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Increased Visual Attention to Moderate Causes Mitigates the Discounting Effect

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Increased Visual Attention to Moderate Causes Mitigates the Discounting Effect

by

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Abstract

Previous research has demonstrated that people exhibit discounting when presented with two possible causes of an event. That is, when a moderately effective cause is learned about in the presence of a highly effective cause, the efficacy of the moderate cause is underestimated (e.g. Goedert & Spellman, 2005). According to the EXIT model (Kruschke, 2001), people learn which cues in their environment are relevant and shift attention away from non-relevant cues; thus, discounting may involve a "learned inattention." Here, I directly assessed whether forcing individuals to attend to a candidate cause changes their perceptions regarding the cause's effectiveness. Participants simultaneously learned about two potential causes of a common outcome: one moderately effective in producing the outcome (target) and the other either strongly effective, weakly effective or confounded with the target. During encoding of the contingency information, I manipulated participants' visual attention by asking them to perform a secondary peripheral cueing task that directed their attention primarily towards the left or the right. After encoding the contingency information, participants rated the effectiveness of each cause on a numeric scale ranging from -100 to +100. When the target appeared on the right, discounting disappeared, which suggests that discounting may be due in part to an a-priori rightward attentional bias. At the same time, increasing attention to the alternative, confounded cause enhanced participants' propensity to control for that alternative when judging the effectiveness of the target cause.

Introduction

Everyday, humans are confronted with multiple potential causes of various events. For example, perhaps you are suffering from a toothache. You decide to take an aspirin and apply a cold compress. Over time, your toothache subsides. How do you know whether to attribute the pain relief to the aspirin or the cold compress? Having multiple potential causes in the environment does not mean that they all produce the outcome, nor do they have the same predictive strength. In particular, people must account for potential alternative causes of an outcome in order to discover the true relationship between a candidate cause and that outcome (Cheng; 1997; Spellman, 1996a; Spellman, 1996b; Ward & Jenkins, 1965). One basic cognitive process that may play an essential role in causal attribution is how an individual allots attention to potential causes in her environment. Indeed, changes in the distribution of attention affect the acquisition of contingencies in basic learning paradigms (Kruschke, 2001; Kruschke, Kappenman& Hetrick, 2005). What about attention's role in human causal reasoning when we are confronted with multiple potential causes? The goal of this study is to examine the hypothesis that preferentially directing an individual's attention to one of two cues during contingency acquisition will affect that individual's causal inferences.

Causal Inference from Contingency Information

Statistical models of causal reasoning claim that a cause's strength can be determined statistically. For example, in the probabilistic contrast model (Cheng& Novick, 1990), a person can infer the effectiveness of a cause in producing an outcome by determining the difference between the probability of the effect when the cause is present and that when it is absent. A cause is apparent when the P(E) is different in the presence of the candidate cause than in the absence of the candidate cause. When the change in probability (ΔP) is non-zero, there is a covarational relationship (Cheng& Novick, 1990). This is mathematically defined as follows:

$$\Delta P = P(E|C) - P(E|{\sim}C)$$

Here, P(E|C) indicates the probability of the effect given the presence of the cause and P(E|~C) indicates the probability of the effect given the absence of the cause. This model accounts for generative causes (a positive ΔP up to 1), non-causal event (a ΔP equal to 0) as well as inhibitory causes (a negative ΔP up to -1). For example, if there is a 1.0 probability of effect E in the presence of candidate cause C and a zero chance that effect E would occur in the absence of the candidate cause, the equation reflects this: $\Delta P = 1\text{-}0 = 1$. To the contrary, if there is a 1.0 probability of effect E in the presence of the candidate cause and a 1.0 chance that effect E would occur in the absence of the candidate cause, solving for ΔP would yield: $\Delta P = 1\text{-}1 = 0$. In this example, no predictive value is attributable to the candidate cause because the probability of the effect in the presence and in the absence of the cause is equal. The presence of the candidate cause does not increase the probability of the effect. If there is a 0 probability of effect E in the presence of the candidate cause C and a 1.0 chance that effect E would occur in the absence of the candidate cause, the equation is: $\Delta P = 0\text{-}1 = -1$. Here, the candidate cause has an inhibitory effect; when the candidate cause is present, the effect is actually less likely to occur.

	Smoke	No Smoke	
Coffee	15/15	0/5	15/20
No Coffee	5/5	0/15	5/20
	20/20	0/20	

Figure 1. Contingency table detailing the occurrences of lung cancer (numerator) out of the population partaking in smoking and/or coffee drinking behaviors. The marginal totals represent contingencies not taking the alternative cause into account.

Although calculation of ΔP yields information about the contingency between a candidate cause and an effect, correlation does not equal causation. One must control for alternative potential causes when determining whether the covariational relation is also a causal one (Cheng, 1997; Spellman, 1996a; Spellman, 1996b; Ward& Jenkins, 1965). Imagine that a long-term study concluded that drinking coffee increases the likelihood of lung cancer. This claim does not take into account confounding behaviors. Most importantly, the study may have ignored whether or not the participants also smoked. We can utilize this study design to look at different ways to calculate contingency with multiple potential causes (coffee drinking/smoking) of an outcome (lung cancer). Figure 1 depicts a contingency table in which the denominator in each of the ratios represents the number of individuals who did or did not smoke and who did or did not drink coffee and the numerator represents the instances of lung cancer in that group. One way of evaluating the relation between coffee and lung cancer would be to calculate ΔP for coffee drinking while ignoring the alternative cause of smoking. In this instance, we would add across the row for coffee drinkers and non-coffee drinkers to calculate the marginal totals. This calculation reveals that instances of lung cancer in the coffee drinking sample is higher (15/20) than in the non-coffee drinking sample (5/20) ΔP =

15/20-5/20 = 10/20 = .5. This ΔP indicates that drinking coffee has a generative effect. However, this calculation did not take into account another, confounding variable: smoking. To control for the alternative potential cause, one can calculate ΔP for coffee only across those instances in which the alternative cause is absent. Thus, when people drink coffee but do not smoke, the instance of lung cancer is 0/5. When people do not drink coffee and also do not smoke, the instance of lung cancer is 0/15. When controlling for this confounding variable, ΔP changes: 0/5-0/15 = 0. Now that the alternative potential cause is taken into account, the contingency between coffee drinking and lung cancer is 0. Experimental evidence suggests that people do indeed control for alternative causes (Spellman, 1996a) and some authors speculate that they do so by focusing on events in which alternative causes of the outcome are absent (Cheng & Holyoak, 1995; Melz, Cheng, Holyoak & Waldmann, 1993).

Discounting

Although people control for alternative potential causes, not all observations in this field conform to statistical models. When participants assess multiple candidate causes, one phenomenon they demonstrate is discounting. In discounting, when learning about two potential causes of a common event, the presence of a highly effective cause often reduces the perceived efficacy of a moderately effective one (Goedert & Spellman, 2005; Baker, et al, 1993; Busemeyer, Myung & McDaniel, 1993). Accounting for a second, confounding cause may lead a person to reduce their judgments of a moderately effective target, but such a reduction in the judgments of a moderately effective target sometimes occur when two causes are not confounded. Figure 2 displays two contingency tables used in experimental designs to assess discounting (Goedert, Harsch

& Spellman, 2005; Goedert & Spellman, 2005). The target cause in both cases is moderately effective with a contingency of .33; that is, the cause increases the probability of the outcome by 33%. Unlike our previous example, these two causes are not confounded. This means that the ΔP value when taking the alternative into account (calculating based on the absence of the alternative cause) and not controlling for the alternative (using the marginal totals) is the same. Table 1 displays participants' ratings of the target and alternative in both conditions (Goedert & Spellman, 2005). When comparing the mean causal ratings of the target between conditions, participants rated the target as less causal when there was a strong alternative cause present than when there was a weak alternative cause present. This result is an example of discounting.

STRONG ALTERNATIVE INDEPENDENT

		Alternative Present	Alternative Absent	
Target	Present	18/18	6/18	24/36
	Absent	12/18	0/18	12/36
		30/36	6/36	

Not accounting for alternative
Target ΔP = .33
Alternative ΔP = .67

Accounting for alternative
Target ΔP = .33
Alternative ΔP = .67

WEAK ALTERNATIVE INDEPENDENT

		Alternative Present	Alternative Absent	
Target	Present	6/18	6/18	12/36
	Absent	0/18	0/18	0/36
		6/36	6/36	

Not accounting for alternative
Target ΔP = .33
Alternative ΔP = 0

Accounting for alternative
Target ΔP = .33
Alternative ΔP = 0

Figure 2. Contingency tables for two conditions; Strong Alternative Independent and Weak Alternative Independent. In both conditions, the causes are not confounded.

Table 1
Mean ratings and standard errors of the target and alternative causes (Goedert & Spellman, 2005) in Strong Alternative Independent and Weak Alternative Independent conditions.

	Target	Alternative
Strong Alternative	-2.4 (10.5)	43.8 (7.2)
Weak Alternative	37.2 (9.9)	-45.8 (10.8)

Researchers have offered several different possible reasons why discounting occurs. Discounting may result from competition among the causes for associative strength with the outcome (Baker et al, 1993). Some assert that people discount because a secondary cause does not fit into a previously formulated explanation of a first cause and therefore they discount the effectiveness of the second cause (Ahn & Gordon, 1994). Perhaps discounting is due to a general cognitive comparison (Goedert & Spellman, 2005). Simply by having a highly effective cause present, the moderately effective cause is perceived to be less causal by comparison (Valleé-Tourangeau, Baker & Mercier, 1994). Another plausible reason for discounting is that if one strong cause is present, there is a belief that it is unlikely for there to be another strong cause present, so the moderate cause is discounted (Morris& Larrick, 1995; Goedert & Spellman, 2005). If discounting is the product of the learning process, one possible factor in this process is attention. As people learn about two potential causes of the same outcome, there may be systematic shifts in attention between the causes (Kruschke, 2001). These attentional shifts may affect causal judgments. In accordance with this, discounting would involve "learned inattention."

Learned Inattention

According to Kruschke's (2001) EXIT model, by virtue of comparison during the learning process, there will be shifts of attention to more predictive cues. This model asserts that "learned inattention" is the mechanism by which these shifts happen (Kruschke, 2001). Attention is holistic and connected. That is, if attention to one cause increases, then attention to another, simultaneously presented cause must decrease. When learning that a single cue is predictive of a single outcome, attention is undivided.

In this instance, all attention is directed towards the single cue-outcome relationship. When an additional cue is present alongside the original cue, attention is now divided between the two cues. In this model, the predictive value of the original cue is lower due to the split attention. To correct this and return attention allocation to its original state, attention shifts back to the original cue, therefore lowering the attention to the subsequently learned cue. In this theory, people learn to attend to causes that reduce interference with already learned knowledge (Kruschke, 2001). Further, when learning occurs, feedback provides information regarding the cue-outcome relationship. Attention then shifts away from causal cues that have high associative error and towards causal cues that reduce error. From this, there can be adjustment for the strength of the association of attended cues. The goal in the shifting of attention is to reduce attention to cues that create error.

The experimental research of Kruschke (Kruschke, Kappenman& Hetrick, 2005) has also demonstrated that people learn to shift attention away from non-relevant cues. Experimentally, blocking paradigms result in non-relevant cues (Kamin, 1968, 1969). By using the blocking paradigm, one can assess the attentional diffusion away from the blocked (non-relevant) cue. In blocking, participants learn that a cue is associated with an outcome 100% of the time. Then, the original cue and a new cue are presented simultaneously, with the same outcome. People do not learn to associate the new, second cue, with the outcome. Thus, learning of the original cue effectively blocks learning the new cue. In an eyetracking experiment (Kruschke, Kappenman & Hetrick, 2005) participants were shown two cue words with four option response words. When participants clicked on a word response, feedback immediately followed regarding whether or not their response was correct. Through this system of response and feedback, it is possible to block a word cue. The eyetracking component of this experiment indicated that participants shifted their visual attention away from blocked cues. This shift in visual attention may be a reflection of the shift in cognitive attention. Participants did not attribute causal power to the blocked cue and that manifested in diminished amount of visual attention to the blocked cue. The EXIT model accounts for this experimental result and the shifts in attention.

Our own previous research suggests that people tend to shift their visual attention towards items they believe to be more causal (Czarnecki & Goedert, 2008). Kruschke's study utilized phased blocking, in which words appear in different, distinct phases to create blocking. The blocked (first solely presented) and unblocked cues do not appear together until a later phase. Unlike the Kruschke experiment, we did not use a phased blocking paradigm. Instead, we presented two causes simultaneously and participants acquired information about each potential cause's contingency at the same time. In that research, we filmed the eye movements of participants during a causal reasoning task. Participants who discounted spent more time looking at a target cause when presented alongside a weak alternative than when the target cause was presented with a strong alternative. Participants who did not discount showed the opposite pattern. In both cases, this suggests that people direct a greater proportion of their visual attention towards a cue perceived to be more causal. Additionally, most participants displayed an overall rightward attentional bias. Since the visual component of the experiment (computer screen) took place in far space, this bias is consistent with previous research showing rightward attentional biases in far space (Varnava, McCarthy& Beumont, 2002). When the target cause was presented on the right (attentionally biased) side of the screen, most participants did not discount. When the target cause was presented on the left side of the screen, all but one participant exhibited discounting. This result indicates that having the target presented in the biased side of space (thus receiving more visual attention) mitigated the discounting effect. Perhaps, by manipulating attention on a trial-by-trial basis, attention can be drawn to one event for a longer proportion of time and similarly induce changes in causal judgment, namely mitigating discounting.

Experiment Rationale

Kruschke and colleagues (2005) have found that blocking of a redundant cause is associated with a decrease in overt visual attention to that blocked cause. Similarly, our previous research indicated that people, when presented with two potential causes, spend more time looking at what is perceived to be more causal (Czarnecki & Goedert, 2008). This eyetracking work assessing the relation between visual attention and perceived causal effectiveness is essentially correlational. It does not tell us whether people spend less time looking at a potential cause because the person already believes the event to be ineffective or whether the person believes the cause to be ineffective because she is spending less time looking at it. In this experiment, I manipulated attention to investigate the causal direction of this relation. The attentional manipulation involved an adaptation of a peripheral cueing paradigm (i.e. Posner, 1980; Jonides, 1980). Peripheral cues have been shown to reduce reaction time to a previously cued spatial location (Lambert, 2000). Research utilizing attentional cues indicates that additional attentional allotment to a particular spatial location enhances its processing (e.g. Bashinski & Bacharach, 1980).

Accordingly, I utilize a non-informative peripheral cue in order to force visual attention to one cause a majority of the time.

In the present study, participants performed a causal reasoning task. Participants assessed the effectiveness of a moderately effective target cause and an alternative cause in one of three conditions: strong alternative independent (SA-Ind), strong alternative confounded (SA-Con), and weak alternative independent (WA-Ind). Participants simultaneously performed a secondary spatial cueing task in which a non-informative peripheral cue oriented participants' attention to one candidate cause 75% of the time. I hypothesize that this induced attention will strengthen the association between that particular cue-outcome relation. I therefore anticipate seeing a shift in causal judgments in favor of the cued cause. This enhanced processing may mitigate the discounting effect. To assess discounting, I compared the numeric ratings of the target in the SA-Ind and WA-Ind conditions. Typically, discounting is observed when participants rate the target as less effective in the SA-Ind relative to the WA-Ind condition. To assess controlling for the alternative, I compared the ratings of the target in the SA-Ind and SA-Con conditions. Typically, controlling for the alternative is observed when participants rate the target as less effective in the confounded condition (SA-Con) relative to the independent condition (SA-Ind). I hypothesized that the attentional cue, when associated with the moderate cause, would eliminate the difference in participants' rating between the SA-Ind and WA-Ind conditions, thereby, eliminating discounting. It is more difficult to anticipate the role of the attentional cue on accounting for the confounded cause. Perhaps increasing attention towards the moderate target in the strong alternative confounded cause will disrupt the participants' ability to account for the alternative cause. If this were the case, I would anticipate increased attention to the target to increase the rating of the target in the SA-Con condition and eliminate the difference between SA-Con and SA-Ind target ratings.

Method

Participants

Two hundred and thirty two undergraduate students from the Psychology Department participant pool at Seton Hall University participated in partial fulfillment of course requirement. All participants had normal or corrected to-normal vision.

Design

The experiment was a 3 x 2 between subjects design with strength of the alternative cause (strong alternative independent [SA-Ind], strong alternative confounded [SA-Con], weak alternative independent [WA-Ind]) and asterisk location (75% left vs. 75% right) as factors. The side of the screen on which the alternative appeared was counterbalanced between participants. The strength of the alternative cause was manipulated by changing the frequency with which the outcome occurred across the different cause combinations (see Figures 3a-3c for contingency tables representing one block of each condition). The primary dependent variable was the perceived effectiveness of each of the two causes, as assessed by a numeric ratings scale from -100 to +100.

A

STRONG ALTERNATIVE INDEPENDENT

Target		Alternative Present	Alternative Absent
	Present	9/9	3/9
	Absent	6/9	0/9

Target ΔP = .33
Alternative ΔP = .67

B

WEAK ALTERNATIVE INDEPENDENT

Target		Alternative Present	Alternative Absent
	Present	3/9	3/9
	Absent	0/9	0/9

Target ΔP = .33
Alternative ΔP = 0

C

STRONG ALTERNATIVE CONFOUNDED

Target		Alternative Present	Alternative Absent
	Present	12/15	0/3
	Absent	3/3	3/15

Not accounting for alternative
Target ΔP = .33
Alternative ΔP = .67

Accounting for alternative
Target ΔP = -.2
Alternative ΔP = .8

Figure 3. Contingency tables of the three conditions in this experiment. In all conditions, the target is held constant at .33. The causes in the SA-Ind and WA-Ind conditions are not confounded.

The target had a contingency of .33 across the SA-Ind and WA-Ind conditions. In the SA-Ind condition, the alternative cause had a contingency of .67. In the WA-Ind condition, the alternative cause had a contingency of .00. In the confounded condition, the target had a conditional contingency of -0.20 and an unconditional contingency of .33. In the confounded condition, the strong alternative had a $\Delta P = .8$ when the target was controlled for but a $\Delta P = .67$ if the target was not controlled for.

Participants' attention was directed primarily to the left or right side of the screen by the asterisk (spatial cue), which either appeared on the right 75% of the time and the left 25% of the time, or vice versa (75% of the time and right 25% of the time). The location of the asterisk was probabilistic rather than deterministic (i.e., the location of the was not completely predictable) so that participants continued to attend to it rather than automatically responding with the location of the asterisk.

Materials & Procedure

Participants tested in small groups of up to four. They first read and signed the informed consent agreement. The remainder of the task (i.e., cover story, directions and stimuli) was delivered on a PC using E-Prime. Participants also read a cover story that explained that they were to rate the effectiveness of several colored liquids in either making plants bloom or in preventing plant blooming. Specifically, the task consisted of viewing pairs of colored liquids poured in different combinations on a plant without a bloom (see Appendix A for a sample stimulus). Participants performed two blocks of 36 prediction trials each and made numeric causal judgments after each block. Each trial represented one occurrence in the contingency table (Figures 3a-3c). Within a block, the trials were presented in a pseudo-random order. When a trial appeared, the participants first responded to the asterisk location. The participant pressed the "L" key if the asterisk appeared on the left side of the screen or pressed the "R" key if the asterisk appeared on the right side of the screen. Next, the participant pressed the "Y" key if she thought the plant would bloom and the "N" key if she thought the plant would not bloom. After the participant entered her prediction, a results screen appeared for 2500ms with feedback regarding whether or not the plant actually bloomed. The asterisk appeared for the duration of the prediction screen, but terminated when the feedback screen appeared. After each block of 36 trials, the participants gave a numeric rating ranging from -100 to 100 for each liquid. Negative one hundred meant the liquid would completely inhibit plant blooming. Positive one hundred meant the liquid was a complete plant fertilizer. Zero meant the liquid had no effect; the plant would bloom regardless of the use of the liquid.

Results

Table 2
Appearance of discounting or accounting for an alternative confounded cause based on target side and cue location for target ratings (a) and trial-by-trial predictions (b).

A

Target on Left	Discounting?	Accounting for Alternative?
Target Cued	Yes	Yes
Alternative Cued	Yes	Yes

Target on Right	Discounting?	Accounting for Alternative?
Target Cued	No	Yes: Less
Alternative Cued	No	Yes: Greater

B

Target on Left	Discounting?	Accounting for Alternative?
Target Cued	Yes	No
Alternative Cued	Yes	Yes

Target on Right	Discounting?	Accounting for Alternative?
Target Cued	No	Yes: Less
Alternative Cued	No	Yes: Greater

I used participants' performance on the asterisk location task as a criterion for inclusion of their data in analyses. Given the simplicity of this task (i.e., reporting the location, left vs. right, of a visually obvious stimulus), a multitude of errors would indicate that the participant was not paying attention during the experiment. Participants with more than three errors in any given block were excluded (n = 12), leaving a total of 220 participants in the study. Tables 2a and 2b reflect observations of discounting and accounting for the alternative cause as well as the relative magnitude of strength of the phenomena in the case of an interaction. These tables summate results of causal ratings (Table 2a) and trial-by-trial predictions (Table 2b) each divided by target side.

All significant results reported here reached an alpha level of $p<.05$. Repeated measures were performed using the MANOVA Pillai's Trace procedure and post-hocs using the Bonferroni correction.

Causal Ratings of Target

Figure 4 depicts the relation between contingency condition, asterisk location and target position. Numeric target ratings are the main measure to assess discounting and accounting for the alternative. As anticipated, participants' causal judgments varied with the target position and to an extent, the asterisk location. A repeated measures MANOVA on the target ratings with block (one, two) as a within subjects factor and contingency (SA-Ind, WA-Ind, SA-Con), asterisk location (left, right), and target position (left, right) as between-subjects factors revealed main effects of contingency condition, $F(2, 219)= 48.9$, $\eta_p^2 = .32$, target position, $F(1, 219)=48.2$, $\eta_p^2 = .19$, and asterisk location, $F(1, 219) = 8.2$, $\eta_p^2 = .038$, as well as a three-way target position by asterisk location by contingency condition interaction, $F(2, 4) = 6.5$, $\eta_p^2 = .06$. Post-hoc analysis revealed that mean ratings (across all target positions and asterisk locations) were statistically higher in the SA-Ind condition ($M = 38.02$, $SE = 3.9$) than in the SA-Con condition ($M = -12.86$, $SE = 3.99$), which indicates that overall, participants accounted for the alternative cause. Mean ratings were directionally higher in the SA-Ind condition ($M = 38.02$, $SE = 3.99$) than in the WA-Ind condition ($M = 31.79$, $SE = 4$), a pattern opposite that of discounting. On average, ratings of the target were higher when the asterisk appeared on the right ($M = 25.53$, $SE = 3.30$) than on the left ($M = 12.52$, $SE = 3.16$). On average, ratings of the target were higher when the target appeared on the right (*M* = 34.85, *SE* = 3.21) than on the left (*M* = 3.11, *SE* = 3.26). However, the three-way interaction tempers the interpretation of these main effects (Figure 4).

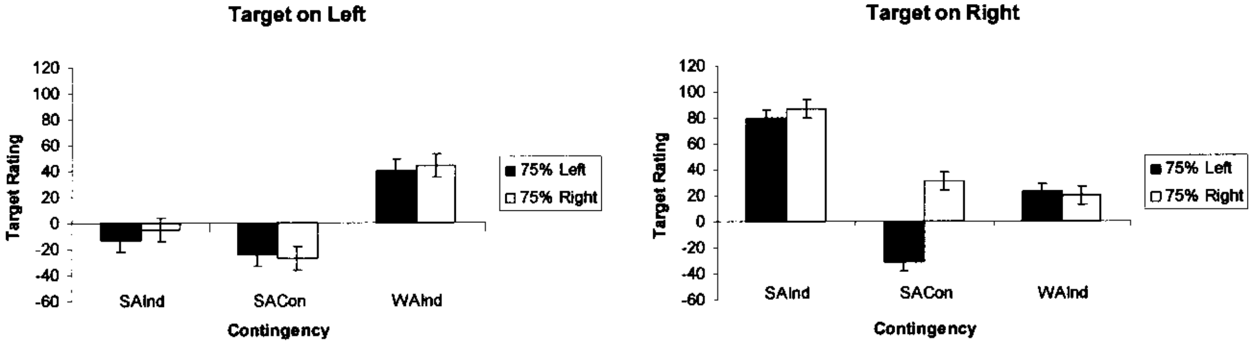

Figure 4. Average causal ratings of the target as a function of target side, contingency condition and asterisk location, averaged across blocks.

Effect of Target Side on Target Rating

The three-way interaction indicates that, across blocks, the effects of the asterisk location and contingency condition differed depending on whether the target appeared on the left or right (Figure 4). When the target appeared on the left side of the computer screen, participants both discounted and accounted for the alternative regardless of whether or not the target was cued. The asterisk location by contingency condition univariate ANOVA revealed a main effect of contingency condition, $F(2, 109) = 31$, $\eta_p^2 = .38$, and no other effects. Participants rated the target as less causal in the SA-Ind condition (*M* = -8.9, *SE* = 6.14) than in the WA-Ind condition (*M* = 41.2, *SE* = 6.39), indicating discounting. Demonstrating accounting for the alternative, the mean target ratings in the SA-Ind condition (*M* = -8.9, *SE* = 6.14) were higher than that in the SA-Con condition (*M* = -25.6, *SE* = 6.3).

When the target was on the right, the asterisk by contingency ANOVA revealed main effects of contingency condition, $F(2, 109) = 79.5$, $\eta_p^2 = .6$, and asterisk location, $F(1, 109) = 15.4$, $\eta_p^2 = .13$, as well as a contingency by asterisk interaction, $F(2, 109) = 12.19$, $\eta_p^2 = .19$. Consistent with the previously observed phenomenon (Czarnecki & Goedert, 2008), when the target was on the right side of the computer screen, participants did not discount. Mean target ratings in the SA-Ind condition (*M* = 83.3, *SE* = 4.79) were actually higher than those in the WA-Ind condition (*M* = 21.37, *SE* = 4.92). However, participants still controlled for the alternative cause: mean target ratings in the SA-Ind condition (*M* = 83.3, *SE* = 4.79) were higher than in the SA-Con condition (*M* = -.13, *SE* = 4.97). Again, these main effects are tempered by the significant interaction between asterisk location and contingency. The simple main effect of contingency condition revealed that participants did not discount when the asterisk was on the left. Mean target ratings were significantly higher in the SA-Ind condition (*M* = 79.57, *SE* = 6.79) than in the WA-Ind condition (*M* = 22.63, *SE* = 6.96). Participants also accounted for the alternative; mean target ratings were higher in the SA-Ind condition (*M* = 79.57, *SE* = 6.79) than in the SA-Con condition (*M* = -30.94, *SE* = 7.34). When the asterisk was on the right, participants also did not discount; mean target ratings were higher in the SA-Ind condition (*M* = 87.03, *SE* = 6.69) than in the WA-Ind condition (*M* = 20.12, *SE* = 6.87). Participants did account for the alternative; mean target ratings were higher in the SA-Ind condition (*M* = 87.03, *SE* = 6.69) than in the SA-Con condition (*M* = 30.69, *SE* = 7.03). Increased attention to the moderate target through a-priori rightward attentional bias mitigated discounting while increased attention towards the confounded alternative cause increased accounting for that alternative cause, as shown by the greater difference when the target was on the right side of the screen, but the asterisk cued left.

Causal Ratings of Alternative

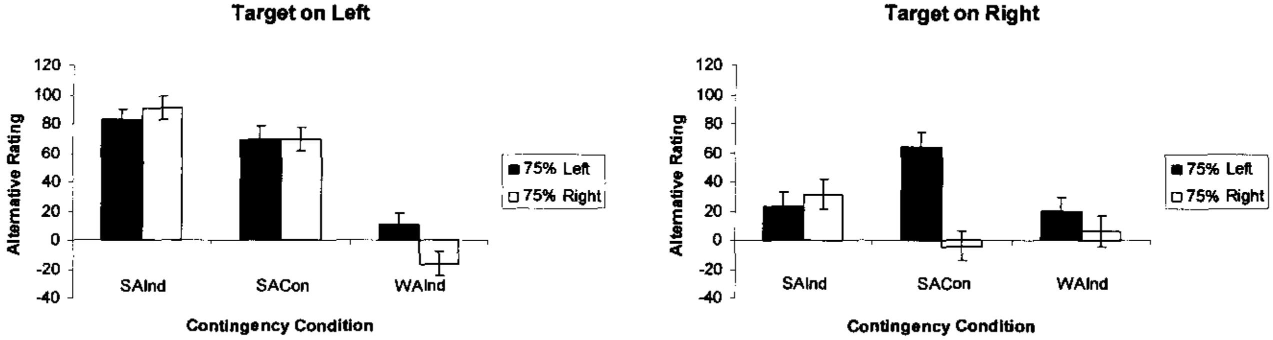

Figure 5. Average causal ratings of the alternative as a function of target side, contingency condition and asterisk location, averaged across blocks.

Causal ratings of the alternative are not diagnostic of discounting but are informative when assessing accounting for a confounding cause. A repeated measures MANOVA with block (one, two) as the within-groups factor and contingency (SA-Ind, WA-Ind, SA-Con) asterisk location (left, right) and target position (left, right) as between-groups factors revealed main effects of contingency condition, $F(2, 219) = 35.8$, $\eta_p^2 = .26$, target position, $F(1, 219) = 27.6$, $\eta_p^2 = .12$, and asterisk location, $F(1, 219) = 9.2$, $\eta_p^2 = .04$, as well as a three-way contingency condition by target position by asterisk location interaction, $F(2, 4) = 5.5$, $\eta_p^2 = .05$. As anticipated, ratings of the alternative cause also varied with respect to target position and asterisk location. Post-hoc tests revealed a significant difference between SA-Ind (M = 55.58, SE = 4.62) and WA-Ind (*M* = 4.79, *SE* = 4.66) conditions, reflecting the relationship between the strong and weak alternatives. There was, however, no overall difference in participants' ratings of the target in the SA-Ind (M = 55.58, SE = 4.62) and SA-Con (*M* = 49.89, *SE* = 4.65) conditions, suggesting that overall they did not control for the target in their judgments of the alternative. Once again, the three-way interaction (Figure 5) indicates that the effects of asterisk location and contingency condition depended upon the target's location.

When the target appeared on the left, hence the alternative was on the right (i.e., a-priori biased) side of the screen, participants demonstrated sensitivity to the different strengths of that alternative cause but overall they did not control for the target cause when rating the alternative. The asterisk location by contingency condition ANOVA on the causal ratings of the alternative revealed a main effect of contingency, $F(2, 109) = 69.67$, $\eta_p^2 = .57$ and no other effects. Demonstrating sensitivity to the contingencies, participants rated the alternative as more causal in the SA-Ind condition ($M = 86.56$, $SE = 5.56$) than mean target ratings in the WA-Ind condition ($M = -3.17$, $SE = 5.78$). But, overall their mean alternative ratings in the SA-Ind condition ($M = 86.56$, $SE = 5.56$) were higher than those in the SA-Con condition ($M = 69.68$, $SE = 5.7$), a pattern opposite that expected were participants controlling for the target in their ratings of the alternative.

When the target was presented on the right side, hence the alternative was on the left (i.e., relatively unattended side), the asterisk location by contingency ANOVA revealed a main effect of asterisk location, $F(2, 109) = 8.6$, $\eta_p^2 = .08$, as well as a contingency condition by asterisk location interaction, $F(2, 109) = 7.6$, $\eta_p^2 = .13$. The main effect of asterisk location is due to the fact that overall, participants gave higher ratings to the alternative when the asterisk was on the left ($M = 35.57$, $SE = 5.74$) than when the asterisk was on the right ($M = 11.11$, $SE = 6.05$). To follow up on the asterisk location by contingency condition interaction, simple main effects tests were conduced for when the asterisk appeared on the left side of the screen (i.e., cued the target) and when it appeared on the right side of the side of the screen (i.e., cued the alternative). When the asterisk appeared on the right side of the screen, mean alternative ratings in the SA-Ind condition (M = 31.47, SE = 11.56) were higher than mean target ratings in the WA-Ind condition (M = 6.09, SE = 10.22) showing a reflection of the actual nature of alternative strength. When the asterisk did not cue the alternative, mean alternative ratings in the SA-Ind condition (M = 31.47, SE = 11.53) were higher than mean alternative ratings in the SA-Con condition (M = -4.22, SE = 9.93) indicating not accounting for the alternative cause. When the asterisk was on the left, mean alternative ratings in the SA-Ind condition (M = 22.91, SE = 9.96) were higher than in the WA-Ind condition (M = 19.4, SE = 10.21) once again reflecting the relative strength of the alternative. When the asterisk cued the alternative, mean alternative ratings in the SA-Ind condition (M = 22.91, SE = 9.96) were lower than in the SA-Con condition (M = 64.42, SE = 10.76) indicating accounting for the alternative confounded cause. When the confounded alternative was cued, participants' causal judgments more closely showed accounting for the confounded cause. Generally, this pattern of results is complimentary to the previously reported target ratings, showing the same effect of target and asterisk.

Trial-by-trial analyses

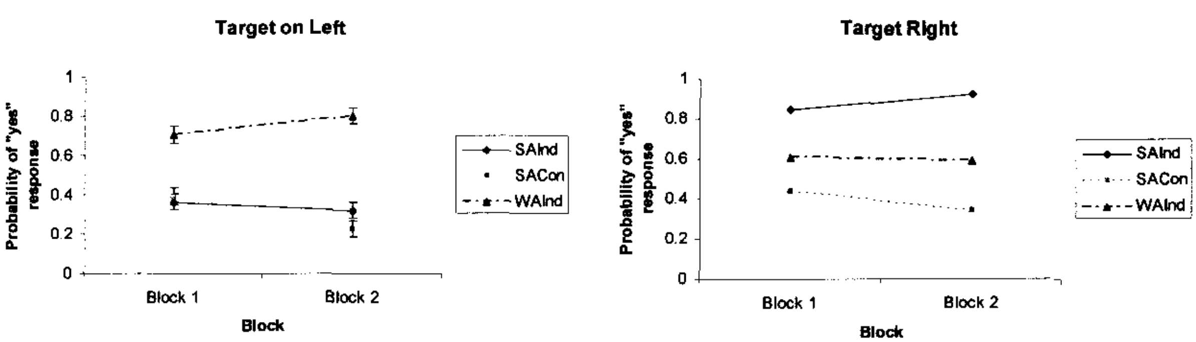

Figure 6. Probability of a "yes" shown across blocks for each contingency condition.

Because it is participants' responses to the target cause that are essential to the assessment of discounting and accounting for the alternative, I present the analysis of the trial-by-trial predictions for the target-only trials (but not for other trial types). Analyses of the proportion of "yes" responses that participants gave on the target only trials yielded patterns similar to their causal ratings of the target.

A repeated measures MANOVA with block (one, two) as the within-subjects factor and contingency (SA-Ind, WA-Ind, SA-Con), asterisk location (left, right) and target position (left, right) as between-subjects factors revealed main effects of contingency condition, $F(2, 219) = 41.9$, $\eta_p^2 = .32$, and target position, $F(1, 219) = 23$, $\eta_p^2 = .12$, an asterisk location by target position by contingency condition interaction, $F(2, 4) = 3.7$, $\eta^2 = .04$, and a block by target position by contingency condition interaction, $F(2, 4) = 4.5$, $\eta_p^2 = .05$. Participants' trial-by-trial predictions varied with the target position and asterisk location. Although the proportion of "yes" responses were directionally lower in the SA-Ind condition ($M = .62$, $SE = .03$) than in the WA-Ind condition ($M = .68$, $SE = .02$), this difference was not significant: therefore, participants did not discount in their trial-by-trial prediction on the target-only trials. They did, however demonstrate accounting for the alternative: the mean proportion of "yes" responses were higher in the SA-Ind condition ($M = .62$, $SE = .03$) than in the SA-Con condition ($M = .3$, $SE = .04$) indicating a pattern consistent with accounting for the alternative cause. Once again, these interpretations are tempered by the three-way interactions.

Following up the block by contingency condition by target position interaction (Figure 6), a univariate ANOVA revealed a main effect of contingency condition, $F(2, 109) = 43.5$, $\eta_p^2 = .45$, and a block by contingency condition interaction, $F(2, 109) = 7.8$,

η_p^2 = .13 when the target was on the left. Predictions in each condition were different across blocks depending upon whether the target was presented on the right side of the screen or the left side of the screen. When the target was presented on the left side of the computer screen, mean prediction probability in the SA-Ind condition (*M* = .34, *SE* = .04) was lower than in the WA-Ind condition (*M* = .76, *SE* = .04), indicating a pattern consistent with discounting. Mean probability of a yes response in the SA-Ind condition (*M* = .34, *SE* = .04) was equal to the mean probability in the SA-Con condition (*M* = .31, *SE* = .04), indicating not accounting for the confounding cause. When the target was on the right, ANOVA revealed a main effect of contingency condition, $F(2, 109) = 45.7$, η_p^2 = .45, and a block by contingency condition interaction, $F(2, 109) = 3.9$, η_p^2 = .07. Similar to the numeric ratings of the target, when the target was presented on the right, mean prediction probability in the SA-Ind condition (*M* = .88, *SE* = .04) was higher than in the WA-Ind condition (*M* = .60, *SE* = .04), indicating a pattern opposite that of discounting. Mean probability of a yes response in the SA-Ind condition (*M* = .88, *SE* = .04) was higher than the mean probability in the SA-Con condition (*M* = .39, *SE* = .04), indicating accounting for the confounding cause.

Once again, the interactions necessitate simple main effects to assess the impact of target location on block. When the target was on the left, target ratings in the SA-Ind and SA-Con conditions decreased across blocks. In block one, when the target was on the left, mean probability in the SA-Ind condition (*M* = .36, *SE* = .04) was lower than the WA-Ind condition (*M* = .71, *SE* = .05), indicating discounting. The mean probability in the SA-Ind condition (*M* = .36, *SE* = .04) was equal to that in the SA-Con condition (*M* = .4, *SE* = .05), indicating not accounting for the alternative cause. In block two, when the target was on the left, the mean probability in the SA-Ind (*M* = .32, *SE* = .04) condition was lower than the WA-Ind condition (*M* = .80, *SE* = .04), indicating discounting. Unlike block one, the mean probability in the SA-Ind (*M* = .32, *SE* = .04) condition was directionally higher than that in the SA-Con condition (*M* = .23, *SE* = .04), indicating accounting for the alternative cause. When the target was on the right, the differences between contingencies were greater in block two than in block one. Simple main effect of contingency in block one show mean prediction probability in the SA-Ind condition (*M* = .84, *SE* = .04) was higher than in the WA-Ind condition (*M* = .60, *SE* = .04), indicating a pattern opposite that of discounting. Mean probability of a yes response in the SA-Ind (*M* = .84, *SE* = .04) condition was higher to the mean probability in the SA-Con condition (*M* = .44, *SE* = .04), indicating accounting for the confounding cause. When the target was on the left, accounting for the alternative developed in block two. When the target was on the right, the differences between contingency conditions, not discounting, but accounting for the alternative, became greater.

Following up on the target position by asterisk location by contingency condition interaction (Figure 7), similar to the ratings of the target, discounting occurred when the target was presented on the left side of the screen, but not when it was presented on the right side of the screen. Accounting for the alternative was greater when the target was presented on the right side of the screen and the asterisk cued the alternative. When the target was on the left, there was a main effect of contingency, $F(2, 109) = 46.3$, $\eta_p^2 = .47$ and no other effects. Mean prediction probability in the SA-Ind condition (*M* = .34 *SE* = .04) was lower than in the WA-Ind condition (*M* = .76 *SE* = .04), indicating discounting. Mean probability of a yes response in the SA-Ind condition (*M* = .34 *SE* = .04) was equal to the mean probability in the SA-Con condition (M = .30, SE = .04), indicating not accounting for the confounding cause. When the target was on the right, there were main effects of contingency, $F(2, 109) = 57.32$, $\eta_p^2 = .51$, asterisk location, $F(2, 109) = 4.6$, $\eta_p^2 = .04$ and a contingency condition by asterisk location interaction, $F(2, 109) = 10.9$, $\eta_p^2 = .17$. The main effect of asterisk was due to the asterisk presented on the right side of the screen having higher mean probability (M = .66, SD = .03) than when the asterisk was on the left side (M = .58, SD = .03). Running simple main effect of contingency condition for each asterisk location revealed that when the asterisk was on the left (cueing the alternative cause), mean prediction probability in the SA-Ind condition (M = .87 SE = .04) was higher than in the WA-Ind condition (M = .65, SE = .05), indicating no discounting. Mean probability of a yes response in the SA-Ind condition (M = .87 SE = .04) was higher than the mean probability in the SA-Con condition (M = .22 SE = .05), indicating accounting for the confounding cause. When the asterisk was on the right (cueing the target), the simple main effect of contingency condition shows mean prediction probability in the SA-Ind condition (M = .89, SE = .05) was higher than in the WA-Ind condition (M = .55, SE = .05), indicating no discounting. Mean probability of a yes response in the SA-Ind condition (M = .89, SE = .05) was higher than the mean probability in the SA-Con condition (M = .55, SE = .05), indicating accounting for the confounding cause. Generally, the pattern of response in trial-by-trial predictions are similar to the target ratings reported earlier. A pattern similar to discounting occurred when the target was presented on the left side of the screen, but not when the target was presented on the right side of the screen. When the target was presented on the left side of the screen, participants did not account for the confounded cause in their predictions.

When the target was on the right, participants did not discount and accounted for the confounded alternative regardless of asterisk location, although the difference between the SA-Ind and SA-Con conditions was greater when the asterisk cued the alternative cause.

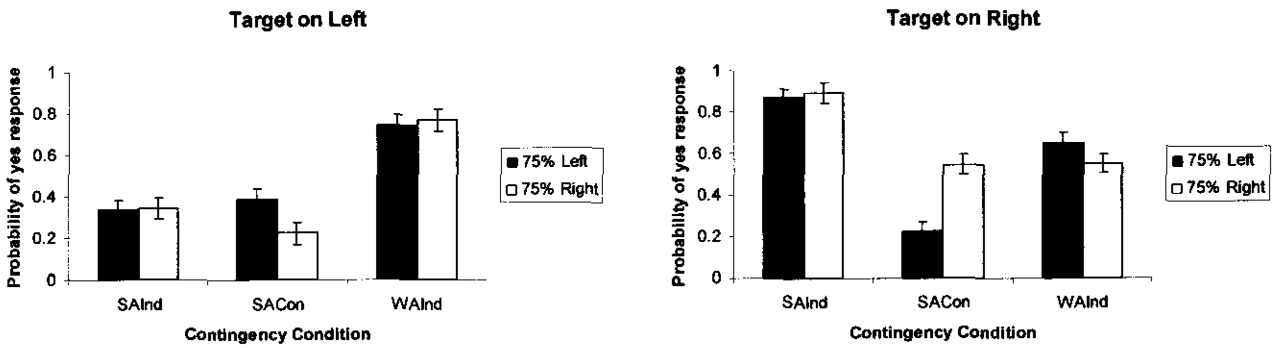

Figure 7. Probability of a "yes" response as a function of target side and asterisk location, averaged across block.

DISCUSSION

The goal of the current experiment was to determine whether manipulating participants' lateral distribution of attention using a peripheral cue would influence their discounting and accounting for an alternative, confounded cause. I hypothesized that increased attention to a moderate target would mitigate discounting and disrupt accounting for a confounded cause. Increased attention came in the form of a non-informative peripheral cue as well as a-priori rightward attentional bias. The results on discounting are consistent with my hypothesis. However, my hypothesis on accounting for an alternative cause was not completely accurate. I hypothesized that increased attention towards the moderate target would result in disruption of accounting for the alternative cause. Accounting for a confounded alternative was not disrupted through attention to the target, but increased attention towards the alternative enhanced the accounting for that confounded alternative. In terms of target ratings, when the moderate target was on the left side of the screen, participants displayed discounting and accounting for an alternative, confounded cause. When the moderate target was on the right side of the screen, as predicted, participants did not display discounting. In fact, this effect appears to be the opposite of discounting, which from here will be referred to as "anti-discounting". When the target was on the right, participants showed accounting for the alternative cause. The attentional cue had different effects dependent upon if the target was on the left or right. When the target was on the right with a cued alternative, participants showed a greater amount of accounting for the confounded alternative. Overall, increasing attention towards a moderately effective target cause (here, mainly through a-priori rightward attentional bias) reduced or reversed discounting and increased the ability of the cue to enhance processing of the confounded alternative. The numeric ratings of the target are the primary dependant variable, but numeric ratings of the alternative and trial-by-trial predictions reveal a similar pattern of results, adding to the efficacy of the attentional effects on causal judgments.

This current data replicates our previous findings that a target appearing in the attentionally biased side of space (i.e., the right) mitigates discounting (Czarnecki & Goedert, 2008). Previous research on near (i.e., peri-personal space, within hand's reach) and far space (i.e., extra-personal, outside of hand's reach) indicates that there is an a-priori rightward attentional bias when stimuli appear in far space (Varnava, McCarthy & Beaumont, 2002). This rightward bias may be due to a lateralization of neural co-ordinate systems; each system has different mechanisms dependent upon the distance of stimuli and the bias may come from the strength of hemispheric activation (Varnava, McCarthy & Beaumont, 2002). In the current experiment, the stimuli appeared in far space, and it is therefore possible to attribute the difference in left/right judgments to increased attention through this a-priori bias.

Since discounting and accounting for the alternative are dissociable cognitive processes (Goedert, Harsch & Spellman, 2005), lateralized attentional orientation may recruit proper or improper systems for these tasks. Similarly, other researchers have also begun to question the interaction between cognitive tasks and attentional biases after noting the impact of stimuli in near versus far space on spatial perceptions (Heilman, Chatterjee & Doty, 1995). In research involving callosotomy patients, Roser and colleagues presented physically causal (i.e., a ball hit another ball and caused it to move) and inferred causes (i.e., participant needed to make inferences to determine causality) to different visual fields to assess the importance of each hemisphere in determining causality (Roser, Fugelsang, Dunbar, Corballis& Gazzaniga, 2005). Results from this study indicate that the right hemisphere is critical in physical causality involving moving stimuli and the left hemisphere is important in inferring contingencies. The implication of the left hemisphere is important not only in the current task, since participants are inferring contingencies, but also in the rightward attentional bias. The activation of the left hemisphere in this task may be a reason for the bias. As previously described, researchers have observed rightward attentional bias in far space, but leftward attentional biases in near space. One might then, expect the effects observed here to reverse when the stimuli presented in near space.

The attentional effects of "anti-discounting" when the target was cued and enhanced accounting for the confounded cause when the alternative was cued may be beneficial. Since discounting involves lowered judgments of a moderate target, increased attention towards the moderate target may increase processing and thus coax causal perceptions away from a non-advantageous misjudgment. Accounting for an alternative, confounded cause is a beneficial judgment and increased attention to the alternative cause would be a further enhancement. Perhaps this is a more stable effect and less likely to be disrupted by moderate attentional shifts to the target. In both cases, the increased attention (to the target in discounting and to the confounded alternative when accounting for it) resulted in judgments that were more accurate, compared to true contingencies.

These findings may also further explain the nature of the discounting effect. The fact that the target's location (right vs. left) influenced discounting may be the reason why discounting is traditionally a small effect when the location of the target is counterbalanced within participants. The "anti-discounting" when target is presented on the right may water down the overall effect. Attention may prove to be a promising approach to understanding nonnormative causal perceptions such as discounting. Since here, an attentional manipulation and a-priori attentional bias have been shown to affect judgments of causality, the attentional approach may be informative in understanding phenomena that do not conform to current statistical predictions.

These results are indicative as to the directional nature of the visual attention-causal reasoning relation; increased visual attention towards a moderate target disrupted discounting and increased attention towards an alternative cause enhanced the accounting of that confounded alternative. In Kruschke's EXIT model (2001), visual attention decreases when learning reveals a cause to be ineffective or non-relevant. Perhaps the converse is also true, increased (or decreased) attention to one cause may induce the judgments of causality, a hypothesis supported by the current data. With these results, we are closer to assessing the directional impact in the relationship between causal reasoning and visual attention. With previous work integrating information such as feedback into the causal network, there must now be a model of causal reasoning including not only visual feedback, but also accounting for this newly found role of visual attention. However, more experimentation is necessary to determine this. This integration will be of great assistance in managing and continue to assess current models, such as the EXIT model.

. These findings are useful in assessing the impact of attention on discounting, but it does not explain why discounting occurs. Visual attention may influence causal judgments, but this does not necessarily discredit any of the previously mentioned hypotheses of why discounting occurs. There may be competition between causes for associative strength (Baker et al, 1993) and attention could further increase associative weight for one cause. Increased attention towards one cause means lowered attention towards the competing cause. This may serve to influence the associative strength between each cause, thus increasing the perceived associative strength of one competing cause over the other. This current research seems to fit plausibly with Baker's hypothesis. Discounting may be a general cognitive comparison in that having something highly causal discounts something moderately causal (Goedert & Spellman, 2005; Valleé-Tourangeau, Baker & Mercier, 1994). Furthermore, biased attention could increase the inspection of the more causal cue thus increasing its mental representation, changing the perceived cognitive comparison to facilitate discounting. While the previous explanations sound plausible within the framework of attention, the current findings do make some explanations seem less likely. For instance, some assert that a secondary cause does not fit into a previously formulated explanation of a first cause and therefore discount the effectiveness of the second cause (Ahn & Gordon, 1994). It is unlikely that attention would influence the results while working within this supposition. Attention most likely would not influence a judgment formed to support a previously formed explanation. Another less likely explanation in terms of the present findings is that if one strong cause is present, it is unlikely that another strong cause would also be present (Morris& Larrick, 1995; Goedert& Spellman, 2005). Attention seems unlikely to sway a previously formed belief on the frequency of strong causes. Once again, the present experiment does not discredit these hypotheses, but some seem more plausible in terms of this attentional hypothesis. There must be further research to find the cause of discounting.

Although there was a statistically significant effect of asterisk location, this manipulation was seemingly unable to overcome a-priori attentional bias. Further research increasing the attentional strength of cue will more closely investigate the experimental hypothesis. That is, an attentional cue that beyond a-priori bias orients attention would presumably replicate these results on both sides of the screen, irrespective of target location. This would give a more precise indication that manipulated attention towards a moderate target disrupts discounting and increased attention towards a confounded alternative enhances accounting of that alternative. The current data provides promising evidence that further attentional manipulation may provide these results. In this study, there was no way to ensure (i.e. no eye-tracking data) that people were orienting attention to the cued cause. If collected, this data would be further evidence pointing to the impact of manipulated visual attention. Even if participants successfully responded to which side the cue (asterisk) was on, it is unknown what proportion of time was fixated on the cued cause. Although the effect of asterisk location in the trial-by-trial data indicates that participants were using the asterisk, subsequent studies should utilize eye-tracking procedures to ensure attention towards the cued cause as anticipated.

In the context of day-to-day life, findings of this nature indicate that attending to one cause over another may influence our judgments. From our first example, perhaps we believe that the cold pack alleviated our toothache more effectively than the aspirin because we spend more time attending to the cold pack than the aspirin. In this example, attention may be overriding, to some degree, causal reasoning. Conceivably, attention may even increase the effectiveness of causal reasoning. Overall, increased attention towards a moderate target not only mitigated discounting, but resulted in "anti-discounting". Increased attention towards a confounded alternative increased participants accounting for that confound. This experiment increased attention towards moderate targets and confounded alternatives and in both cases, attention had the capacity of maximizing the outcome compared to actual contingencies.

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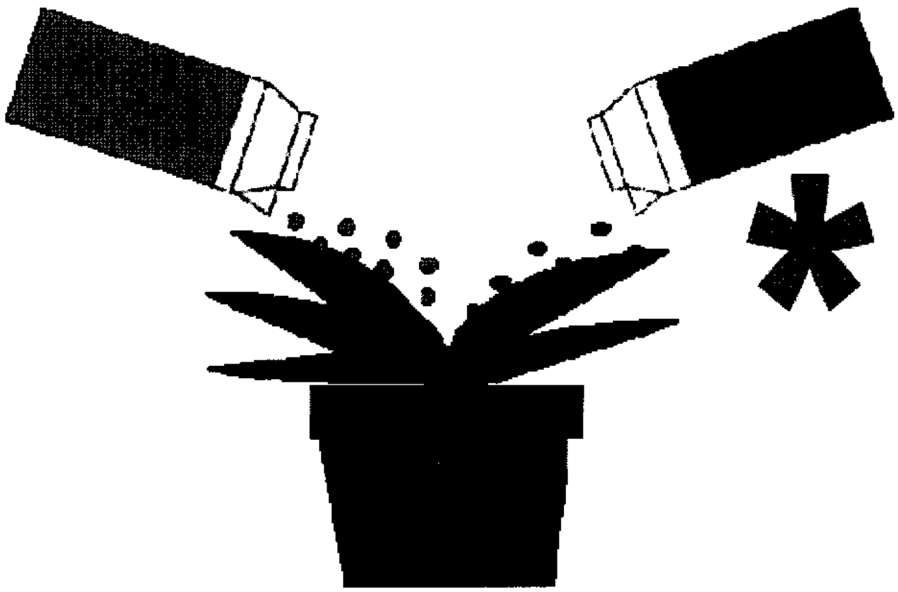
Appendix A: Sample stimuli with asterisk placement for attentional cueing


BROWN
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PURPLE
LIQUID