Judgment and Decision Making, Vol. 14, No. 5, September 2019, pp. 573–590

Limited resources or limited luck? Why people perceive an illusory negative correlation between the outcomes of choice options despite unequivocal evidence for independence

Déborah Marciano*† Eden Krispin‡§ Sacha Bourgeois-Gironde¶ Leon Y. Deouell‖**

Abstract

When people learn of the outcome of an option they did not choose (the alternative outcome) before they know their own outcome, they see an illusory negative correlation between the two outcomes, the Alternative Omen Effect (ALOE). Why does this happen? Here, we tested several alternative explanations and conclude that the ALOE may derive from a pervasive belief that good luck is a limited resource. In Experiment 1, we show that the ALOE is due to people seeing a good alternative outcome as a bad sign regarding their outcome, relative to seeing a neutral alternative, but find no evidence for seeing a bad alternative outcome as a good sign. Experiment 2 confirms that the ALOE replicates across tasks, and that the ALOE cannot be explained by preconceptions regarding outcome distribution, including: 1) the Limited Good Hypothesis (zero-sum bias), according to which people see the world as a zero-sum game, and assume that resources there means fewer resources here, and/or 2) a more specific assumption that laboratory tasks are programmed as zero-sum games. To neutralize these potential beliefs, participants had to draw actual colored beads from two real, distinct bags. The results of Experiment 3 were consistent with a prediction of the Limited Luck Hypothesis: by eliminating the value of the outcomes we eliminated the ALOE. Taken together, our results show that either the limited good belief is so robust that it defies strong situational evidence, or that individuals perceive good luck itself as a limited resource. Such a limited-luck belief might have important consequences in decision making and negotiations.

Keywords: alternative outcome, illusory correlation, alternative omen effect, zero-sum bias

1 Introduction

Imagine you are at the casino. You spot a nice little corner with two slot machines, and hesitate between the two: should you sit on the blue one or the yellow one? You eventually decide to go with the blue one. A moment later, a woman sits next to the yellow one. You haven't even pulled yet the handle of your machine when you hear a cry of joy: the woman on the yellow slot machine just won the jackpot! If you had to guess, what would you say are the odds that you too will get the jackpot when you pull the handle of the blue machine? Given what happened to the lucky lady on the yellow machine, would you say the odds went up? Down? Are you now more or less likely to give up using your machine and go have a quiet dinner?

The results of our recent study (Marciano-Romm et al., 2016) suggest that most individuals would believe that their odds of winning went down despite the clear lack of correlation between the two machines. We found that information about the outcome of the unchosen option ("the alternative outcome") induces biased predictions regarding the unknown outcome of the chosen option ("the chosen outcome"). Specifically, individuals seem to perceive an illusory negative correlation between the two outcomes: they see a good (bad) alternative outcome as a bad (good) sign re-

Sacha Bourgeois-Gironde acknowledges the support of French National Research Agency grant ANR-10-0RAR-O1122.

Deborah Marciano is grateful to the Azrieli Foundation for the award of an Azrieli Fellowship.

Leon Y. Deouell is the Jack A. Skirball professor of neuroscience and is supported by the Jack A. Skirball research fund.

The authors thank Alvin Roth, Maya Bar-Hillel, and Tal Golan for raising questions about the original ALOE study, which motivated the present one. We also thank Peter Ayton for his comments on a previous version of the manuscript and especially for suggesting non-trivial ways in which local correlations could affect the results.

*Department of Psychology, The Hebrew University of Jerusalem, Israel. Email: dvorah.marciano@gmail.com.

†Federmann Center for the Study of Rationality, The Hebrew University of Jerusalem, Israel.

‡Department of Psychology, The Hebrew University of Jerusalem, Israel.

§Department of Economics, Bar Ilan University, Israel.

¶Institut Jean-Nicod - Institut d'Étude de la Cognition, Departement d'Études Cognitives, École Normale Supérieure, PSL-Research University, Paris.

‖Department of Psychology, The Hebrew University of Jerusalem, Israel.

**The Edmond & Lily Safra Center for Brain Sciences, The Hebrew University of Jerusalem, Israel.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

garding their own outcome when the two outcomes are in fact uncorrelated. We coined this phenomenon the "Alternative Omen Effect" (ALOE).

Similar situations in which one has to choose between two or more options with uncertain outcomes abound. Consider choosing between two stocks to invest in, choosing whether to take the highway or the city roads on one's commute without information about the traffic situation, or choosing between two resorts to go to for vacation. In all of these cases, the alternative outcome might be revealed first, creating the Alternative Omen Effect, and affecting one's subsequent decisions (selling the stock or zigzagging between routes). However, whereas we found that the effect is robust, the sources of the bias remained unclear. In the present paper, we investigate the sources of the Alternative Omen Effect: why do individuals perceive an illusory correlation between the outcomes of choice options?

1.1 Illusory correlations

The ability to detect correlations between events is an essential component of adaptive behavior. However, past studies have shown that individuals are often inaccurate in their evaluation of the strength and/or the direction of correlations between events (for reviews see Alloy & Tabachnik, 1984; Beyth-Marom, 1982). In particular, people tend to perceive association where there is in fact none (e.g., Bar-Hillel & Wagenaar, 1991; Chapman & Chapman, 1967, 1969). While illusory correlations were previously shown between an action and its outcome or between two separate events, the perception or misperception of correlation between the outcomes of two choice options has received little attention.

1.2 The alternative option as a creator of expectations

In many instances, following a choice between two uncertain options, the uncertainty is eventually resolved for both options, and we get feedback on the outcomes of both the unchosen option (henceforth the *alternative option*) and the chosen option. For instance, in such a "total feedback" situation (Mellers, Schwartz & Ritov, 1999), while stuck in traffic on the expressway, you might hear on the radio that the city roads are clear. Total feedback is also common in social settings, where one can observe the outcomes of those who selected a different option, especially in the era of social media. A large body of work has shown that individuals' satisfaction with their own outcome varies as a function of the value of the alternative's outcome (Bell, 1982; Loomes & Sugden, 1982; Inman et al., 1997; Mellers et al., 1999).

In all the above examples, the alternative outcome might be presented before that of the chosen option. For example, the annual fiscal reports of a company you decided not to invest in may be published before those of the company whose stocks you purchased. Or, in the vacation example, sometime before your planned vacation, you may see on Facebook pictures of your friend having fun at the unchosen resort. In such cases, the alternative's outcome may induce expectations regarding the (as yet unrevealed) value of the chosen option. Indeed, individuals might believe, either rightly or not, that the two outcomes are correlated and hence that the alternative's outcome has some predictive value regarding the outcome of the chosen option. This may be true in some cases but not in others.

1.3 The Alternative Omen Effect (ALOE)

The ALOE was established in a series of 3 behavioral experiments, using the "Sequential Coin in the Box" (sCIB; Marciano-Romm et al., 2016, see also Marciano et al., 2018, for neural correlates of the effect). In this task, participants chose in each trial between two boxes appearing on the screen, and then the outcomes of the two boxes were sequentially revealed (the alternative outcome first in two experiments and the chosen outcome first in the remaining experiment). For each box, the outcome was either a monetary gain or loss. In a minority of trials, after the first outcome had been revealed, the subjects were explicitly or implicitly probed to predict the other outcome. In all three experiments, unbeknown to participants, the outcomes were actually drawn randomly (P(Gain)=0.5) and independently. Nevertheless, participants predicted a good chosen outcome more often following a bad alternative outcome than following a good alternative outcome, as if a negative correlation existed between the outcomes of the two boxes. The importance of this bias was underlined by the fact that participants actually modified their behavior based on this illusory correlation: they were willing to pay to give up a trial before they even saw their outcome, based on the content of the unchosen box. Interestingly, the ALOE was significantly diminished when participants predicted the alternative outcome after seeing the chosen outcome (vs. the opposite), suggesting that the ALOE is modulated by self-relevance.

1.4 Understanding the sources of the ALOE

Understanding the sources of the ALOE is imperative. First, as noted, individuals might change their behavior based on the alternative outcome, when it is in fact an irrelevant and uninformative signal, even at a cost (Marciano-Romm et al., 2016). For instance, in the above stocks example, one might decide to sell the purchased stocks prematurely, following exposure to the positive results of the unchosen stocks. Second, forming expectations for upcoming outcomes modulates the emotional impact of these outcomes: surprising wins are more pleasurable than expected wins, and surprising losses are more painful than expected losses (Mellers et al., 1997;

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

Oliver, 1980; Churchill & Surprenant, 1982; Thompson & Yarnold, 1995; Oliver & DeSarbo, 1988).

The results of the 3 experiments in Marciano-Romm et al. suggested that the ALOE is not based on a bias of statistical learning, in which subjects overweigh alternating sequences, nor is it based on novelty seeking, in which subjects a-priori prefer alternating sequences. Both explanations were not consistent with the diminished ALOE effect when the alternative was revealed after, rather than before, the chosen outcome and participants had to predict the alternative outcome. Another potential mechanism is emotion regulation. Participants might predict bad received outcomes as an attempt to reduce their potential disappointment with actual bad outcomes or increase their joy from unpredicted good outcomes (Meller et al., 1997). A recent study has shown that under certain circumstances people may bet against the occurrence of desired outcomes in order to reduce the impact of negative outcomes – a process called emotional hedging (Morewedge et al., 2016). In fact, in the sCIB paradigm, participants did not appear to always get ready for the worst: rather, they tended to predict that their outcome would be a gain (wishful thinking; Marciano-Romm et al., 2016). Nevertheless, as seeing a good alternative outcome sets the ground for a potential experience of regret, participants might choose (consciously or not) to expect a bad received outcome specifically in this case, as a way to alleviate the potential pain of regret (Zeelenberg, 1999). While we cannot rule out the contribution of emotion regulation to the ALOE, this explanation is complicated by the results of Experiment 2 of Marciano-Romm et al. (2016), in which one may experience not only regret based on the outcome, but also regret based on the validity of the prediction. Moreover, it is also incompatible, in any simple way, with the results of Experiment 3 of Marciano-Romm et al. in which the participants first saw their outcome and had to predict the alternative outcome. Consider the case of a trial in this experiment in which the received outcome happens to be a loss. If the alternative is then revealed to be a gain, the participant would experience regret for not choosing the alternative option. Therefore, under the assumption that the participant aims to alleviate the experience of regret, she should predict a gain in the alternative. However, we found no evidence of biased expectations in this condition.

Why is it then that people see a negative correlation between the outcomes of choice options, when they are in fact uncorrelated? In the present study, we examine the "why" question empirically. First, we address the symmetry of the ALOE. Do individuals perceive a bad alternative as a good sign, a good alternative as a bad sign, or is the ALOE a combination of these two effects (Experiment 1)? Next, we investigated whether the ALOE can be explained by prior beliefs regarding the limitedness of good outcomes (Experiment 2). Finally, we tested whether the ALOE could be due to individuals' preference for novelty over repetition (Novelty Preference), or to prior beliefs regarding the limitedness of luck rather than of material resources (Experiment 3). We elaborate on each one of these questions in the introduction to each experiment.

2 Experiment 1

Is the ALOE produced by the belief that a *good alternative* signals a *bad chosen outcome*, by the belief that a *bad alternative* signals a *good chosen outcome*, or by a combination of the two? The answer depends on people's baseline tendency to predict that their outcome will be a gain. To examine this question, we tested for individuals' predictions when no information regarding the alternative is given. This situation provides a reasonable baseline against which the effect of a good/bad alternative can be compared.

We predicted that participants would see a good alternative as a bad sign for their own outcome. This hypothesis was motivated by the Limited Good theory (Foster, 1965). Foster claims that, because many desirable goods exist in limited quantity (e.g., arable lands), people tend to generalize and assume that other valuable goods are exhaustible as well, even when they are not. In our task, participants would thus assume that a good alternative means fewer good outcomes for them, which would lead to a smaller tendency to predict a gain in the chosen box. The Limited Good theory makes no predictions regarding the influence of a bad alternative on prediction.

2.1 Methods

2.1.1 Participants

The experiment was conducted in Hebrew on 50 participants (24 females, mean age=24.5, SD=2.0). All were students recruited at the Hebrew University of Jerusalem. On average, the experiment lasted 35 minutes and participants received 40 New Israeli Shekels (approximately $11.70).

2.1.2 Stimuli and procedure

Participants sat in cubicles, about 60 cm away from the computer monitor. The task was programmed in C++ language. Participants encountered the following types of trials:

Regular trials (120 trials; Figure 1a): Participants saw two boxes on the screen (7.93 by 7.93 cm). They were told that each box would contain either a green or a red coin (radius: 2.31 cm). Participants had to choose a box by clicking on it using the computer mouse. If the participant did not make a choice within 45s, a choice was randomly made by the computer (however, this time limit was never reached). When a choice was made, a blue frame (0.26 cm wide) immediately appeared around the chosen box and remained visible until the end of the trial. One second after the appearance of

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

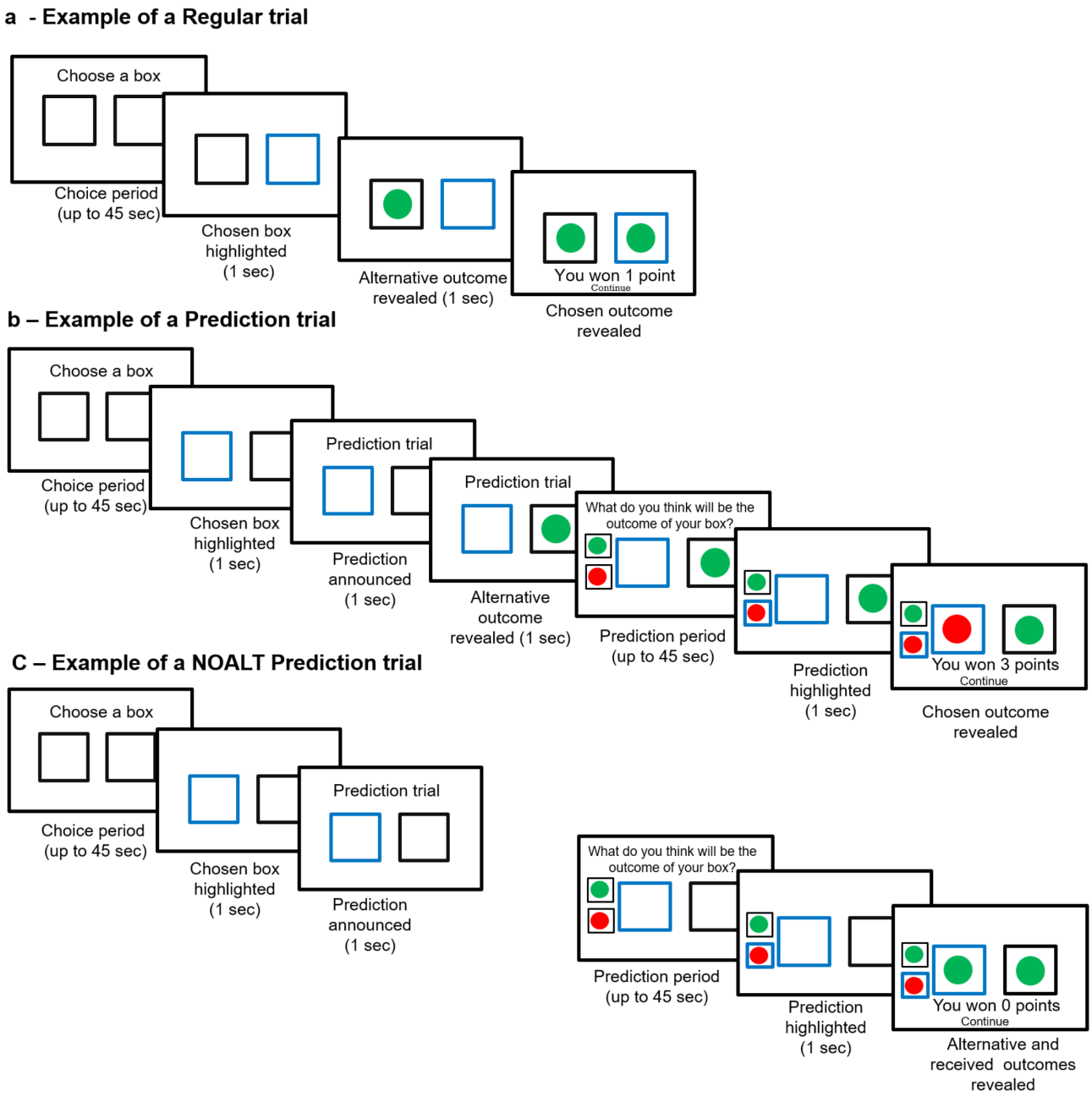

FIGURE 1: The Sequential Coin in the Box task.
(a) Example of a Regular trial. In this example, the participant won one point because the chosen box contained a green coin.
(b) Example of a classical Prediction trial ("ALOE Prediction trial" in Exp. 1). In this example, the participant accurately guessed that the chosen box would contain a red coin, and thus he won 3 points.
(c) Example of a NOALT Prediction trial (Exp. 1). In this example, the participant guessed that the chosen box would contain a red coin, but it actually contained a green coin. Therefore, he did not win points. Note that when the participant made a prediction, he had no information regarding the value of the alternative outcome.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

the blue frame, the outcome of the unchosen box appeared in the middle of the box. After one additional second, the outcome of the chosen box appeared as well, together with written feedback ("You lost 1 point"/"You won 1 point"), based solely on the outcome of the chosen box: if the chosen box contained a green (red) coin, participants won (lost) 1 point. In order to move on to the next trial, participants had to click on a "Continue" box that appeared at the bottom of the screen together with the opening of the second box.

ALOE Prediction trials (40 trials; Figure 1b): The trials began exactly as Regular trials. Participants saw two boxes on the screen and were asked to choose a box by clicking on it. After a choice was made, a blue frame immediately appeared around the chosen box and remained until the end of the trial. One second after the blue frame appeared, yet before any box opened, the words "Prediction trial" appeared on the screen, and stayed on the screen for one second. The outcome of the unchosen, alternative box then appeared in the middle of the box. After a second, the following question appeared on the screen: "What do you think will be the outcome of your box?" Together with the question, two small "prediction buttons" (5.29 by 5.29 cm) appeared on the side of the chosen box, one on top of the other. One contained a small red coin, and the other one a small green coin. Whether the upper button contained a red or a green coin was determined randomly in each trial. Participants had to guess the outcome by clicking on one of the two buttons. If no choice was entered within 45s, the prediction was chosen randomly by the computer (this time limit was never reached). Once the choice had been made, a blue frame appeared around the chosen prediction button. After a second, the outcome of the chosen box appeared on the screen, together with the written feedback "You won 3 points" if the participant correctly predicted her outcome, or "You won 0 points" if the prediction was wrong. That is, winning was based solely on the accuracy of the prediction, rather than on the chosen outcome.

NOALT Prediction trials (40 trials; Figure 1c): The trials were identical to ALOE Prediction trials, except that the "alternative outcome revealed" step was skipped. That is, participants were asked to guess the outcome of their box without seeing the alternative outcome. In the last step of the trial, the two outcomes were revealed simultaneously, together with the feedback regarding the accuracy of the participant's prediction.

As noted, to reduce the motivation to form strategies irrelevant to the study, the payoff for both NOALT and ALOE Prediction trials was determined by participants' predictions only. That is, participants did not lose or win money according to the color of the coin in the chosen box. Indeed, if we had rewarded/punished participants based on the outcome as well as the prediction, participants aiming to limit their losses might have been tempted always to predict that the chosen box would contain a red coin (Morewedge et al., 2016). The same logic held for Experiment 2 below.

There were no Prediction trials in the first 10 trials of the experiment, so that participants had a chance to experience the lack of correlation between the outcomes. The distribution of the remaining 190 trials was pseudo-random. The trials were divided into 10 concatenated chunks: in each chunk there were 11 Regular trials and 8 Prediction trials (4 of them ALOE Prediction and 4 of them NOALT Prediction). Within each chunk the order of the trials was random. This procedure ensured a constant probability of Prediction trials during the experiment. Participants were also unaware of the number of trials (neither in total nor divided into "Regular" and "Prediction" trials).

Participants were not told that, overall, the two boxes had the same probability of containing a green coin (0.5). That is, there were no "good" or "bad" boxes. Moreover, unbeknown to the participants, the outcomes of each trial were predetermined. That is, each outcome combination (Received=Gain + Alternative=Loss; Received=Loss + Alternative=Gain; both = loss; or both = gain) appeared in 25% of the trials.

Every 3 points accumulated during the game were worth one New Israeli Shekel (approximately \$0.29).[1]

2.2 Statistical analysis

For each participant, we computed the probability of choosing "Gain" in each of the three experiment conditions: in NOALT trials; in trials when the alternative was a gain (AltGain trials); and in trials when the alternative was a loss (AltLoss trials). These probabilities were entered into a one-way repeated measure ANOVA with conditions NOALT, AltGain, AltLoss.

In addition, to be consistent with the analyses presented in Marciano-Romm et al., we ran a series of logistic regressions using a Generalized Estimating Equation (GEE) clustered by participant (Hanley et al., 2003). The regression analysis allows us to control potential confounding factors. The details of the regressions and the results are provided in the Supplement (Tables 1-2) All the analyses presented in this paper resulted in similar results with both approaches.

[1] At the end of the game, in all three experiments presented in this paper, participants were asked to fill in a brief version of the Big Five Inventory (Goldberg, 1992), the most widely used classification of personality in psychological research (John & Srivastava, 1999). As this was the first study examining the existence of individual differences in the ALOE, we had no clear hypothesis regarding which traits might be associated with the ALOE. We did not manage to reach any conclusion regarding the ALOE and personality traits, possibly because of lack of sufficient power. The results of these analyses are not reported here.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

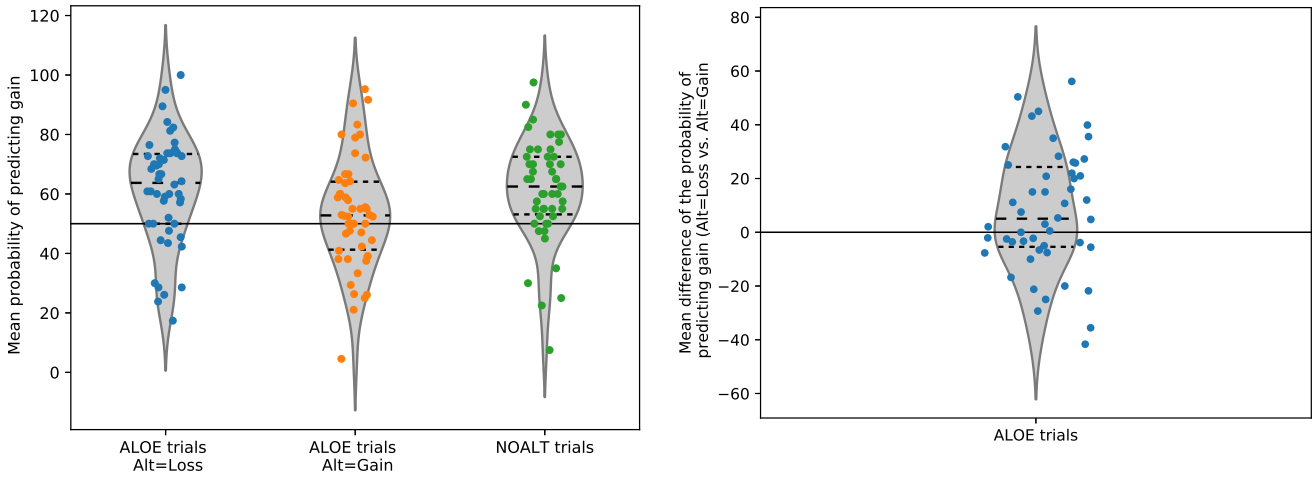

FIGURE 2: Violin plots. Each dot represents a participant. The black dashed lines indicate the 25th, 50th and 75th quartiles of the distribution. The width of the outline ('violin') represents the density of observations at each level. The plots were realized using the seaborn.violinplot function in Python.
a) Distribution of the mean probability of predicting Gain by type of prediction trial. The solid horizontal line indicates 50%.
b) Distribution of the difference between the mean probability of predicting gain when the alternative was a loss vs. a gain. The solid horizontal line indicates zero.

2.3 Results

2.3.1 Descriptive statistics

On average, participants chose the right-side box in 54.84% of the trials (SD=25.009, Range: [2.5–99.5]). In ALOE Prediction trials, participants predicted that there was a green coin in the chosen box in 57.15% of the trials (SD=15.278, Range: [22.5–97.5]); in NOALT Prediction trials, this number was equal to 61.2% (SD=17.285, Range: [7.5–97.5].

As expected, participants' overall predictions were at chance: they were accurate on average in 47.93% of the trials (SD= 6.10, Range: [35–60]).

2.3.2 ALOE results

The probability of predicting gain differed significantly across the 3 conditions $F(2,98)=4.97$, $p=0.0088$; Figure 2). Planned contrasts demonstrated that the probability of predicting gain was significantly lower when the alternative outcome was a gain (mean=53.55, SD=18.930) than when the alternative was a loss (mean=61.248, SD=18.369; $t(49)=-2.43$, $p=0.0189$), thus replicating the ALOE effect. Critically for the present experiment, the probability of predicting gain was significantly lower when the alternative outcome was a gain than when no alternative was shown (NOALT trials, mean=61.20, SD=17.285; $t(49)=-3.084$,$p=0.0034$). However, the probability of predicting gain when the alternative outcome was a loss did not significantly differ from the probability of predicting gain when no alternative outcome was shown ($t(49)=0.017$, $p=0.9862$). Similar results were found in the GEE analysis (see Supplement Tables 1–2).

There was a larger absolute difference between AltGain and NOALT, than between NOALT and AltLoss, but the difference was not quite significant two-tailed ($t(49)=1.8338$, $p=0.0728$).[2] The same contrast using the GEE approach, which included potentially relevant covariates as well using a different statistical approach, was significant ($p=0.0058$; Supplement).

2.4 Discussion

Experiment 1 provides a clear replication of the Alternative Omen Effect. In ALOE Prediction trials, participants were significantly less likely to predict that the outcome of the chosen box would be a gain when the alternative's outcome was a gain than when it was a loss. Going beyond the replication, the results of Experiment 1 also show that prediction of a gain was less likely when the alternative's outcome was not reported (the NOALT Prediction trials). It thus seems that the Alternative Omen Effect is an asymmetric bias: we found that optimism was reduced, compared to the NOALT Prediction trials, when the alternative outcome was a gain, but we found no evidence that predictions differed from this baseline when the alternative outcome was a loss. We can therefore refine the ALOE: it appears to be mostly due to individuals seeing a good alternative outcome as a bad sign

[2]Given our prior hypothesis that a good outcome would be perceived as a bad sign regarding the chosen outcome, and our lack of hypothesis regarding the influence of a bad outcome, the most powerful analysis to test for the difference between these effects is a one-tailed t-test, with a p-value of 0.0364.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

regarding their outcome. The ALOE could thus be classified as a negative superstition (Wiseman & Watt, 2004), as it reflects the idea that a certain omen (seeing a good alternative outcome) is magically associated with potentially harmful consequences (getting a bad outcome). This result seems consistent with the notion that most superstitions that come to mind are negative rather than positive (e.g., in Western societies: walking under a ladder, seeing a black cat, breaking a mirror, spilling salt) rather than positive (e.g., finding a penny),[3] although we couldn't find scientific literature supporting this intuition.

Experiment 1's findings also reinforce the idea that the Novelty Preference Hypothesis cannot provide a good explanation for the Alternative Omen Effect: why would individuals be attracted to change when the alternative outcome is a green coin, but not when it is a red coin?

Experiment 2 was designed to test whether the ALOE can be explained by prior beliefs regarding outcome distribution.

3 Experiment 2

3.1 Introduction

In their seminal paper on the assessment of correlation by humans and animals, Alloy and Tabachnik (1984) argue that the perception of correlation between events is determined not only by the information provided by the environment about the objective correlation, but also by a person's prior expectations about this correlation. When the situational information is unavailable or weak, individuals rely on their prior expectancies. In Experiment 1 above, one could argue that the situational information was weak: a null correlation is ambiguous. Moreover, while the outcomes of the two boxes were drawn randomly and independently, the drawing mechanism was not visible, nor explained to participants: it was hidden in the computer's "black box". Thus, according to Alloy and Tabachnik, these settings might have encouraged participants to make predictions according to their prior beliefs, at least until they got enough information on the actual correlation. As it appears, these prior beliefs were, on average, that the outcomes of the two boxes were negatively correlated, or at least that a good alterntative outcome was correlated with a bad received outcome (per Experiment 1 above). Why is it then that people expect the outcomes of the two choice options to be correlated? We offer two putative explanations, which are not mutually exclusive, related to the way people might perceive an outcome distribution.

3.1.1 Individuals might assume that good outcomes exist in limited quantities: The Limited Good Hypothesis

People might subscribe to a belief that life is a zero-sum game for goods: they might assume (perhaps for a good reason) that particularly valuable goods and resources exist in finite limited quantities and generalize from goods that are indeed limited to other goods that are not (Foster, 1965). One might thus believe that there are only so many green coins in the world of the sCIB game. With this belief in mind, a participant seeing a green coin in the alternative box will conclude that there are fewer green coins available in this trial, and thus that the chances of getting a green coin in the chosen box are smaller than if the alternative outcome was red.

3.1.2 Individuals might have preconceptions about experimental design

A less far-reaching yet plausible possibility is that the Alternative Omen Effect we observed does not reflect an overarching belief about the world, but merely a belief about the way experimenters design and program computerized experiments. Subjects might believe that lab experiments are programmed as zero-sum games; that is, they believe that experimenters are unlikely to design a game in which you win or lose no matter which option you choose. With such a belief in mind, seeing a good alternative outcome also translates to a higher chance of receiving a bad outcome.[4]

If the ALOE is indeed a manifestation of prior beliefs regarding outcome distribution, either in general or in the experiment, then neutralizing these beliefs should lead to an elimination of the effect. To that end, we made the situational evidence of the outcome distribution unequivocal in the present experiment. We developed the Sequential Bead in the Bag task (sBIB), a task very similar in essence to the Sequential Coin in the Box (sCIB), but happening in the real, analog world, outside of the computer's digital realm. Instead of choosing between two boxes presented on a computer screen, participants are asked to choose between two physical bags and to manually draw actual palpable colored beads from them. In the sBIB, the generating mechanism is doubly transparent. First, it is clear that the two bags are separate entities, that the outcomes of the two bags must be independent, and that the resources cannot be exhausted as the beads are returned to the bags after each trial. Second, participants are the ones drawing beads from the bags, thus experiencing the randomness of the game and the fact that it is not rigged. In such conditions, there is no room for participants' potential preconceptions about the kind of sequences that can be generated in the game. This experiment also neu-

[3] We focus here on chance omens and thus do not include talismans and charms that are used (proactively) to bring good luck.

[4] We thank Prof. Alvin E. Roth for raising this challenging hypothesis at the 25th Jerusalem Summer School in Economic Theory.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

FIGURE 3: The experimental settings.

tralizes by design the potential effect of local correlations. Even if the subject noticed such spurious correlations, the physical situation is such that participants should deduce that this happened by pure chance.

We also asked participants to fill the recently introduced Belief in a Zero-Sum Game scale (BZSM; Różycka-Tran et al., 2009; Różycka-Tran et al., 2015). While the questionnaire focuses on the perception of social interactions, Różycka-Tran and colleagues hypothesize that it is likely to reflect one's belief that life in general has a zero-sum game structure. If the ALOE reflects prior beliefs regarding outcome distribution, we should expect people scoring higher on the BZSM to evince a stronger ALOE than people scoring lower.

3.2 Methods

3.2.1 Participants

The experiment was conducted on 50 students from the Hebrew University of Jerusalem (34 females, mean age=24.1, SD=2.54). On average, the experiment lasted 35 minutes and participants received 40 New Israeli Shekels (approximately $11.70).

3.2.2 Procedure

The Sequential Bead in the Bag game (sBIB) Participants sat in a small room, in front of a desk (Figure 3). Before the game began, oral instructions regarding the task as well as regarding the payment were given to participants. Participants were instructed to blindly pick beads from two identical totally opaque dark blue cotton bags (depth: 30cm) hanging down from the side of the desk facing the participant, the participant's own knees separating the two bags. There underside of the table was free of any objects and visible to the participant. The distance of the subjects from the bags was such that they could put their right and left hand comfortably down the right and left bags, respectively, but could not see into the bags. Participants were told that each bag contained green and red beads. They were not informed of the precise beads distribution (50 green beads and 50 red beads in each bag). With the exception of their color, all the beads (13mm diameter) were identical and could not be differentiated based on touch. A computer screen placed on the desk was used solely for presenting instructions regarding each step of the trials and for recording decisions and events by the experimenter, who sat in the room behind the participants.

Participants encountered two different types of trials, equivalent to those presented digitally in Experiment 1:

"Regular trials (50 trials; Figure 4a): Participants were asked to put their right hand in the right bag and their left hand in the left bag, and to draw one bead in each hand. Participants could not see the beads or their hands in the bag (Figure 4a). While holding the selected beads in their closed fists outside the bag, participants had to choose a hand by stating out loud "Right" or "Left" (Figure 4a-i). As soon as the experimenter entered the choice into the computer, a black frame appeared around the drawing of the corresponding hand on the screen (Figure 4a-iii) and remained visible until the end of the trial. The goal of this feature was to help the participant remember his or her current choice. Five hundred milliseconds after the appearance of the frame, participants were asked to open the unchosen hand and to report out loud the color of the bead in this hand (that is, the alternative outcome; Figure 4a-iv). Once the alternative outcome was entered into the computer by the experimenter, participants were asked to open the chosen hand and to report the color of the bead in this hand (that is, the chosen outcome; Figure 4a-v). Feedback then appeared on the screen accordingly (Figure 4a-vi). Participants earned one point if there was a green bead in the chosen hand, and they lost one point if there was a red bead in the chosen hand. At the end of the trial, participants were instructed to drop each bead back into its bag[5,6] and to mix the beads.

"Prediction trials (30 trials; Figure 4b): The trials began exactly like the Regular trials (steps (i) to (iv)). However, after participants opened the unchosen hand, instead of being asked to open the chosen hand, the following sentence appeared on the screen: "Prediction trial: what do you think is the color of the bead in the hand you chose?" (Figure 4b-vii). Participants had to guess the outcome of the chosen hand by

[5]Replacement of the beads was necessary as we wanted the red/green ratio to remain constant throughout the experiment. Otherwise, participants' predictions in a given trial might have been strongly influenced by the bead picked (and left out of the bag) in the previous trials – an effect that might have obscured the ALOE.

[6]We specifically asked participants to *drop* the beads into the bags before the next trial in order to make sure that participants who had drawn a green bead in the previous trial would not be tempted to keep it in their hand.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

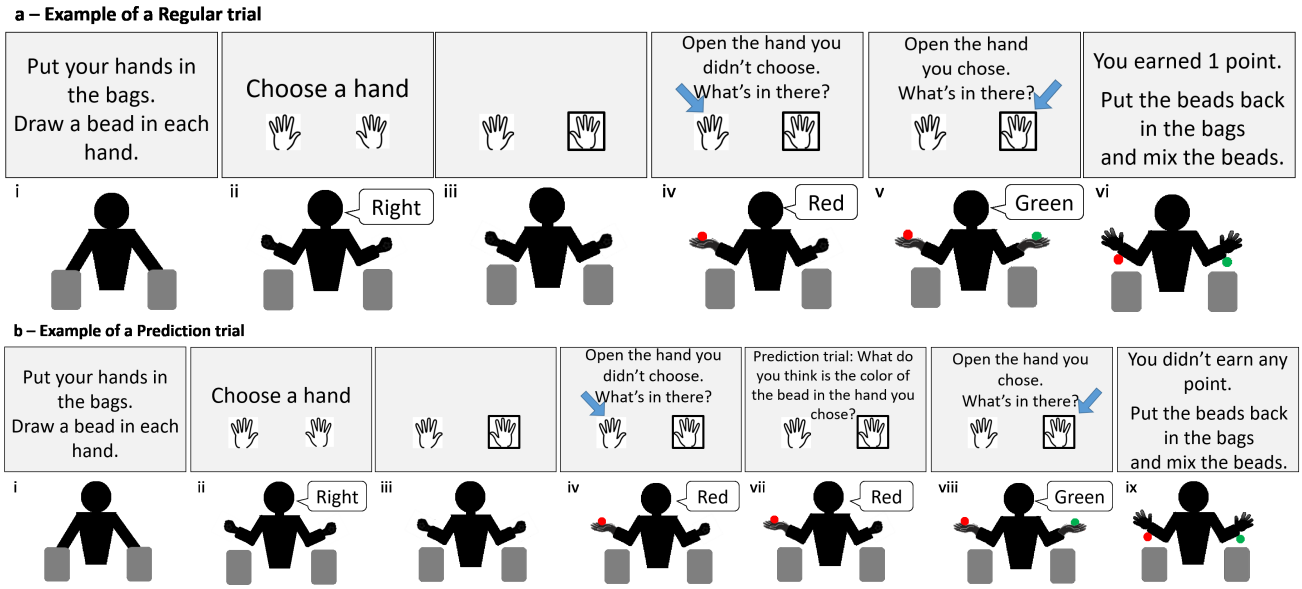

FIGURE 4: The Sequential Bead in the Bag game (sBIB) Upper panel: the computer screens displayed to participants. Lower panel: a schematic back view of the participant and the bags.
(a) Example of a Regular trial. In this example, the participant earned one point because there was a green bead in the chosen hand.
(b) Example of a Prediction trial. In this example, the participant didn't earn points because his guess wasn't accurate.

saying out loud "Green" or "Red."[7] Once the experimenter entered the prediction into the computer, participants were asked to open the chosen hand and to report the color of the bead (Figure 4b-viii). Feedback then appeared on the screen (Figure 4b-ix). Participants earned 3 points if their prediction was accurate, and they did not earn or lose points if their prediction was wrong. As in Experiment 1, to reduce the motivation to form strategies irrelevant to the study, the payoff on Prediction trials was determined by prediction accuracy only.

Regular and Prediction trials were pseudo-randomly mixed, under the constraint that there would be no Prediction trials in the first 10 trials of each block. Participants were unaware of the number of trials (neither in total nor divided into "Regular" and "Prediction" trials).

The room was dimly lit by the computer screen and a small table lamp (either on the right or the left side of the computer screen, counterbalanced across subjects). The light was sufficient to allow the participants and the experimenter to see the colors of the drawn beads clearly but did not allow the participants to see into the bags.

Participants were told that they would earn 20 New Israeli Shekels (approximately $5.85) for their participation in the experiment, and that they could earn a significant bonus depending on their performance in the task. Every 3 points accumulated during the game were worth one New Israeli Shekel (approximately $0.29).

Questionnaires At the end of the experiment, participants were asked to fill in the Belief in a Zero-Sum Game scale (Różycka-Tran et al., 2009; Różycka-Tran et al., 2015). Forty participants filled out the questionnaire. The scale was composed of 8 items, rated on a seven-point Likert scale, ranging from one (strongly disagree) to seven (strongly agree). Examples of items from the questionnaire are: "Life is so devised that when somebody gains, others have to lose" and "When some people are getting poorer, it means that other people are getting richer."

3.3 Statistical analysis

3.3.1 Analysis of the behavioral data

For each participant, we computed the difference between the probability of predicting that the received outcome would be a gain given that the alternative was a loss, and the probability of predicting that the received outcome would be a gain given that the alternative was a gain (P(pred=gain|alt=loss) – P(pred=gain|alt=gain). We then ran a t-test across subjects to test whether this difference was superior to zero as hypothesized. In addition, to be consistent with our previous report of the ALOE (Maciano-Romm et al., 2016), we ran a logistic regression clustered by participant (see Table 3 in the Supplement for details and results) All the analyses

[7] In 56 Prediction trials (out of 1500 Prediction trials across participants), participants opened the chosen hand before they gave a prediction. These trials were not included in the analysis.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

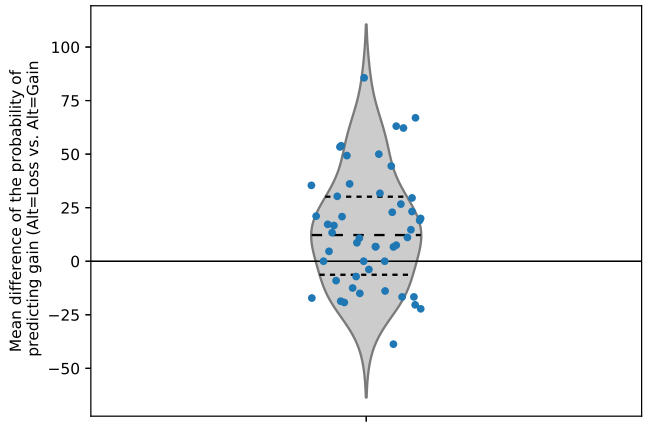

FIGURE 5: Distribution of the difference between the mean probability of predicting Gain when the alternative was a loss vs. a gain. Each blue dot represents a participant. The black solid line indicates zero. The black dashed lines indicate the 25th, 50th and 75th quartile. The width of the outline ('violin') represents the density of observations at each level.

presented in this paper resulted in similar results with both approaches.

3.4 Results

3.4.1 Descriptive statistics

On average, participants chose the right hand on 53.85% of the trials (SD=25.132, Range: [0–100]). There was a green bead in the chosen hand on 52.45% of the trials (SD=6.045, Range: [38.75–67.5]), and in the alternative hand in 50.275% of the trials (SD=6.465, Range: [33.75–63.75]). In Prediction trials, participants predicted that there was a green bead in the chosen hand in 52.267% of the trials (SD=21.322, Range: [0–100]).[8] As expected, participants' overall predictions were at chance: they were accurate on average in 49.4% of the trials (SD=11.851, Range: [30–83.333]).

3.4.2 Effect of the alternative

Across participants, the probability of predicting "Gain" was significantly higher when the alternative outcome was a loss (mean=59.401, SD=22.146) vs. a gain (mean=44.614, SD=28.538, t(49)=3.8382, p=0.0004; Figure 5). Similar results were obtained with the regression analysis (see Supplement Table 3).

[8]One participant always predicted that the received outcome would be a red bead, and one other participant always predicted that the received outcome would be a green bead. We chose not to exclude these participants from the sample so as to give an accurate picture of the way participants behaved in the task. Note that these outlying behaviors go against our hypothesis as these participants were indifferent to the value of the alternative outcome.

The correlation between the effect of the alternative value on predictions and the scores on the zero-sum questionnaire was not significant (Spearman's ρ=−0.0536, p=0.7117).

3.5 Discussion

Experiment 2 shows that the ALOE cannot be explained solely by preconceptions participants might have regarding outcome distributions, or regarding the way experimenters design computerized experiments. The ALOE did not disappear when we tested it in a non-computerized, physical setup in which any dependence between the two outcomes, and thus any effect of resource limitation, was physically inconceivable.

The lack of correlation between the Belief in a Zero-Sum Game questionnaire and the ALOE is consistent with these conclusions, although, as a null result, it should be taken with caution. First, the power (40 participants) was relatively low for this type of questionnaire. Second, it could also be a matter of construct validity. The Belief in a Zero-Sum Game questionnaire focuses on whether people believe that one person's gain is possible only at the expense of other persons. In our experiments, no social relations are formed.

The persistence of the ALOE in the current low-tech version of the experiment alleviates any explanation of the ALOE as resulting from effects of local correlations, or from other spurious effects that might influence the way participants estimate the actual relationship between the outcomes.[9] However, by design, the current experiment renders control for such relationships redundant: regardless of any biased calculations, the physical situation is such that the independence between outcomes is unequivocal. Moreover, the fact that the beads were returned to the bags after each trial, by the participants, "resets" the game, and mitigates the possible effects of any perceived local correlations.

In summary, Experiment 2 suggests that the ALOE does not derive from a limited goods belief — at least in its explicit form — as it persisted despite unequivocal situational evidence to the contrary. This raised the possibility that, even if participants cannot possibly believe that the drawing of a green bead from one bag depletes the amount of green beads in the other bag, they might still believe that it reduces their chances of drawing another green bead because of the restriction of *good luck* (henceforth Luck) in each trial. In the final experiment, we began to address this hypothesis.

[9]In all experiments here (see Supplement for the GEE analyses) and in Marciano-Romm et al., (2016), we controlled for local correlations by calculating, for each trial, the actual correlation experienced up to that trial and regressing out this effect. However, one could argue that this control is suboptimal if participants have biased contingency detection. That is, they may weigh negative experienced contingencies higher than positive contingencies. It is also possible that the experienced correlation should be calculated not from the beginning of the block but in some running window, reflecting subject-specific memory span of past trials. It is impossible to control for all such peculiarities using regressions as the parameter space is vast.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

4 Experiment 3

4.1 Introduction

In the Limited Goods Hypothesis presented in Experiment 2, *green coins* are perceived as the limited goods. In the Limited-Luck Hypothesis, on the other hand, *Luck itself*, rather than green coins, is the resource perceived as limited. Indeed, one might believe that there is only so much luck in the world, or in the game, and that if some of it has been allocated to the alternative outcome in a given trial, then there is that much less luck left for one's received outcome. With this belief in mind, a participant seeing a green coin in the alternative box or hand will conclude that luck has been "depleted" in this trial, and thus that his or her chances of getting a green coin in the chosen box (in the sCIB) or hand (in the sBIB) have been reduced. We hypothesized that if luck is the determining factor, then removing the value from the outcomes should eliminate the ALOE.

In the present experiment, we replicated the original ALOE experiments using the Sequential Coin in the Box task (Figure 1a,b); the only difference was that in the present experiment we did not attach value to the content of the boxes. That is, participants did not win or lose money in Regular trials, but only in Prediction trials. This manipulation allowed us to eliminate the role of luck, as there was no good or bad outcome, and thus no lucky or unlucky draw. Persistence of the effect would rule out the Limited Luck Hypothesis and could suggest that the ALOE was due to a preference for novelty.

4.2 Methods

4.2.1 Participants

The experiment was conducted on 50 students (26 females, mean age=24.4, SD=1.87). On average, the experiment lasted 35 minutes and participants received 40 New Israeli Shekels (approximately $11.70).

4.2.2 Procedure

The task The task was a computerized game replicating the sCIB task (Experiment 1) with the following exceptions:

1. Instead of green and red disks we used a blue disk and a blue triangle. The color blue was chosen in order to avoid the possible cultural association of red and green with specific valence (Figure 6).

2. Participants could not win or lose money in Regular trials and thus the disk or triangle were not associated with gain or loss. Participants could only gain money (3 points per trial) by making correct predictions in the Prediction trials.[10]

4.3 Statistical analysis

The analysis scheme was equivalent to the analysis of Experiments 1 and 2, with the necessary changes. For each participant, we computed the difference between the probability of predicting that the received outcome would be a disk, when the alternative outcome was a disk, and when the alternative outcome was a triangle. We then ran a one-sample t-test across participants on these differences.

4.4 Results

4.4.1 Descriptive statistics

On average, participants chose the right-side box in 57.78% of the trials (SD=36.574, Range: [0–100]). In Prediction trials, participants predicted that there was a disk in the chosen box in 48.775% of the trials (SD=8.966, Range: [8.75–61.25]). As expected, participants' overall predictions were at chance: they were accurate on average in 50.58% of the trials (SD=9.620, Range: [37.5–86.25]).

4.4.2 Effect of the alternative

We found no significant difference between the probability of predicting "disk" when the alternative was a disk (mean=49.274, SD=14.952), and when the alternative was a triangle (mean=48.138, SD=10.946; t(49)=0.4185, p=0.6774; Figure 7). Similar results were obtained with the regression analysis (see Supplement Table 4).

The absence of the ALOE in this experiment suggests that for the ALOE to occur, the outcomes of the choice options have to hold some value. However, these results should be interpreted cautiously as they rely on the acceptance of the null hypothesis. To directly test the impact of the outcomes' value on the ALOE, we conducted two additional analyses. First, we compared participants' behavior in Experiment 3 to participants' behavior in the zero correlation block of Experiment 1 of Marciano-Romm et al. (2016, 53 participants).[11] Importantly, Experiment 3 was purposely designed to be identical to Experiment 1 of Marciano-Romm et al. (2016): we used the same instructions, the same stimuli (colored

[10] In spite of the change in the incentives, participants should likely be as motivated as in the other experiments in which the regular trials had value. As in the experiments with value, the expected gains for Regular trials were equal to zero, and the potential reward per trials was much higher in prediction trials than in regular trials (3 points vsi or zero). Thus, the monetary bonus from all experiments was based mainly on performances in Prediction trials and not in Regular trials.

[11] In Experiment 1 from the original ALOE paper, trials were divided into three blocks, each block being characterized by a certain correlation (0; 0.4; −0.4). Here we took into consideration only trials from the "null correlation" block, which is comparable to the current experiment.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

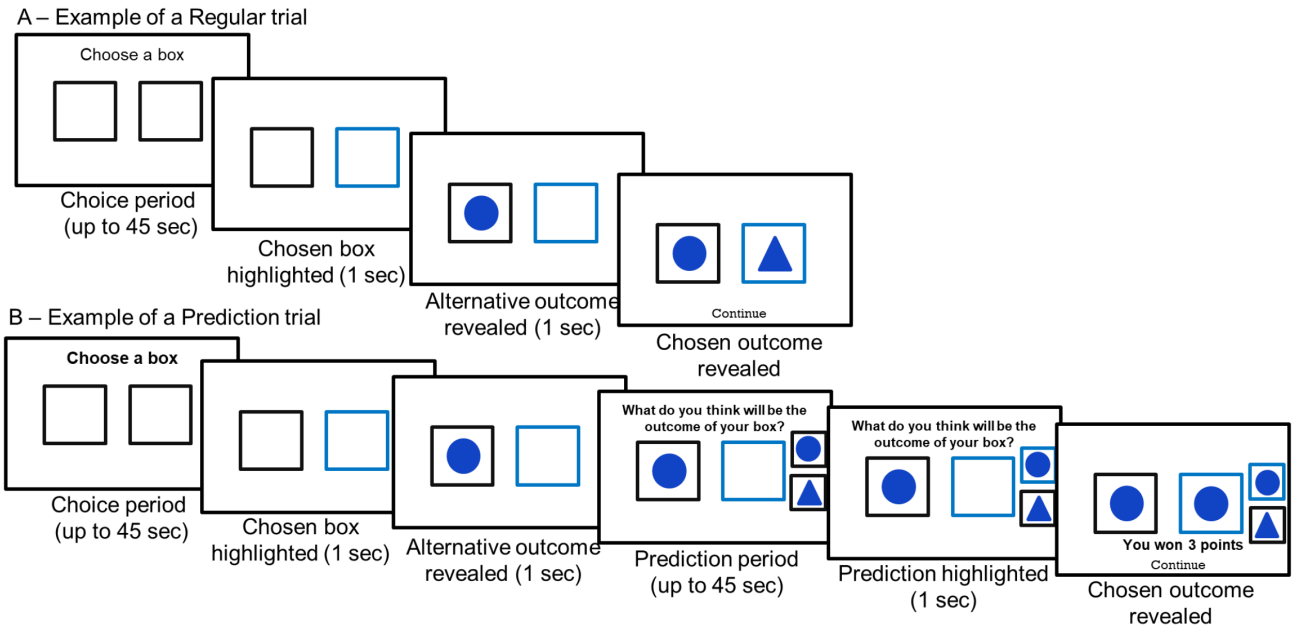

FIGURE 6: Experiment 3 paradigm.
(a) Example of a Regular trial. Notice that the participant does not win or lose points in Regular trials.
(b) Example of a Prediction trial. In this example, the participant accurately guessed that the chosen box would contain a triangle, and thus he won 3 points.

disks and triangles), and the same incentives for predictions (3 points for accurate predictions). The only difference between the two paradigms is that in Marciano-Romm et al., participants lost or gained money in Regular trials according to the content of the chosen box, whereas in the current Experiment 3, the outcomes had no value. For each participant in Experiment 1 of Marciano-Romm et al. we calculated the difference in the probability of predicting "Gain" when the alternative was a gain vs. a loss, as we did for the current study. We then ran a t-test between the groups from the different experiments on these differences. We found that the differential influence of the alternative on predictions in the current study (mean=−1.136, SD=19.193) was significantly lower than in Experiment 1 of Marciano-Romm et al. (mean=7.313, SD=22.635, t(101)=2.0374, p=0.0442). A similar approach was taken with the GEE analysis, which yielded similar results (see Table 5 in the Supplement). This confirms that the ALOE is significantly modulated by the value (or the absence thereof) of the choice options' outcomes.

Second, we performed a Bayesian analysis, to assess the likelihood of having no effect of the alternative outcome in Experiment 3, given the data. Bayes factors (*BF*s) reflect the strength of evidence for one hypothesis relative to another. In contrast with null-hypothesis significance testing, *BF*s can distinguish sensitive evidence for the null hypothesis H0 from no evidence for any conclusion at all (Dienes, 2014). The results of the analysis indicate evidence for a lack of ALOE when the outcomes of choice options are val-

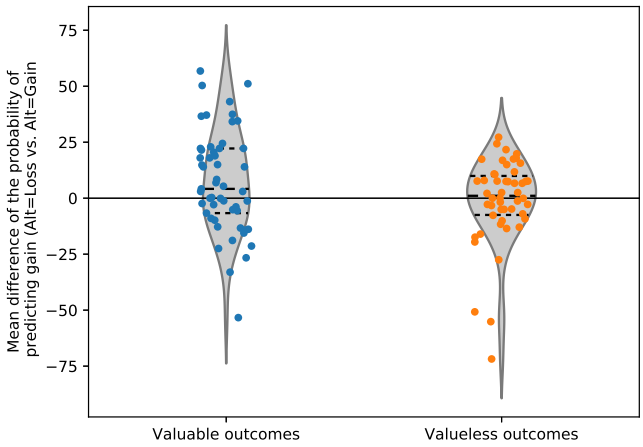

FIGURE 7: Distribution of the difference between the mean probability of predicting Gain when the alternative was a loss vs. a gain. The black dashed lines indicate the 25th, 50th and 75th quartile. The width of the outline ('violin') represents the density of observations at each level.
The left "violin" shows the distribution for Experiment 1 of Marciano-Romm et al. (2016), which is used here as a control condition in which the outcomes were valuable; the right violin shows the distribution for Experiment 3 in which the outcomes were valueless. Each dot represents a participant.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

ueless (BF<1/3). The details of this analysis appear in the Supplement (Table 6).

4.5 Discussion

According to the Limited Luck Hypothesis, the positive value of the alternative outcome indicates a depletion of good luck, which instigates negative expectations for the value of one's outcome. A direct prediction of this hypothesis is that the elimination of value will eliminate the ALOE. The results of Experiment 3 are consistent with this prediction: we neutralized the potential role of luck by making the outcomes of the boxes equally valueless, and the ALOE was eliminated. In addition, these results rule out mechanisms based on Novelty Preference. Indeed, under the Novelty Preference hypothesis, one would expect the ALOE to persist in Experiment 3, independently of the value (or lack of value) or the outcomes.

5 General discussion

We recently showed that after making a choice between two uncertain options, people tend to perceive an illusory negative correlation between the outcomes of these two options. That is, people see a good (bad) alternative outcome as a bad (good) sign of their own outcome, when the two outcomes are in fact uncorrelated – an effect we coined the Alternative Omen Effect (Marciano-Romm et al., 2016). Here, we confirmed the robustness of the ALOE across settings, and explored potential explanations for this novel bias. We find that the ALOE is due to individuals seeing specifically a good alternative outcome as a bad sign regarding their outcome, but find no evidence that they see a bad outcome as a positive sign. In that respect, the ALOE seems to be asymmetric. We rule out explanations of the ALOE based on (1) Novelty Preference, (2) local correlations with or without biased contingency perception, and (3) the Limited Goods Belief. Rather, we suggest that the ALOE could be related to the Limited Luck Belief.

5.1 The ALOE is a robust bias

The Alternative Omen Effect is a newly described bias that has been reported so far in one article only. Experiment 1 provided a direct replication of the original ALOE findings (Marciano-Romm et al., 2016). Experiment 2 allowed us to test the ALOE's robustness in two ways. First, we tested the ALOE in a different environment: we used a low-tech paradigm instead of a computerized task. Second, we investigated whether the effect survives when the lack of correlation between the outcomes is made obvious. We believe that having participants draw beads from two real, distinct cloth bags and experience by themselves that the two bags did not communicate (i.e., there was no "secret tunnel" between the two) is stronger than explicitly telling participants about the lack of correlation between the outcomes, as individuals in general are not acquainted with the statistical terms "correlation" and "covariation". Despite the changes in the paradigm, and despite the unequivocal situational evidence, we found a strong ALOE in this experiment too.

5.2 The Alternative Omen Effect is distinct from the Gambler's Fallacy

The Alternative Omen Effect bears a similarity to the Gambler's Fallacy, yet the two phenomena are distinct. First, the ALOE relates to the perception of a correlation between the outcomes of two different generators (two boxes or two bags), whereas the Gambler's Fallacy does not occur when a second generator is introduced (e.g., when the coin is changed in the middle of the experiment; Gold & Hester, 2008; or when a different person tosses the coin; Roney & Trick, 2009). Second, the Gambler's Fallacy occurs even when the outcomes of the random process are valueless (e.g., in the case of a coin toss, "heads" is not considered a good or a bad outcome). In contrast, in Experiment 3 we found no ALOE when the outcomes of the choice options are valueless. Finally, while the ALOE seems to be asymmetrical (Experiment 1), the Gambler's Fallacy is symmetrical: people predict tails after a streak of heads just as they predict heads after a streak of tails.

5.3 The ALOE is not due to novelty preference

According to the Novelty Preference Hypothesis, individuals are attracted to change rather than repetition, and thus would *prefer* to see a red coin after seeing a green coin, regardless of the value attached (or not) to these events. This is inconsistent with Experiment 3's findings, as making the boxes' outcomes valueless made the ALOE disappear. Additionally, the Novelty Preference Hypothesis cannot provide a good explanation of the asymmetry found in Experiment 1. Similarly, the Novelty Preference Hypothesis cannot account for the effect of self-relevance (Marciano-Romm et al., 2016): there is no good reason to expect individuals to be attracted to change when they have to predict the content of their box, but not when they have to predict the alternative outcome. It thus seems reasonable to conclude that the ALOE is not a manifestation of novelty preference.

5.4 The ALOE could be due to emotion regulation

The findings of the present studies can be explained by the emotion regulation hypothesis. According to this mechanism, individuals form expectations regarding the value of the received outcome aiming to regulate the emotions this outcome might elicit. In this framework, the asymmetry of

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

the ALOE found in Experiment 1 indicates that it is specifically regret that people try to regulate by expecting that a good alternative will be followed by a bad received outcome. In Experiment 3, when there were no valuable outcomes at stake, one does not need to regulate emotions as much, which is in line with the lack of ALOE found in this study. However, as discussed in the introduction section, emotion regulation cannot explain some of the previous results. Nevertheless, the implications of emotion regulation in the ALOE should be further investigated.

5.5 The ALOE and the Limited Good Belief

Our main hypothesis regarding the source of the ALOE was that it might be due to the belief that material goods and resources exist in limited quantities. A more limited version of this hypothesis, leading to the same predictions, is that the ALOE reflects only participants' specific belief that computerized lab experiments are designed like zero-sum games in which good outcomes come in finite quantities.

5.5.1 Previous empirical evidence for the limited-good hypothesis

Evidence for a zero-sum/limited good bias comes from various fields. Individuals tend to see negotiations as zero-sum, "fixed-pie" situations and often assume that their interests directly conflict with the other party's interests (Bazerman, 1983). For example, students tend to predict that a series of good grades will be followed by a bad one, seeing good grades as a limited good (Meegan, 2010), people assume that having more than one romantic partner in a polyamorous relationship results in less love for each of the partners (Burleigh et al., 2017), and tend to assume that the success of one person in the workplace implies less success for others (Sirola & Pitesa, 2017). In these examples, good grades, romantic love, and work success are seen as limited commodities.

The Limited Good belief can have a tremendous impact on behavior and decision-making. For example, it might lead negotiating parties to suboptimal agreement or no agreement at all (Baron et al., 2006; Bazerman, 1983), make employees less inclined to help each other (Sirola & Pitesa, 2017), reduce cooperation in the classroom (Burleigh, 2016), lead to social bias against consensual non-monogamists (Burleigh et al., 2017), or to prejudice against immigrants perceived as players in a zero-sum game (Esses et al., 1998). Given the pervasiveness of the Limited Good belief and its substantial effects, it is important to deepen our understanding of the bias, as well as try to identify the conditions under which the bias can be reduced.

5.5.2 Is the ALOE explained by the Limited Good belief?

Experiment 2, the "Beads in the Bag Experiment", was designed to test whether the ALOE is caused by the Limited Good belief: if the ALOE is indeed a manifestation of beliefs regarding the limitedness of goods, then neutralizing these beliefs should lead to an elimination of the effect. Some of the zero-sum studies mentioned above have used a similar rationale, but it is unclear whether they have managed to convince participants that the resource at stake was indeed unlimited. In the academic grades study (Meegan, 2010), the experimenter highlighted the unlimitedness of good grades by explicitly telling participants that grading was absolute (vs. relative); however, participants' own experience with grades distribution might have led them to assume otherwise. In the study on the zero-sum construal of success in the workplace (Sirola & Pitesa, 2017), participants read a scenario describing a work situation in which they were told that all the department members were to submit a proposal, and that a bonus would be given to all proposals satisfying a certain standard of quality. Participants were then asked whether they would be willing to help a coworker, who had obviously misunderstood the assignment. Here too, it is unclear whether mentioning that the proposals were judged in an absolute fashion was enough to overcome years of experience in the workplace, where usually only top performers are rewarded. Moreover, participants might have assumed that other resources beyond the scope of the scenario (e.g., future promotions) are in fact limited, and that helping a coworker now might come at a cost later.

The Beads in the Bag Experiment, on the other hand, tested the Limited Good Belief for the first time in a controlled environment in which: 1) the participants had no prior experience; 2) the unlimitedness of the resources was visible, palpable, and physically unequivocal. Yet, despite the unequivocal situational evidence, the ALOE held: participants acted as if they saw a good alternative outcome as a bad sign regarding their outcome.

These findings could indicate one of two things. First, some heuristic behaviors persist despite the existence of rational reasons why they should not (Denes-Raj & Epstein, 1994), and the Limited Good belief might be one of these. However, undermining the possibility that the Limited Goods belief is immutable, Marciano-Romm et al. (2016) found that participants got debiased with time: they evinced a smaller ALOE in the second half of the experiments than in the first half. Similar effects of experience were found for Experiment 1 herein (see Table 1 in the Supplement). This seems to indicate that individuals are sensitive to the information provided by the environment.

A second possibility is that the ALOE — and potentially some of the zero-sum behaviors referenced above — are explained at least partly by a somewhat different mechanism.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

We suggest that such a mechanism could be the Limited Luck belief.

5.6 The ALOE and the Limited Luck Belief

5.6.1 The Limited Luck Belief

According to the Limited Luck Hypothesis, luck – rather than material goods – is the resource perceived as limited in the ALOE experiments. The Limited Luck belief states that there is only so much luck in a given situation and that if some of it has been allocated, then there is less luck left.

For luck to be invoked as a causal factor for an outcome, two conditions must be realized. First, the outcome must be generated by a process involving at least a certain degree of randomness, as without uncertainty, there is no room for luck to affect outcomes. Second, the outcome of a random event needs to be associated with some value (either positive or negative) to be considered lucky or unlucky. In Experiment 3, we removed the value from the outcomes, and hypothesized that this manipulation should neutralize the Limited Luck belief and thus eliminate the ALOE. Consistent with this conjecture, we found that when the outcomes of the boxes were valueless geometrical shapes (vs. shapes associated with monetary gains and losses), participants did not evince the ALOE. Together with the asymmetry of the ALOE found in Experiment 1, these results suggest that it is specifically *good luck* that is perceived as limited. Interestingly, the studies of Meegan on students' perception of grades report a similar asymmetry: when many high grades had already been given, participants were more likely to predict that the next assignment would receive a low grade; however, when many low grades had already been given, there was not a corresponding increase in high grade predictions (Meegan, 2010).

The idea that luck can be conceived as an exhaustible resource might appear at first as a little farfetched. Yet, it is consistent with the observations of Keren and Wagenaar (1985), who found that people believe that luck can be detected and used wisely, or that it can be squandered foolishly and wasted – for example if one fails to recognize that it is his lucky day. It is also consistent with the Stock of Luck belief (Sundali & Croson, 2006), according to which individuals believe they have a fixed amount of luck and that once it is exhausted, their probability of winning decreases.

The Limited Luck Belief might explain why the ALOE results apparently contradict the findings of Kareev (1995) and Wilke and Barrett (2009), who reported an illusory positive correlation between sequential events. In Kareev's sequential task, participants were told that someone had produced a list of Xs and Os, and they were asked to predict, in each trial, the next item on the list. In Wilke & Barrett (2009), participants played a computerized sequential foraging game in which they experienced a sequence of hits and misses and were asked, after each event, to predict whether the next event would be a hit or miss. Notably, in these experiments, while accurate predictions were rewarded (as in our own studies), the specific outcomes of the sequential events (e.g., Xs and Os) were valueless. These experiments were thus by essence free of the Limited Luck Belief.

The Limited Luck Belief could partly explain the findings of some of the zero-sum studies mentioned above. Getting a good grade on an assignment, being successful at one's job, or finding a meaningful romantic relationship, are valuable outcomes that all comprise a certain amount of uncertainty and that could be perceived as benefiting from some good luck – or suffering from the lack of it.

5.6.2 Disentangling the Limited Luck belief from the Limited Good belief

Under certain circumstances, the Limited Good hypothesis and the Limited Luck hypothesis might have different predictions, allowing future studies to explore the unique contribution of each one of these biases to the observed behaviours.

5.6.3 Individual differences

The data from past and present studies of the ALOE indicate that some participants were more strongly biased than others, and that a minority were even biased in the opposite direction. Questionnaires targeting specific luck-related beliefs, such as the Belief in Good Luck scale (Darke & Freedman, 1997; Maltby et al., 2008), as well as targeting the locus of control, might shed some light on the heterogeneity between individuals.

5.6.4 Situations with low vs. high controllability

Individuals are likely to attribute a bigger role to luck in situations that are perceived as less controllable or more uncertain than others (Vyse, 1997). For example, superstitious beliefs increase following exposure to unsolvable, but not solvable problems (Dudley, 1999). The Limited Luck belief — but not the Limited Good belief — thus predicts that increasing the perceived randomness of a situation will lead to more ALOE and zero-sum-like behaviors. This prediction is consistent with our finding of a strong ALOE effect in the Beads in the Bag Experiment. By making the situational evidence unequivocal, we might have neutralized any part of the ALOE due to the Limited Good Belief, but at the same time, we might have strengthened the effect of the Limited Luck Belief, as the randomness of the game and its uncontrollability became obvious.

The controllability parameter might also explain why worse economic periods are associated with a more zero-sum-like construal of success (Sirola & Pitesa, 2017). Economic crises are characterized by greater uncertainty and

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

feelings of insecurity regarding the future. As a result, individuals might give a larger weight to luck in determining their success than they would in better times. Indeed, individuals who were subject to macroeconomic volatility during early adulthood tend to believe that individual success depends more on luck than effort (Giuliano & Spilimbergo, 2008), and individuals in bad macroeconomic environments offer higher prices on vehicle license plates with lucky numbers (Ng et al., 2010). Controllability could be manipulated by introducing some stochastic noise to the mechanism generating the outcomes. For example, in the grades experiment (Meegan, 2010), participants could be told that the professor grading the assignments tends to make mistakes when summing up the scores of the different parts of the assignment – resulting in some students getting better or worse grades than they actually deserve.

5.6.5 Interventions to reduce the bias

The Limited Good belief and the Limited Luck belief have different predictions regarding the efficiency of specific interventions. Esses et al. (1998) suggest that tensions between immigrants and host populations could be alleviated by interventions specifically targeting zero-sum beliefs (e.g., "jobs are not a limited resource"). We suggest that such interventions might not have the expected impact because, while neutralizing false beliefs regarding the scarcity of material resources, they do not address the Limited Luck belief. On the other hand, increasing individuals' sense of control over desired outcomes might diminish the place given to luck, and thus decrease the bias. Managers and teachers could highlight the fact that success is highly correlated with skills and efforts. They could provide the criteria they use to judge one's work in order to show that the evaluation process is immune to external noise (e.g., the boss being in a bad mood) – thus reducing the uncertainty experienced by their employees and students. Interventions targeted to reduce the Limited Luck belief may decrease the tendency to perceive the successes of others as a threat to one's own success, and in consequence encourage cooperation and reduce discrimination.

5.7 Open questions

The Limited Luck Hypothesis assumes that individuals see luck as limited for a certain situation. In our studies, for example, participants acted as if luck was limited per trial. But in general, what is perceived as "a situation"? One can think of a few factors that are likely to play a role in grouping events into a situation, such as temporal proximity (temporally contiguous events are more likely to be grouped together than events spread out over time), similarity (similar events are more likely to be grouped than dissimilar events), or context (events happening in the same context are more likely to be grouped than events happening in different contexts). Further experiments will be necessary to understand how and when individuals see distinct events as being governed by the same limited amount of luck – that is, how the luck economy works.

5.8 Conclusions

Following a choice between two options, individuals tend to see a good alternative outcome as a bad sign regarding their outcome. This is the Alternative Omen Effect (Marciano-Romm et al., 2016). Our current findings bolster the robustness of the ALOE and show that it cannot be explained by a preference for novelty or from perception of local sequential correlations. Importantly, our findings are inconsistent with the possibility that the ALOE results from the Limited Good belief. Rather, our findings could be explained either by individuals trying to regulate their anticipated emotions, or by individuals assuming that good luck is limited. The Limited Luck belief, which should be explored in future studies, could be the cause of a wide range of behaviors that have been attributed to the Limited Good belief, such as suboptimal negotiations, poor cooperation in the workspace and negative views toward immigration. Interventions specifically designed to neutralize this belief could reduce deadlocks and harmful, costly behaviors.

6 Bibliography

Alloy, L. B., & Tabachnik, N. (1984). Assessment of covariation by humans and animals: The joint influence of prior expectations and current situational information. *Psychological Review, 91*(1), 112–149.

Bar-Hillel, M., & Wagenaar, W. A. (1991). The perception of randomness. *Advances in Applied Mathematics*, *12*(4), 428–454.

Baron, J., Bazerman, M. H., & Shonk, K. (2006). Enlarging the societal pie through wise legislation: A psychological perspective. *Perspectives on Psychological Science, 1*(2), 123–132.

Bazerman, M. H. (1983). Negotiator judgment: A critical look at the rationality assumption. *American Behavioral Scientist, 27*(2), 211–228.

Bell, D. E. (1982). Regret in decision making under uncertainty. *Operations Research*, *30*(5), 961–981.

Beyth-Marom, R. (1982). Perception of correlation reexamined. *Memory & Cognition*, *10*(6), 511–519.

Burleigh, T. J. (2016). "Your gain is my loss": An examination of zero-sum thinking with love in multi-partner romantic relationships and with grades in the university classroom (Doctoral dissertation). http://hdl.handle.net/10214/10034.

https://doi.org/10.1017/S1930297500004873 Published online by Cambridge University Press

Burleigh, T. J., Rubel, A. N., & Meegan, D. V. (2017). Wanting 'the whole loaf': Zero-sum thinking about love is associated with prejudice against consensual non-monogamists. *Psychology & Sexuality, 8*(1–2), 24–40.

Chapman, L. J., & Chapman, J. P. (1967). Genesis of popular but erroneous psychodiagnostic observations. *Journal of Abnormal Psychology*, *72*(3), 193–204.

Chapman, L. J., & Chapman, J. P. (1969). Illusory correlation as an obstacle to the use of valid psychodiagnostic signs. *Journal of Abnormal Psychology*, *74*(3), 271–280.

Churchill, G. A., Jr., & Surprenant, C. (1982). An investigation into the determinants of customer satisfaction. *Journal of Marketing Research, 19*(4), 491–504.

Darke, P. R., & Freedman, J. L. (1997). The belief in good luck scale. *Journal of Research in Personality*, *31*(4), 486–511.

Denes-Raj, V., & Epstein, S. (1994). Conflict between intuitive and rational processing: When people behave against their better judgment. *Journal of Personality and Social Psychology*, *66*(5), 819–829.

Dienes, Z. (2014). Using Bayes to get the most out of non-significant results. *Frontiers in psychology*, *5*, 781.

Dudley, R. T. (1999). The effect of superstitious belief on performance following an unsolvable problem. *Personality and Individual Differences, 26*(6), 1057–1064.

Esses, V. M., Jackson, L. M., & Armstrong, T. L. (1998). Intergroup competition and attitudes toward immigrants and immigration: An instrumental model of group conflict. *Journal of social issues, 54*(4), 699–724.

Foster, G. M. (1965). Peasant society and the image of limited good. *American Anthropologist*, *67*(2), 293–315.

Giuliano, P., & Spilimbergo, A. (2008). *Growing up in bad times: Macroeconomic Volatility and the Formation of Beliefs*. UCLA mimeo.

Gold, E., & Hester, G. (2008). The gambler's fallacy and the coin's memory. In J. I. Krueger (Ed.), *Rationality and Social Responsibility: Essays in Honor of Robyn Mason Dawes* (pp. 21–46). London: Psychology Press.

Hanley, J. A., Negassa, A., & Forrester, J. E. (2003). Statistical analysis of correlated data using generalized estimating equations: An orientation. *American Journal of Epidemiology*, *157*(4), 364–375.

Inman, J. J., Dyer, J. S., & Jia, J. (1997). A generalized utility model of disappointment and regret effects on post-choice valuation. *Marketing Science, 16*(2), 97–111.

Kareev, Y. (1995). Positive bias in the perception of covariation. *Psychological Review*, *102*(3), 490–502.

Keren, G. B., & Wagenaar, W. A. (1985). On the psychology of playing blackjack: Normative and descriptive considerations with implications for decision theory. *Journal of Experimental Psychology: General, 114*(2), 133–158

Loomes, G., & Sugden, R. (1982). Regret theory: An alternative theory of rational choice under uncertainty. *The Economic Journal, 92*(368), 805–824.

Maltby, J., Day, L., Gill, P., Colley, A., & Wood, A. M. (2008). Beliefs around luck: Confirming the empirical conceptualization of beliefs around luck and the development of the Darke and Freedman beliefs around luck scale. *Personality and Individual Differences*, *45*(7), 655–660.

Marciano, D., Bentin, S., & Deouell, L. Y. (2018). Alternative outcomes create biased expectations regarding the received outcome: Evidence from event-related potentials. *Neuropsychologia*, *113*, 126–139.

Marciano-Romm, D., Romm, A., Bourgeois-Gironde, S., & Deouell, L. Y. (2016). The Alternative Omen Effect: Illusory negative correlation between the outcomes of choice options. *Cognition*, *146*, 324–338.

Meegan, D. V. (2010). Zero-sum bias: perceived competition despite unlimited resources. *Frontiers in psychology, 1*, 191.

Mellers, B. A., Schwartz, A., Ho, K., & Ritov, I. (1997). Decision affect theory: Emotional reactions to the outcomes of risky options. *Psychological Science, 8*(6), 423–429.

Mellers, B. A., Schwartz, A., & Ritov, I. (1999). Emotion-based choice. *Journal of Experimental Psychology: General*, *128*(3), 332–345.

Morewedge, C. K., Tang, S., & Larrick, R. P. (2016). Betting your favorite to win: Costly reluctance to hedge desired outcomes. *Management Science*, *64*(3), 997–1014.

Ng, T., Chong, T., & Du, X. (2010). The value of superstitions. *Journal of Economic Psychology, 31*(3), 293–309.

Oliver, R. L. (1980). A cognitive model of the antecedents and consequences of satisfaction decisions. *Journal of Marketing Research*, *17*(4), 460–469.

Oliver, R. L., & DeSarbo, W. S. (1988). Response determinants in satisfaction judgments. *Journal of Consumer Research, 14*(4), 495–507.

Roney, C. J., & Trick, L. M. (2009). Sympathetic magic and perceptions of randomness: The hot hand versus the gambler's fallacy. *Thinking & reasoning*, *15*(2), 197–210.

Różycka, J., & Wojciszke, B. (2009). Dlaczego ludzie myślą, że życie jest grą o sumie zerowej? Uwarunkowania i konsekwencje społeczno - ekonomiczne w Polsce i na świecie [Why do people think, that life goes like a zero-sum game? Determinants and socio-economic consequences, in Poland and in the world]. In K. Skarżyńska (Ed.), Przekonania w życiu jednostek, grup, społeczności [Convictions of individuals, groups and community] (pp. 67–83). Warsaw, Poland: SWPS Academica Press.

Różycka-Tran, J., Boski, P., & Wojciszke, B. (2015). Belief in a zero-sum game as a social axiom: A 37-nation study. *Journal of Cross-Cultural Psychology*, *46*(4), 525–548.

Sirola, N., & Pitesa, M. (2017). Economic downturns undermine workplace helping by promoting a zero-sum construal of success. *Academy of Management Journal, 60*(4), 1339–1359.

Sundali, J., & Croson, R. (2006). Biases in casino betting: The hot hand and the gambler's fallacy. *Judgment and*

Decision Making, *1*(1), 1–12.

Thompson, D. A., & Yarnold, P. R. (1995). Relating patient satisfaction to waiting time perceptions and expectations: The disconfirmation paradigm. *Academic Emergency Medicine, 2*(12), 1057–1062.

Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. *The Quarterly Journal of Economics*, *106*(4), 1039–1061.

Vyse, S. A. (1997). Believing in Magic. New York, NY: Oxford University Press.

Wilke, A., & Barrett, H. C. (2009). The hot hand phenomenon as a cognitive adaptation to clumped resources. *Evolution and Human Behavior*, *30*(3), 161–169.

Wiseman, R., & Watt, C. (2004). Measuring superstitious belief: Why lucky charms matter. *Personality and Individual Differences*, *37*(8), 1533–1541.

Zeelenberg, M. (1999). Anticipated regret, expected feedback and behavioral decision making. *Journal of behavioral decision making*, *12*(2), 93–106.