
345 reversal and choice reversal are present at the same time. For example, one might wonder
346 whether attention reversal mediates the relationship between the decoy and choice reversal
347 demonstrated in Table 4. However, apart from the technical difficulties of carrying out a
348 mediation analysis within a mixed-model with a continuous mediator and a binary outcome
349 variable, the complex, bi-directional nature of the attention-choice link we mentioned in the
350 introduction is what prevents us from doing so. In particular, it is likely that the properties of the
351 decoy affect, in the first instance, both attention to the choice options and a latent preference
352 towards them. At the same time, the emerging preference is bound to influence attention, and
353 vice versa, until a choice is finally made according to the preference at the time.

354 In Table 5, we present an auxiliary regression, which differs from the one in Table 4 in
355 one feature only – namely that attention-reversal is included as an independent variable. As
356 expected, this suggests a positive link between attention-reversal and preference-reversal
357 ($\beta_{\text{attention-reversal}} = 1.956, p < .001$), while the other coefficient estimates are similar to those in Table
358 4. Although this might suggest that attention does not mediate the link between the decoy and
359 choices, one should interpret the results of the model in Table 5 with caution, due to the fact that
360 attention-reversal and choice-reversal may be co-determined by the latent preference variable
361 that is omitted from the model, and the resulting endogeneity problem could bias the regression
362 estimates.

363 Despite the lack of a straightforward causal relationship between attention and choice, we
364 believe that our results so far suggest that the link between them could potentially be exploited
365 for predictive purposes. In particular, we now explore the possibility of predicting, based on
366 attention to the choice options in the matching trial, whether or not a choice reversal has taken
367 place.

368 **Detecting choice reversals based on eye-data**

369 Our aim here was to check if it is possible to use eye-data to detect choice reversals ex-
370 post, i.e. to determine whether or not a subject who chose the target did so because of or
371 regardless of the decoy. While not central to our hypothesis regarding the attentional mechanism
372 underlying the attraction effect, this analysis could have important practical implications. If
373 successful, it would indicate, for example, that online retailers might in the future use their
374 customers' increasingly easy to obtain eye-data (e.g. from smartphone cameras) to determine if
375 decoys that they deployed actually change the choices of individual consumers. For example,
376 suppose that a retailer wants to establish which 'types' of consumers (say, those who spent a lot
377 at its online store in the past vs. those who did not) are most susceptible to the attraction effect
378 and can be influenced by decoys. Suppose further that a similar fraction of consumers in each
379 group who were exposed to decoys have nevertheless opted for the competitor options, i.e. were
380 clearly not influenced. However, those 'low-spenders' who chose the target tended to focus their
381 attention on it while ignoring the decoy and the competitor. In contrast, the 'high-spenders' who
382 chose the target tended to look at the competitor and the decoy a lot more. Should the retailer
383 conclude that both groups were similarly influenced by the decoy, or perhaps the 'high-spenders'
384 were more strongly influenced but also liked the target options less in the first place, giving rise
385 to a similar overall proportion of target purchases? While such questions could eventually be

386 answered by continued experimentation with product offerings and analysing the aggregate sales,
387 using eye-data could potentially help to more quickly determine which individual consumers'
388 choices were successfully altered.

389 With such practical applications in mind, we wished to verify if the prediction of choice
390 reversals from attention measures can be done 'out of sample', based on a model estimated on data
391 obtained from other people (e.g. through market research). Hence, we conducted a cross-validation
392 procedure using data from those matching trials in which the target was chosen.

393 To predict choice reversals, we used a mixed effects logistic regression model with
394 random subject intercept, 'choice reversal' as a dependent variable, and the proportional
395 attention to the competitor and target (computed as a fraction of total fixation time) being the two
396 independent variables (the proportional attention to decoy was thus redundant and not included).
397 In Table 6, we report the model estimated for the entire sample of 68 subjects. This indicates that
398 increased attention to the competitor (not chosen by the subject) is associated with an increased
399 likelihood that the competitor has been chosen in the initial trial, i.e. that a choice reversal has
400 taken place ($\beta_{\text{attention-to-competitor}} = 8.085, p = .001$). However, this effect is weaker when attention
401 to the chosen target bundle is larger, which means, for a given attention-to-competitor, that
402 attention to the decoy is smaller ($\beta_{\text{attention-to-competitor*attention-to-target}} = -6.935, p = .048$). In other
403 words, the choice is more likely to have been altered by the decoy when attention to both the
404 decoy and the competitor is large, perhaps indicating a preference for the competitor that is
405 'suppressed' by the decoy.

406 Moving on to the actual cross-validation procedure, for each subject, we estimated the
407 same model as the one in Table 6, but using data from the remaining 67 subjects. In each case,

408 we then used the model to estimate the choice reversal likelihood in the choice trials of the one
409 subject whose data we set aside.

410 Having saved the cross-validated regression scores estimated for each subject, we then
411 conducted a signal detection analysis to evaluate the overall out-of-sample predictive power. In
412 particular, for each cross-validation fold, we computed a receiver operating characteristic curve
413 (ROC) that combines all possible false positive – sensitivity pairs (points) that would obtain
414 depending on where we set the threshold value of choice reversal likelihood estimated by the
415 regression model above which a prediction of a choice reversal is made. For instance, a retailer
416 may take a ‘liberal’ approach and judge as effective all those decoys it used where the estimated
417 choice reversal likelihood is not extremely low. In contrast, a ‘conservative’ retailer might stop
418 using all decoys that do not achieve a high choice reversal likelihood. The total area under the
419 ROC (‘AUC’) is a measure of the overall signal detection power, and the overall potential of
420 eye-data to inform such decisions across all possible threshold values. Formally, the AUC is
421 equivalent to the probability that the likelihood of choice reversal estimated for a randomly
422 chosen trial in which choice reversal occurs is higher than for a randomly chosen trial in which it
423 does not occur, and it is also equal to the value of the corresponding Wilcoxon-Mann-Whitney
424 test statistic.

425 In our case, we found the mean AUC to be equal to 0.62, with a 95% Confidence Interval
426 [.579; .663], obtained using the method of computing confidence intervals for cross-validated
427 AUC estimates for pooled repeated measures data sets developed by LeDell, Petersen, and van
428 der Laan (2015). Thus, the mean AUC was significantly above the chance level of 0.5 (whereby
429 a choice reversal is predicted by chance in a given fixed proportion of cases).

430

431

Discussion

432 Although several theories (Roe et al., 2001; J. S. Trueblood et al., 2014, and others
433 outlined in the introduction) pointed to attention transfers as a key mechanism behind the
434 attraction effect, little or no process tracing evidence to support this role of attention has been
435 provided so far. Similarly, while recent work has examined other context effects in non-
436 hypothetical choices (Pinger, Ruhmer-Krell, & Schumacher, 2016), research on the attraction
437 effect has been predominantly based on hypothetical ones.

438 The present experiment combined eye-tracking and real economic consequences of
439 choices in a spatial grid design that allowed subjects to identify and assess both similarity and
440 inferiority relationships between choice options with similar ease. The relative strength of these
441 two relationships could be quantified, manipulated, and was included in the regression models as
442 an explanatory variable. The aim was to investigate whether the failure to replicate the attraction
443 effect under pictorial rather than abstract choice visualization could be explained by the fact that
444 the abstract choice presentation makes the inferiority relationship between the decoy and target
445 salient, while the pictorial presentation emphasizes their similarity.

446 We found that attention is transferred from one's more preferred choice option to the less
447 preferred one if a decoy option is set inferior to the less preferred option (rather than the more
448 preferred one). Crucially, this transfer of attention was stronger when the decoy was less similar
449 and hence more inferior relative to the target, suggesting that inferiority rather than similarity is
450 key for the attentional spotlight effect to occur.

451 What makes this result particularly compelling is that the spatial grid presentation of
452 choices made similarity easy to perceive by virtue of it being represented by visual proximity.
453 Existing eye-tracking research suggests that objects that are close to each other are more likely to

454 be seen as a group and tend to attract more attention (Kimchi et al., 2016). Thus, one would
455 expect a greater transfer of attention to the target if the decoy is more similar and closer to it. The
456 fact that a significant opposite tendency occurs indicates that the ‘attentional spotlight’ due to the
457 decoy’s inferiority to the target must be strong, as we see decoys that are further away but more
458 inferior to the target result in more attention being allocated to the latter.

459 Importantly, the decoy-induced transfer of attention seems well aligned with choice
460 reversals, as we found that these are more likely if a decoy is set inferior to one’s less preferred
461 option but further away from it, so that it is less similar but more inferior relative to the target. In
462 other words, the circumstances that increase the attentional transfer also make choice reversals
463 more likely.

464 It has been argued that the attraction effect might not replicate due to the heterogeneity of
465 subjects’ preferences artificially reducing its aggregate measures in between-subject designs
466 (Simonson, 2014). For instance, some people might be repulsed rather than attracted by the
467 decoy, while others might be unaffected due to strong preferences (Farmer, Warren, El-Deredy,
468 & Howes, 2016) or a clinical condition (Farmer, Baron-cohen, & Skylark, 2017). In the words of
469 Huber et al. (2014), ‘because of heterogeneity in our goals and search experiences, it may be
470 difficult to identify whether uncovering dominance altered a decision; [...] more work in eye
471 tracking and neuroscience is needed to detect the impact of idiosyncratic dominance on choice’.
472 Our use of eye-tracking combined with mixed-models addresses these issues and demands in two
473 ways. First, the fact that we obtain significant results while allowing for random intercept and
474 slope effects suggests that the overall effect of the decoy’s similarity vs. inferiority to target is
475 strong relative to the between-subject variation in this respect. In other words, the overall effect
476 is significant even after accounting for subject heterogeneity. Additionally, thanks to the

477 repeated-measures design, we are able to identify the attentional patterns accompanying choice
478 reversals at an individual subject level, and to determine the within-subject effect of similarity
479 vs. inferiority on both attention and choice. We found that these effects are considerable, ranging
480 from an attraction towards the target for low proximity to target, to ‘repulsion’ at the other
481 extreme (see Table 1 and Table 3, as well as Frederick et al., 2014).

482 To further underline the link between attention and choice reversal, we also wished to
483 investigate if it is possible to predict if a decoy actually induced a change in a subject’s
484 preferences in a given matching trial in which a target was chosen, based solely on how the
485 subject visually examined the available options. In other words, on the basis of how attention
486 was distributed between the decoy, the target and the competitor, we would like to predict if the
487 target has been selected because of or irrespective of the decoy, i.e. if the target would also have
488 been chosen had the decoy been absent.

489 The reason why we thought that this might be possible is as follows. If the decoy was set
490 inferior to the subject’s preferred option (i.e. there was no choice reversal), then it would have
491 only reinforced the subject’s tendency to look at the chosen target bundle as the more attractive
492 option. In contrast, if the target was the less preferred option (i.e. a choice reversal occurred),
493 then the decoy would have artificially inflated attention to the target, but attention to the option
494 that was not chosen might still be substantial due to it being the subject’s more preferred bundle.
495 Thus, we would expect attention to the option that was not chosen to have been higher in case of
496 choice reversal than in those cases when it does not occur, and this should make it possible to
497 ‘diagnose’ choice reversals from eye-data.

498 Indeed, following a cross-validation procedure, we obtained an ‘out-of-sample’
499 classification accuracy that was significantly above chance. This further points to the role of

500 attention in choice reversal, since, given a set of options and an observed choice, the way in
501 which attention was distributed is indicative of whether the choice in question has been affected
502 by the decoy option. It is also a fact that could, in the future, be used in the evaluation of the
503 effectiveness of decoys deployed as marketing tools. Similarly, or in further research of context
504 effects.

505 **Scope and Limitations**

506 Despite the novelty of using eye-tracking and non-hypothetical choices to study the
507 attraction effect, we must acknowledge certain limitations in the extent to which the results
508 would generalize beyond the present experimental framework. In particular, our presentation of
509 the choice trials as a spatial grid was different from both the abstract numerical and the pictorial
510 presentation used in previous studies. We thought that the spatial grid might, from the subjects'
511 point of view, resemble a real-world retail setting in which goods are arranged on shelves with
512 similar products located close together. Nevertheless, one might argue that similarity measured
513 as the distance in the space of product attributes is not the same as one between, say, a fresh vs. a
514 spoiled apple (i.e., as in the studies with pictorial presentation). The fact that, in our setting,
515 similarity is correlated with visual proximity could potentially cause artefacts, such as attention
516 switching from decoy to target merely due to the ease of transferring gaze over a short distance,
517 or indeed result in eye fixations on the decoy being incorrectly registered as ones on a similar
518 and spatially close target. Fortunately, the effect we have found is in the opposite direction, with
519 more attention on the target registered when the decoy is further away from it. Nevertheless,
520 future research might verify if it would still persist if the choice options were presented in a more
521 conventional manner, which would have the additional advantage of facilitating comparisons
522 with previous literature.

523 A separate issue is the within-subjects design, and the fact that subjects would first
524 choose without and then with a decoy being present. This was to identify their ‘true’ preference,
525 undistorted by any current or previous exposure to decoys. However, it may have been that the
526 initial binary choice in some way influenced the choice in the later, matching trial, despite the
527 presence of the distractor tasks.

528 Similarly, the subjects may have noticed a pattern in the matching trials, where one of the
529 options (decoy) was always inferior compared to the target, potentially generating experimenter
530 demand effects (though the chance of this happening is reduced by the fact that the choices were
531 incentivized, and whether the experimenter would demand a choice of the target or the
532 competitor could not have been apparent to subjects). These problems could be addressed in
533 future research, perhaps via more unobtrusive, indirect ways of establishing preferences. Our
534 results on detecting choice reversals from eye-data could provide some guidance as to how this
535 might be achieved.

536 Overall, our results are consistent with and shed light on the abstract vs. pictorial
537 discrepancy reported by previous studies, which may indeed be due to the abstract representation
538 of the choice options making the inferiority relationship between decoy and target salient, and
539 the pictorial one highlighting their similarity instead, thus weakening the attraction effect. On the
540 other hand, the fact that inferiority rather than similarity is crucial for the attentional spotlight to
541 be cast by the decoy on the target can be contrasted with what is postulated by existing theories
542 (Roe et al., 2001; Trueblood et al., 2014, and others), which generally assume that similarity is
543 required for inferiority of the decoy to have an effect. Because of both the novelty and
544 limitations of our experiment design discussed above, it is too early to say if the assumptions
545 about the role of attention present in existing accounts of the attraction effect should be revised.

546 At the same time, the effect was, in the past, demonstrated in various and often unusual settings
547 (e.g. Shafir, Waite, & Smith, 2002; J. Trueblood, Brown, Heathcote, & Busemeyer, 2013). In
548 line with this tradition, our work can be seen as extending the set of circumstances in which
549 attraction occurs, as well as documenting the underlying attentional patterns.

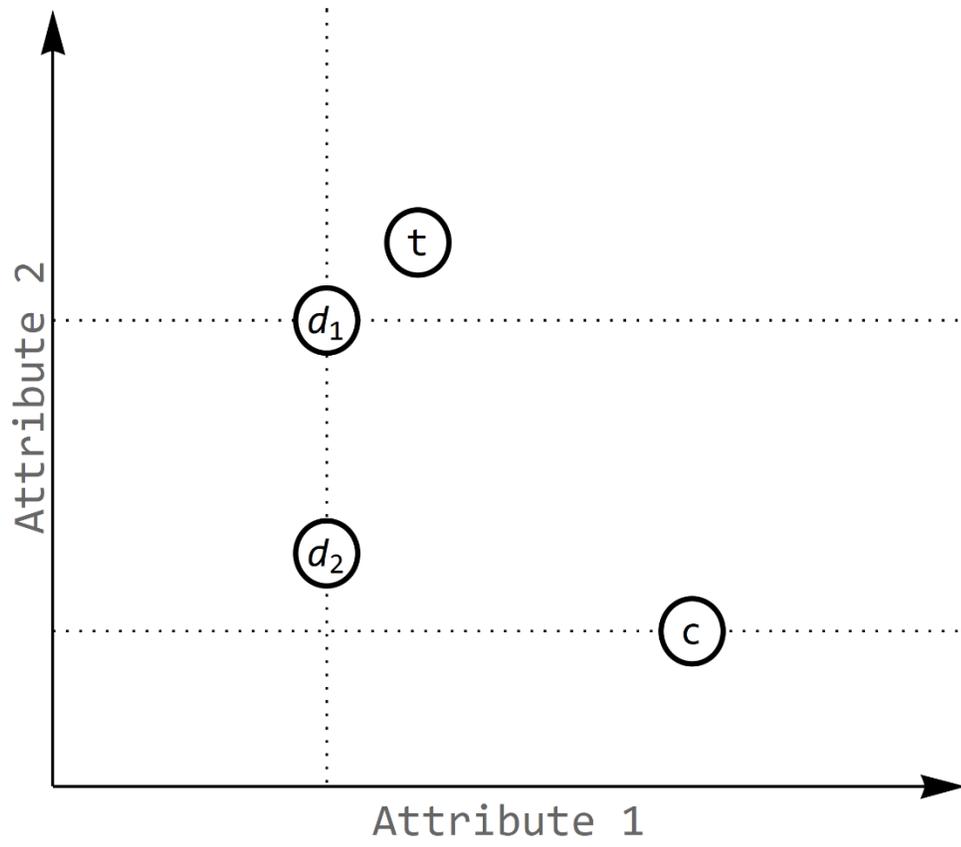
550 **Conclusions**

551 The present study was the first one to investigate the attentional correlates of decoy-
552 induced choice reversals on an individual-trial level, and one of the very few studies of the
553 attraction effect involving non-hypothetical choices. Combining a repeated-measures design with
554 a mixed model analysis of the data allowed for a precise identification of how the attributes of
555 the decoy vis-à-vis those of the target influence the transfer of attention towards the latter and the
556 likelihood of a choice reversal.

557 In particular, we found that a decoy does indeed draw attention towards its target and
558 away from the competitor, but that this effect is reduced as the decoy becomes more similar and
559 hence less strongly inferior relative to the target. We also found that the same circumstances also
560 reduce the choice reversal likelihood.

561 Our results suggest that it is the inferiority, rather than similarity of the decoy to target
562 which drives the attraction effect. This could help explain the discrepancy of results in studies
563 with abstract vs. pictorial representation of the choice options, because the former makes
564 inferiority salient, while the latter tends to emphasize similarity.

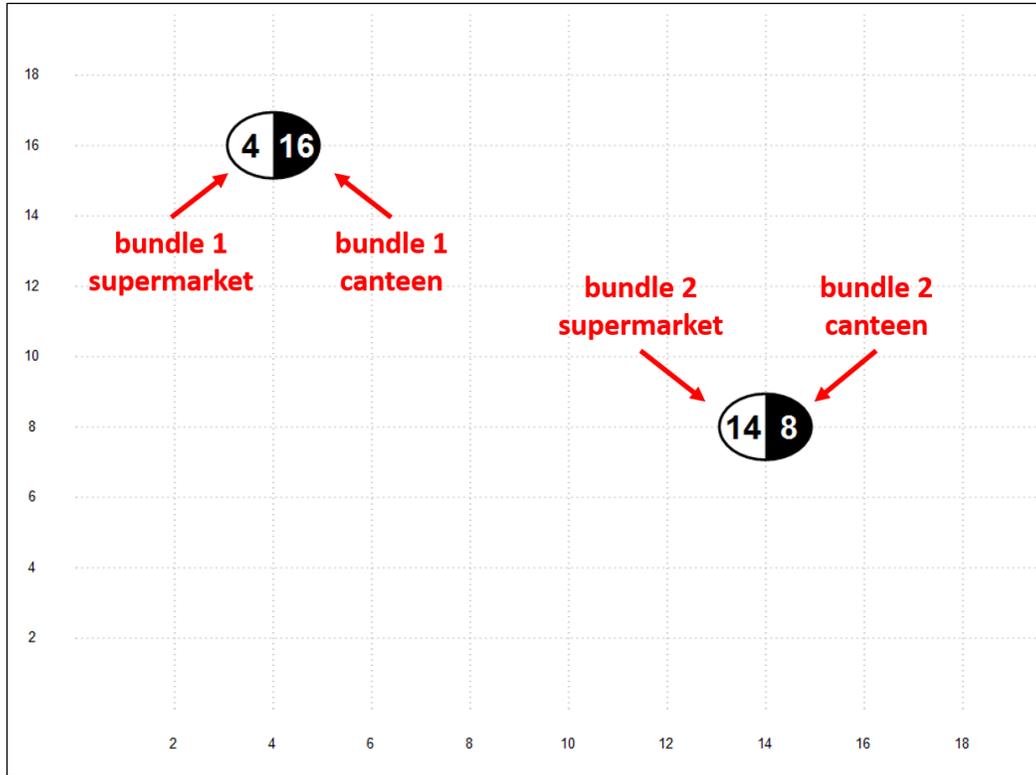
565 To further underline the link between choice reversal and attention, we showed that,
566 based on how a person looked at the available options, it is possible to predict if the presence of
567 the decoy influenced the observed choice. This suggests that eye-data could be used in the
568 assessment of marketing strategies and in the further research of context effects.



569

570

Figure 1. An example choice-problem.



571

572 Figure 2. Example choice screen shown to subjects (subjects do not see the red captions); the
 573 placement of canteen vs. supermarket voucher values within the disks and in the X-Y space was
 574 flipped for half of the subjects.

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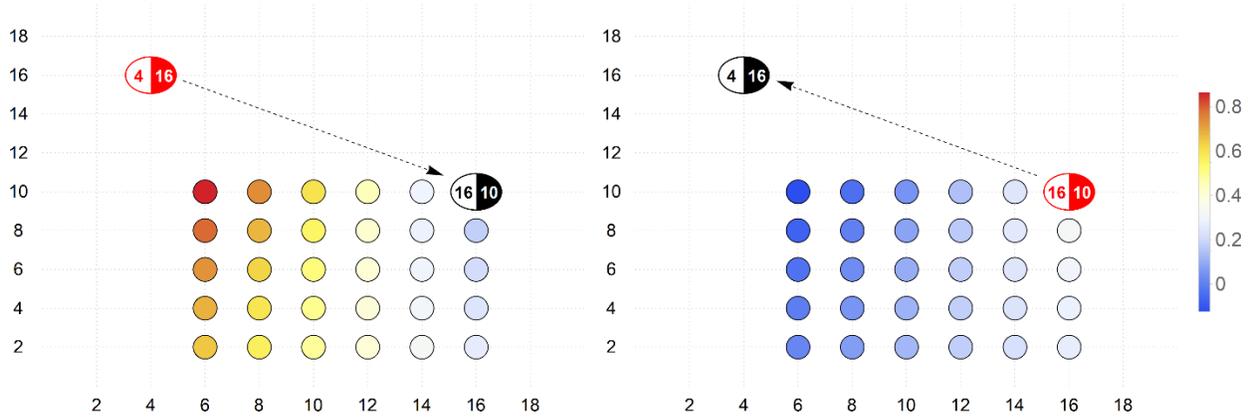
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Figure 3. Example distractor task screen shown to subjects



579

580 Figure 4. Illustration of the estimated regression model of attention reversal. In the example
 581 shown in the left panel, the top-left of the two bundles (in red) is the ‘preferred’ one (chosen in
 582 the initial trial). The coloured circles represent the potential locations of decoy bundles targeting
 583 the ‘not-preferred’, bottom-right bundle (in black). The colour of each circle represents the value
 584 of attention reversal, i.e. the extent to which attention is transferred towards the ‘not-preferred’
 585 bundle (in the direction indicated by the arrow). The value of attention
 586 reversal is obtained from the estimated regression for the value of proximity-to-target calculated
 587 for the given decoy location and target-preferred = 0. In the right panel, the analogous attention
 588 reversal is shown in the opposite case of the bottom-right bundle having been chosen in the
 589 initial trial (in this case, target-preferred = 1).

590

591 Table 1. Average attention reversal (across all subjects and trials) depending on the values of
 592 ‘target-preferred’ (1 = decoy inferior to the option chosen in the initial trial) and ‘proximity-to-
 593 target’ (relative to the competitor).

average attention reversal		
proximity-to-target	target-preferred	
	0	1
$(-\infty, 0]$	.792	.142
$(0, 2]$	.566	.005
$(2, 3]$	.508	-.009
$(3, 4]$	.463	.192
$(4, 6]$	.259	.430
$(6, \infty)$	.126	.389

594

595 Table 2. Coefficient estimates of a mixed-effects model of attention reversal between the matching
 596 and initial trial, modeled as a function of whether the target was set to the option preferred in the
 597 initial trial and of the proximity/similarity of the decoy to the target relative to the competitor.

attention reversal between matched trials (N = 1443)						
fixed effects						
	β	SE	t	p	95% CI	
					Lower	Upper
intercept	0.702	0.113	6.231	<.001*	0.481	0.924
target-preferred	-0.724	0.138	-5.264	<.001*	-0.994	-0.454
proximity-to-target	-0.082	0.026	-3.154	.002*	-0.133	-0.031
target-preferred *proximity-to-target	0.135	0.048	2.790	.006*	0.040	0.230
(*significant at p < .05)						
random effects						
	variance		correlation m.			
intercept	0.294					
target-preferred	0.342		-0.98			
proximity-to-target	0.008		-0.99		0.98	
target-preferred *proximity-to-target	0.056		0.84		-0.94 -0.84	

598

599 Table 3. The frequency of choice reversal (across all subjects and trials) depending on the values
 600 of 'target-preferred' and 'proximity-to-target'.

frequency of choice reversal		
proximity-to-target	target-preferred	
	0	1
$(-\infty, 0]$	.385	.100
$(0, 2]$	.305	.128
$(2, 3]$	.209	.160
$(3, 4]$	.159	.227
$(4, 6]$	.128	.406
$(6, \infty)$	.100	.214

601

602 Table 4. Coefficient estimates of a mixed-effects model of the likelihood of choice reversal
 603 between the matching and initial trial, modeled as a function of whether the target was set to the
 604 option preferred in the initial trial and of the proximity/similarity of the decoy to the target
 605 relative to the competitor.

choice reversal between matched trials (N = 1443)						
	β	SE	t	p	95% CI	
					Lower	Upper
intercept	-0.369	0.241	-1.535	.125	-0.841	0.103
target-preferred	-1.801	0.305	-5.897	<.001*	-2.400	-1.202
proximity-to-target	-0.396	0.067	-5.888	<.001*	-0.529	-0.264
target-preferred *proximity-to-target	0.636	0.100	6.345	<.001*	0.440	0.833

(*significant at p < .05)

random effects			
	variance	correlation m.	
intercept	1.277		
target-preferred	0.502	-0.96	
proximity-to-target	0.058	-0.50	0.71
target-preferred *proximity-to-target	0.108	0.88	-0.98 -0.85

606

607 Table 5. Coefficient estimates of a mixed-effects model of the likelihood of choice reversal
 608 between the matching and initial trial, based on the same specification as the one in Table 4, but
 609 with attention-reversal added as an independent variable.

choice reversal between matched trials						
	β	SE	t	p	95% CI	
					Lower	Upper
intercept	-1.932	0.303	-6.366	<.001*	-2.527	-1.337
target-preferred	-1.393	0.442	-3.154	.002*	-2.260	-0.527
proximity-to-target	-0.447	0.094	-4.777	<.001*	-0.630	-0.263
target-preferred *proximity-to-target	0.688	0.148	4.660	<.001*	0.398	0.977
attention-reversal	1.956	0.132	14.819	<.001*	1.697	2.215
(*significant at $p < .05$)						
random effects						
	variance	correlation m.				
intercept	3.035					
target-preferred	1.339	-0.87				
proximity-to-target	0.095	-0.46	0.54			
attention-reversal	0.186	-0.21	-0.28	-0.30		
target-preferred *proximity-to-target	0.242	0.81	-0.87	-0.87	0.23	

610 Table 6. Coefficient estimates of a mixed-effects logistic regression model of the likelihood of
 611 choice reversal between the matching and initial trial, for matching trials in which the target was
 612 chosen, modeled as a function of proportional attention (fixation time) to the competitor and the
 613 target in the matching trial.

choice reversal between matched trials						
	β	SE	t	p	95% CI	
					Lower	Upper
intercept	-2.792	1.102	-2.533	.012*	-4.955	-0.628
attention-to-competitor	8.085	2.338	3.458	.001*	3.495	12.674
attention-to-target	1.339	1.315	1.019	.309	-1.242	3.920
attention-to-competitor *attention-to-target	-6.935	3.530	-1.964	.048*	-13.869	-0.005

(*significant at $p < .05$)

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Methodological Detail Appendix

The stimulus presentation software was programmed in Wolfram Mathematica. Each subject was seated at a computer terminal, operating Microsoft Windows 8, with a 15.4-inch screen with resolution set to 1280x720, and a SensoMotoric Instruments RED250 mobile eye-tracking device attached underneath the screen and set to 250Hz frequency. Prior to the commencement of the study, we conducted a standard five-point semi-automatic calibration and validation procedure (the average deviation was below 0.5° for all subjects). Each trial was preceded by a fixation cross, and subjects chose their preferred choice option using keyboard or mouse. A headrest was used to stabilize the head position and ensure that the distance between the subject’s eyes and the device was approximately 65cm. We used the SMI Vision high-speed fixation detection algorithm with standard settings (minimum fixation duration = 50ms, peak saccade velocity threshold 40 °/s). All studies were approved by the local Faculty Research Ethics Committee.

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References

Ahn, S., Kim, J., & Ha, Y.-W. (2015). Feedback weakens the attraction effect in repeated choices. *Marketing Letters*, 26(4), 449–459. <https://doi.org/10.1007/s11002-014-9281-6>

Ariely, D., & Wallsten, T. S. (1995). Seeking Subjective Dominance in Multidimensional Space: An Explanation of the Asymmetric Dominance Effect. *Organizational Behavior and Human Decision Processes*, 63(3), 223–232. <https://doi.org/10.1006/obhd.1995.1075>

Ashby, N. J. S., Jekel, M., Dickert, S., & Glöckner, A. (2016). Finding the right fit: A comparison of process assumptions underlying popular drift-diffusion models. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 42(12), 1982.

Bhatia, S. (2013). Associations and the accumulation of preference. *Psychological Review*, 120(3), 522.

Bjork, R. A., & Whitten, W. B. (1974). Recency-sensitive retrieval processes in long-term free recall. *Cognitive Psychology*, 6(2), 173–189.

Bordalo, P., Gennaioli, N., & Shleifer, A. (2013). Saliency and Consumer Choice. *Journal of Political Economy*, 121(5), 803–843. <https://doi.org/10.1086/673885>

Cubitt, R. P., Starmer, C., & Sugden, R. (1998). On the Validity of the Random Lottery Incentive System. *Experimental Economics*, 1, 115–131.

Farmer, G. D., Baron-cohen, S., & Skylark, W. J. (2017). People With Autism Spectrum Conditions Make More Consistent Decisions. <https://doi.org/10.1177/0956797617694867>

Farmer, G. D., Warren, P. A., El-Deredy, W., & Howes, A. (2016). The Effect of Expected Value on Attraction Effect Preference Reversals. *Journal of Behavioral Decision Making*. <https://doi.org/10.1002/bdm.2001>

Frederick, S., Lee, L., & Baskin, E. (2014). The Limits of Attraction. *Journal of Marketing*

653 *Research*, 51(4), 487–507. <https://doi.org/10.1509/jmr.12.0061>

654 Hedgcock, W. M., Rao, R. S., & Chen, H. A. (2016). Choosing to Choose: The Effects of
655 Decoys and Prior Choice on Deferral. *Management Science*, 1909, 1–25.
656 <https://doi.org/10.1287/mnsc.2015.2289>

657 Hedgcock, W., Rao, A. R., & Chen, H. (Allan). (2009). Could Ralph Nader’s Entrance and Exit
658 Have Helped Al Gore? The Impact of Decoy Dynamics on Consumer Choice. *Journal of*
659 *Marketing Research*, 46(June), 330–343. <https://doi.org/10.1509/jmkr.46.3.330>

660 Hu, J., & Yu, R. (2014). The neural correlates of the decoy effect in decisions. *Frontiers in*
661 *Behavioral Neuroscience*, 8, 271. <https://doi.org/10.3389/fnbeh.2014.00271>

662 Huber, J., Payne, J. W., & Puto, C. (1982). Adding Asymmetrically Dominated Alternatives:
663 Violations of Regularity and the Similarity Hypothesis. *Journal of Consumer Research*,
664 9(1), 90. <https://doi.org/10.1086/208899>

665 Huber, J., Payne, J. W., & Puto, C. P. (2014). Let’s Be Honest About the Attraction Effect.
666 *Journal of Marketing Research*, 51(4), 520–525. <https://doi.org/10.1509/jmr.14.0208>

667 Hutchinson, J. W., Kamakura, W. A., & Lynch, J. G. (2000). Unobserved Heterogeneity as an
668 Alternative Explanation for “Reversal” Effects in Behavioral Research. *Journal of*
669 *Consumer Research*, 27(3), 324–344. <https://doi.org/10.1086/317588>

670 Kimchi, R., Yeshurun, Y., Spehar, B., & Pirkner, Y. (2016). Perceptual organization, visual
671 attention, and objecthood. *Vision Research*, 126, 34–51.
672 <https://doi.org/https://doi.org/10.1016/j.visres.2015.07.008>

673 Krajbich, I., Armel, C., & Rangel, A. (2010). Visual fixations and the computation and
674 comparison of value in simple choice. *Nature Neuroscience*, 13(10), 1292–8.
675 <https://doi.org/10.1038/nn.2635>

676 Król, M., & Król, M. E. (in press). Learning from Peers' Eye Movements in the Absence of
677 Expert Guidance: a Proof of Concept Using Laboratory Stock Trading, Eye Tracking, and
678 Machine Learning. *Cognitive Science*.

679 LeDell, E., Petersen, M., & van der Laan, M. (2015). Computationally efficient confidence
680 intervals for cross-validated area under the ROC curve estimates. *Electronic Journal of*
681 *Statistics*, 9(1), 1583–1607. <https://doi.org/10.1214/15-EJS1035>

682 Li, V., Michael, E., Balaguer, J., Herce Castañón, S., & Summerfield, C. (2018). Gain control
683 explains the effect of distraction in human perceptual, cognitive, and economic decision
684 making. *Proceedings of the National Academy of Sciences*, 115(38), E8825--E8834.
685 <https://doi.org/10.1073/pnas.1805224115>

686 Lichters, M., Bengart, P., Sarstedt, M., & Vogt, B. (2017). What really matters in attraction
687 effect research: when choices have economic consequences. *Marketing Letters*, 28(1), 127–
688 138. <https://doi.org/10.1007/s11002-015-9394-6>

689 Lichters, M., Sarstedt, M., & Vogt, B. (2015). On the practical relevance of the attraction effect:
690 A cautionary note and guidelines for context effect experiments. *AMS Review*, 5(1–2), 1–19.
691 <https://doi.org/10.1007/s13162-015-0066-8>

692 Lleras, J. S., Masatlioglu, Y., Nakajima, D., & Ozbay, E. Y. (2017). When more is less: Limited
693 consideration. *Journal of Economic Theory*, 170, 70–85.
694 <https://doi.org/10.1016/j.jet.2017.04.004>

695 Malkoc, S. A., Hedgcock, W., & Hoeffler, S. (2013). Between a rock and a hard place: The
696 failure of the attraction effect among unattractive alternatives. *Journal of Consumer*
697 *Psychology*, 23(3), 317–329.

698 Meier, B. P., & Robinson, M. D. (2004). Why the Sunny Side Is Up: Associations Between

699 Affect and Vertical Position. *Psychological Science*, 15(4), 243–247.
700 <https://doi.org/10.1111/j.0956-7976.2004.00659.x>

701 Mogilner, C., Rudnick, T., & Iyengar, S. S. (2008). The Mere Categorization Effect: How the
702 Presence of Categories Increases Choosers' Perceptions of Assortment Variety and
703 Outcome Satisfaction. *Journal of Consumer Research*, 35(2), 202–215.
704 <https://doi.org/10.1086/588698>

705 Mohr, P. N. C., Heekeren, H. R., & Rieskamp, J. (2017). Attraction Effect in Risky Choice Can
706 Be Explained by Subjective Distance between Choice Alternatives. *Scientific Reports*, 7(1).
707 <https://doi.org/10.1038/s41598-017-06968-5>

708 Ok, E. A., Ortoleva, P., & Riella, G. (2015). Revealed (P) Reference Theory. *American*
709 *Economic Review*, 105(1), 299–321. <https://doi.org/10.1161/ATVBAHA.107.161042>

710 Pinger, P., Ruhmer-Krell, I., & Schumacher, H. (2016). The compromise effect in action:
711 Lessons from a restaurant's menu. *Journal of Economic Behavior & Organization*, 128, 14–
712 34. <https://doi.org/https://doi.org/10.1016/j.jebo.2016.04.017>

713 Reutskaja, E., Nagel, R., Camerer, C. F., & Rangel, A. (2011). Search Dynamics in Consumer
714 Choice under Time Pressure: An Eye- Tracking Study. *The American Economic Review*,
715 101(2), 900–926. <https://doi.org/10.1257/aer.101.2.900>

716 Roe, R. M., Busemeyer, J. R., & Townsend, J. T. (2001). Multialternative decision field theory:
717 A dynamic connectionst model of decision making. *Psychological Review*, 108(2), 370.

718 Samek, A., Hur, I., Kim, S.-H., & Yi, J. S. (2016). An experimental study of the decision process
719 with interactive technology. *Journal of Economic Behavior & Organization*, 130, 20–32.
720 <https://doi.org/https://doi.org/10.1016/j.jebo.2016.06.004>

721 Shafir, S., Waite, T., & Smith, B. (2002). Context-dependent violations of rational choice in

722 honeybees (*Apis mellifera*) and gray jays (*Perisoreus canadensis*). *Behavioral Ecology*
723 *and Sociobiology*, 51(2), 180–187. <https://doi.org/10.1007/s00265-001-0420-8>

724 Shimojo, S., Simion, C., Shimojo, E., & Scheier, C. (2003). Gaze bias both reflects and
725 influences preference. *Nature Neuroscience*, 6(12), 1317–1322.
726 <https://doi.org/10.1038/nm1150>

727 Simonson, I. (2014). Vices and Virtues of Misguided Replications: The Case of Asymmetric
728 Dominance. *Journal of Marketing Research*, 51(4), 514–519.
729 <https://doi.org/10.1509/jmr.14.0093>

730 Smith, S. M., Roster, C. A., Golden, L. L., & Albaum, G. S. (2016). A multi-group analysis of
731 online survey respondent data quality: Comparing a regular USA consumer panel to MTurk
732 samples. *Journal of Business Research*, 69(8), 3139–3148.
733 <https://doi.org/https://doi.org/10.1016/j.jbusres.2015.12.002>

734 Trueblood, J., Brown, S., Heathcote, A., & Busemeyer, J. (2013). Not Just for Consumers:
735 Context Effects Are Fundamental to Decision Making. *Psychological Science*, 24(6), 901–
736 908. <https://doi.org/10.1177/0956797612464241>

737 Trueblood, J. S., Brown, S. D., & Heathcote, A. (2014). The Multiattribute Linear Ballistic
738 Accumulator Model of Context Effects in Multialternative Choice.
739 <https://doi.org/10.1037/a0036137>

740 Yang, S., & Lynn, M. (2014). More Evidence Challenging the Robustness and Usefulness of the
741 Attraction Effect. *Journal of Marketing Research*, 51(4), 508–513.
742 <https://doi.org/10.1509/jmr.14.0020>

743