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A note on negativity bias and framing response asymmetry

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Abstract An "unprocessed risk" is a collection of simple lotteries with a reduction-rule that describes the actual-payoff to the decision-maker as a function of realized lottery outcomes. Experiments reveal that the willingness to pay for unprocessed risks is consistently biased toward the payoff-level in the unprocessed representation. The "anchoring-to-frame" bias in cases of positive framing is significantly weaker than in cases of negative framing suggesting that rational "negativity bias" may reflect in asymmetric violations of rationality.

Keywords Bounded rationality · Framing-invariance · Loss-aversion

1 Introduction

The literature on framing and representation effects in decision and choice is immense in scope and volume. While classic examples like Tversky and Kahneman (1981), Asian disease are eloquently resolved within Prospect theory, other violations of "framing-invariance" generate prolonged debate and controversy. Framing experiments reveal surprising and even anecdotic results suggesting that subtle modifications

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Your initial balance is 100 NIS

We ask you to bid for a lottery-ticket that pays the maximum in 3 independent draws from the lotteries below.

That is, the lottery-ticket pays *max{x,y,z}* where *x* is the outcome of lottery L1, *y* is the outcome of lottery L2 and *z* is the outcome of lottery L3.

What is your price-offer for the lottery?

My price-offer is____________________

Lottery L1 (x)**:**

Probability	Payoff
50%	115
50%	46

Lottery L2 (y)**:**

Probability	Payoff
50%	73
50%	46

Lottery L3 (z)**:**

Probability	Payoff
50%	115
50%	85

Fig. 1 Problem C in unprocessed frame

may significantly alter decision.[1] Recent fMRI studies confirm that the emotional system plays a key role inducing framing bias, while enhanced activity of the "analytical" system may mitigate the effect (De Martino et al. 2006). The large variety of documented bias and the long list of peripheral variables that may distract rational decision defy the attempts to "model bounded rationality" (Rubinstein 1998). Salant (2007) oppositely demonstrates that any choice rule which is procedurally simpler than expected utility maximization would display framing bias.

This note deals with a distinct type of representation effect that has not been examined in preceding literature. We study the case where risks are presented to the decision-maker (DM) in "unprocessed frame". DM is told, for example, that her actual-payoffs would be the maximal (or minimal) realization in independent draws from given simple lotteries. The "unprocessed" representation does not disclose the distribution of final-payoffs; the decision-maker, however, may calculate the specific reduced-form distribution from the data (see Fig. 1 for numerical example).

In the main experiment, we have presented seven pairs of unprocessed risks and corresponding reduced-form lotteries to advanced B.Sc. students with formal backgrounds sufficient for solving the statistical reduction problems. The unprocessed and reduced-form versions were presented in distinct sessions attempting to conceal the relation between dual problems. The lotteries were sold to the subjects in incentive-compatible Vickrey auctions to promote competitive pricing. The auction method was

[1] The literature is too rich and diverse to survey in this note. For a typology and thorough discussion of valence framing effects (and detailed discussion of the Asian disease example) see Levine et al. (1998). Violations of "framing-invariance" that inspired theoretical debates include the "reduction of compound lotteries" (see the survey in Seidl 2002) and "probability-splitting effects" (see the recent discussion in Birnbaum 2007). For an example to the rich spectrum of variables that may affect subjects' response to equivalent frames see Budescu and Fischer (2001) experiments with the process of chance-realization.

described in the instructions and subjects were advised to bid their true willingness to pay (WTP) as deviations might only decrease their payoffs.

Comparison of the individual bids for unprocessed and reduced-form problems reveals that the WTP for unprocessed risks is consistently biased toward the mean-payoff in the unprocessed frame. When the unprocessed representation, for example, specifies that the subject would receive the maximal outcome in three independent draws, the bids for the unprocessed version are lower than the bids for the corresponding reduced-form lottery. When the reduction rule, on the other hand, indicates that actual-payoffs would be equal to the minimal draw, the bids for the unprocessed version are higher than the bids for the reduced-form lottery. Therefore, the subjects appear to anchor their willingness to pay for unprocessed risks to the payoff-level in the unprocessed frame. The "anchoring-to-frame" bias is observed in six examples and is partially confirmed in a binary-choice experiment. An opposite hypothesis suggesting that the use of max/min reduction rules would induce aggressive/cautious bidding relatively to the pricing of corresponding reduced-form versions ("contrast affect") is strongly rejected.

Interestingly, moreover, we find that—in three different comparisons—the bias in cases of positive framing (where the mean-payoff in the unprocessed frame is higher than the mean-payoff on the reduced-form risk) is significantly weaker than the bias in cases of negative framing (where the reverse inequality holds). We attribute the asymmetry to "negativity bias" claiming that the subjects act more attentively in cases of false positive framing, while bidding "loosely" and exhibiting significantly stronger bias in cases of negative framing. The earlier psychological literature on "negativity bias" demonstrates that the effect of negative information is, in general, stronger than the effect of parallel positive information (see the survey in Kanouse and Hanson 1972). In rational choice theory, negativity bias reflects in various forms like loss-aversion, regret or disappointment aversion, and more. Using Prospect theory's loss-aversion (Kahneman and Tversky 1979), the weaker response to false positive frames may be explained by DMs attempt to avoid the losses that may occur if they are mislead by irrelevant positive framing. Regret (Bell 1982; Loomes and Sugden 1982) or disappointment aversion (Gul 1991) provide similar, alternative explanations to the significantly weaker effect of positive framing. Therefore, our experiment demonstrates that established principles of empirical/rational choice, like loss or regret aversion, may reflect in apparent deviations from rationality.[2]

The statistical exercise of reducing an unprocessed risk to a simple-lottery may be non-trivial even for subjects with adequate formal education. The literature on bounded rationality and complex decision suggests that decision-makers resort to rules of thumb, heuristics, or intuition to tackle such complicated tasks (e.g., Gigerenzer and Selten 2001). Only one of 55 subjects that participated in the main experiment formally reduced the unprocessed risks into the corresponding reduced-form lotteries. Examination of individual questionnaires and casual debriefing suggest that subjects constructed their bids informally building on representative figures in the unprocessed frame or arbitrary statistics which we could not rationalize. Then, the asymmetry in

[2] We refer to loss-aversion as "rational," while treating violations of framing-invariance as apparent irrationality; for supporting discussion see, for example, Kahneman (1994).

bias suggests that the procedure or the sorting method employed by the subjects in cases of "positive framing" are substantively different from the procedures employed in cases of "negative framing." Simon (1986) argues that "… in procedural theory, it may be very important to know under what circumstances certain aspects of reality will be heeded and others ignored." The experiments suggest that loss-aversion (or other expressions of negativity bias) may interfere with framing effects directing decision-makers into conservative pricing and leading to significantly weaker bias in cases of false positive framing.

The note proceeds as follows: Sects. 2–5 discuss the experiments and the results. Additional implications are outlined in the concluding discussion (Sect. 6).

2 Method and hypotheses

For concrete motivation, consider the WTP for professional training. At the end of training, the decision-maker will be qualified for three alternative jobs. The payoffs for each job are described in the form of a simple-lottery. Let *L1*, *L2*, and *L3* denote the corresponding payoff distributions and assume that the lotteries are mutually independent. Further, assume that DM is guaranteed to obtain the job with highest realized payoff. The actual-payoff for training is, therefore, MAX{*L1, L2, L3*}. The distribution of actual-payoffs is not described explicitly but can be calculated from the underlying data (see Fig. 1 for a numeric example). The job payoffs are thus provided in "unprocessed" frame. By definition, the distribution of actual-payoffs stochastically dominates each of the underlying lotteries *L1, L2*, and *L3*. The expected-payoff on the reduced-form lottery, in particular, is larger than the average "payoff-level" in the unprocessed frame.[3] Therefore, the unprocessed version represents a "negative framing" (in payoff-levels) of the reduced-form risk in this case.

Alternatively, the reduction rule could refer to the minimal draw across the three lotteries. Then, the actual-payoff is described by the function MIN{*L1, L2, L3*}. In the latter case, we refer to the unprocessed framing as "positive", since the expected reduced-form payoff is lower than the average-payoff in the unprocessed frame.

In the main experiment, advanced B.Sc. students with adequate backgrounds in statistics were asked to price 7 unprocessed risks and their equivalent reduced-form lotteries. The unprocessed and reduced-form versions were presented in distinct separate sessions attempting to conceal the relation between dual problems. The lotteries were sold to the subjects in 2-players Vickrey auctions to examine the pricing decisions in incentive-compatible competitive setting. Subjects received an initial balance of 100 New Israeli Shekels in each problem (see Fig. 1) and the instructions explained that if they win the lottery at price *X* and the realized outcome is *Y*, their final balance would be $100 - X + Y$ (see supplementary appendix for the complete instructions). The instructions clarified that at the end of the experiment, subjects would be randomly matched into pairs and one problem would be selected for each pair to determine their

[3] We use the term "average-payoff (or payoff-level) in the unprocessed frame" to denote the average of expected-payoffs on the lotteries constituting the unprocessed frame. In the example above, the payoff-level in the unprocessed version is $[E(L1) + E(L2) + E(L3)]/3$ where $E(L)$ is the expected-payoff on lottery L.

checks.[4] The auction/payment mechanism was described in the written instructions and carefully demonstrated on the blackboard. Subjects were advised to bid their "maximal willingness to pay" as false bidding might only decrease their payoffs. In order to avoid subject-suspicion, we guaranteed the precise implementation of the different lotteries (e.g., the drawing of three prizes independently to determine the maximum) and invited the subjects to check our payoff files at the end of the experiment.

The experiment was divided into 4 in-class sessions.[5] No time-limits were imposed in any of the sessions and subjects could use a calculator at their discretion. No details were provided on the relation between problems; inquiring students were asked to defer questions to the end of the experiment. The within-subject comparison of bidding for unprocessed and reduced-from versions has the obvious advantage of controlling for individual heterogeneity. On the other hand, the within-subject design runs the risk that subjects would recognize the second version from the first (e.g., subjects may recall the reduced-form version when they examine the unprocessed one and speculate that actual-payoff distributions are similar). In order to reduce such risk, we have used numbers and probabilities with non-zero digits that should be more difficult to recall across sessions (in problems C–G). However, the representation effects also appear in cases, where we use rounded numbers (problems A–B). The instructions did not direct the subjects to formally reduce the unprocessed versions, since this could have shifted the scope of the experiment into checking statistical competency, while our goal was to examine intuitive bidding for unprocessed frames.

In analyzing the results, we say that a subject complies with "reduction" (of unprocessed risks) if, the WTPs for the unprocessed and reduced-form versions are similar.[6] We posit two directed alternatives regarding cases where reduction is violated. Say that the subject exhibits "anchoring-to-frame," when the WTP for the unprocessed version is biased toward the mean-payoff in the unprocessed representation.[7] When the unprocessed version, for example, pays the "maximal draw" among three lotteries, subjects that exhibit "anchoring-to-frame" would submit lower bids for the unprocessed version compared to their bids for the corresponding reduced-form lotteries. The ranking would reverse when the unprocessed version pays the "minimal draw."

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4 Subjects received 1/3 of their final auction-balance. The average actual payout in the experiment was 43.3 NIS (about 9.1 US dollars), the maximal payoff was 77 NIS (16.2 dollars), and the minimal payoff was 30 NIS (6.3 dollars).

5 The reduced-form versions of problems A and B were presented at the beginning of a 90 min class, while the unprocessed versions of the problems were presented 1 h later toward the end of the same class. The unprocessed versions of problems C–G were presented to the class at another meeting; the reduced-from versions were presented one week later.

6 Since the unprocessed and reduced-form versions were presented in distinct sessions, random differences may arise and subjects could be classified as complying with reduction even if their bids differ by some reasonable "band". Since only one subject formally derived the reduced-form distributions, we will not bother with this and assume a band of 0 in testing individual behavior (see Sect. 3.4).

7 The hypotheses can be formalized as follows: let Z denotes an unprocessed risk and $r(Z)$ denotes the reduced-form version. Use $E(Z)$ to represent the average-payoff-level in the unprocessed frame and $E(r(Z))$ to denote the mean actual-payoff; $V(Z)$ and $V(r(Z))$ would similarly denote the valuations of the two versions. Then, anchoring-to-frame requires that $V(Z) \leq V(r(Z))$ when $E(Z) \leq E(r(Z))$, while $V(Z) \geq V(r(Z))$ when $E(Z) \geq E(r(Z))$. The valuation inequalities are reversed to represent the "contrast affect."

The psychological literature on anchoring effects (Tversky and Kahneman 1974) suggests that preliminary impressions may tint judgments and decisions as subjects fail to fully adjust their assessments beyond these anchors. In the current application, the payoff-level in the unprocessed representation may serve as an anchor, effecting the valuations of subjects that conform to the hypothesis.[8]

Alternatively, say that the subject exhibits a "contrast affect" when the bid for the unprocessed version is affected by the type of reduction-rule. The psychological literature on contrast effects suggests that judgments on target objects may become more extreme when contrasted with objects of lesser value (see the survey in Biernat 2005).[9] In the current design, the contrast is generated by using the max/min functions to represent the actual-payoff. Subjects that exhibit a "contrast affect" would submit higher bids for the unprocessed version (compared to their bids for the reduced-form version) in the max-payoff case, thereby reflecting the positive affect of the "max-payoff" rule on their WTP. Again, the ordering should reverse when the unprocessed version discouragingly employs the min-payoff reduction rule.

In the next section, we present three examples, each consisting of two symmetric negative/positive problems to test the competing hypothesis.

3 Experimental evidence

3.1 Example I

The unprocessed version of problem A was built on a payoff-matrix with 6 prizes. Subjects were asked to bid for a lottery-ticket that pays the maximal draw in random selection of three distinct cells from the matrix. Problem B used a similar construct paying the minimal draw in random selection of three cells from a different matrix. The unprocessed versions of the two problems are summarized in italics below (the complete versions are provided in the Supplementary appendix):

Problem A (*Unprocessed frame*) Your prize will be determined by random selection of three different cells from the following matrix:

20	120
70	0
120	70

You will receive the maximal payoff in the three chosen cells.

Problem B (*Unprocessed frame*) Your prize will be determined by random selection of three different cells from the following matrix:

8 We assume the mean-payoff in the unprocessed frame is a sufficient statistic for characterizing the anchoring effect. In the examples examined in this note, the assumption is innocuous.

9 Higgins and Lurie (1983), for concrete example, demonstrate that the sentencing decisions of a given judge may be categorized as "lenient" in the context of other judges that gave higher sentences, while being categorized "harsh" in a context where other judges gave lower sentences. Nayakankuppam and Mishra (2005) interestingly show that contrast effects may attenuate the endowment effect.

20	140
70	20
120	70

You will receive the minimal payoff in the three chosen cells.

Since only two payoffs are lower than 70 in matrix A, the maximal payoff in three different cells can be either 70 or 120. The probability that the maximum will be 70 is $(4/6) \times (3/5) \times (2/4) = 0.2$. The reduced-form lottery, therefore, pays 120 with probability 80% or 70 with probability 20%. The reduced-form version stochastically dominates the payoff distribution in matrix A (under uniform random selection). In the terminology of Sect. 2, the unprocessed version represents a "negative framing" of the reduced-form lottery. The expected-payoff on the reduced-form lottery, in particular, is 110 compared to an average-payoff of 66.67 in the unprocessed frame.

The arguments regarding the reduction of problem B are similar. Since only two payoffs in matrix B are higher than 70, the minimum payoff in three distinct cells can be either 70 or 20. The probability that the minimum will be 70 is $(4/6 \cdot 3/5 \cdot 2/4) = 0.2$, so the reduced-form lottery pays 20 with probability 80% and 70 with probability 20%. Since the reduced-form payoff distribution is dominated by (a uniform distribution on) the payoffs in matrix B, the unprocessed version represents a "positive framing" of the lottery. The expected-payoff on the reduced-form lottery, in particular, is 30 compared to an average-payoff of 73.33 in the unprocessed representation. Note that the difference between actual expected-payoffs and the average-payoff in matrix B $(30 - 73.33 = -43.33)$ is equal, in absolute value, to the corresponding distance for problem A $(110 - 66.67 = 43.33)$. The mean-payoff distance between the reduced-form and unprocessed versions is, therefore, similar (but opposite in sign) in problems A and B.[10]

The unprocessed versions of the two problems were presented to the subjects at the beginning of a 90 min class; the reduced-form lotteries were presented 1 h later toward the end of the same class. The median bid for the unprocessed version of problem A was 72 compared to a median bid of 95 for the reduced-form version of the problem. The hypothesis of equality ("reduction") is rejected in a Wilcoxon signed-rank test at $p < 0.001$ ($z = 4.9$; see Table 1). The direction of bias conforms with "anchoring-to-frame" as the WTP for the unprocessed version is lower than the WTP for the reduced-form lottery. As anticipated by the anchoring hypothesis, the direction of bias is reversed for problem B where the bids for the unprocessed version (median: 45) are higher than the bids for the reduced-form version (median: 30). In this case, the positive frame of the unprocessed version significantly increases the valuation relatively to the reduced-form version ($z = -2.8$; $p < 0.01$).

Individual-level comparisons confirm that 41 subjects (of 55) have bid higher for the reduced-form version of A compared to the unprocessed version, while only 8 subjects have bid higher for the unprocessed version of the problem. The individual-level support for anchoring-to-frame, however, is weaker in problem B, where 30 subjects

[10] An alternative design would elicit the WTP for a given lottery in two distinct (positive and negative) unprocessed frames. In such within-subject design, however, subjects must evaluate the same lottery (or close variations) in three different frames (reduced-form, positive, and negative frames) which increases the risk of dependent/sequential bidding.

Table 1 Comparison of unprocessed and reduced-form pricing

Problem	A	B	C	D	E	F	G
Type of frame (negative or positive)	Negative	Positive	Negative	Positive	Negative	Positive	–
Expected reduced-payoff	110	30	107.5	52.75	89.25	71	80
Mean-payoff-level in unprocessed frame	66.67	73.33	80	80	80	80	80
Median Bid for reduced-form version	95	30	100	49	87	65	75
Median Bid for unprocessed version	72	45	85	52	80	67	74
Wilcoxon statistic (normalized)	+4.9	−2.8	+5.0	−2.0	3.1	−0.4	1.75

We report the results for the 55 subjects that have participated in all 4 sessions; similar results are observed when subjects that have missed some parts of the experiment are included

have bid higher for the unprocessed version while 19 subjects have bid higher for the reduced-form problem. Therefore, the subject-level comparisons suggest that the anchoring effect is weaker in the case of "positive framing" (problem B) compared to the case of "negative framing" (problem A). The significance of the asymmetry is confirmed in a Wilcoxon signed-rank test as follows: let d(P) denote the difference between the bid for the unprocessed version of problem P and the bid for the reduced-form version of the lottery. If the anchoring bias is symmetric (in mean-payoff distance) than the negative bias in problem A should cancel off the positive bias in problem B, so that $d(A) + d(B) = 0$. In the data, however, $d(A) + d(B) = -9.4$ on average and the hypothesis that the effects cancel off is strongly rejected in a Wilcoxon signed-rank test ($z = -1.99$; $p < 0.05$).[11] The anchoring-to-frame effect, therefore, appears significantly stronger in the case of "negative framing" compared to the "positive framing."

3.2 Example II

The unprocessed version of problem C was introduced in the motivating discussion, recall Fig. 1 above. Subjects were asked to bid for a lottery-ticket that pays the maximal realization in three independent draws from distinct independent binary lotteries: *L1*, *L2*, and *L3*. The three basic-lotteries were presented in parallel tables; the reduction-rule was described verbally and in a formula.

Since lottery *L3* pays at least 85, while lottery *L2* pays at most 73; lottery *L2* can never determine the maximum. It follows that $\max\{L1, L2, L3\} = \max\{L1, L3\}$ takes the values 115 with probability 75% and 85 with probability 25%. The reduced-form payoff distribution clearly dominates each of the underlying lotteries *L1–L3*. The unprocessed version of problem C, therefore, constitutes a "negative framing" of the reduced-form lottery.

The unprocessed version of problem D used the same 3 binary lotteries *L1–L3*, but applied the $\min\{x, y, z\}$ reduction-rule instead of the maximal rule of problem C. The reduction argument in similar: Since lottery *L3* pays at least 85 while lottery *L2*

[11] The results of a sign-test are weaker as $d(A) + d(B)$ is negative/positive for 27/19 subjects, respectively. The sign-test results are also weaker (compared to the more powerful Wilcoxon signed-rank tests) for Example II (where $d(C) + d(D)$ is negative/positive for 30/20 subjects) and for Example III (where $d(E) + d(F)$ is negative/positive for 32/21 subjects).

pays at most 73, lottery *L3* can never determine the minimal payoff. It follows that $\min\{L1, L2, L3\} = \min\{L1, L2\}$ and the reduced-form lottery pays 46 with probability 75% or 73 with probability 25%. Since the reduced-form payoff is dominated by the binary lotteries in the unprocessed frame, this constitutes a case of "positive framing" as opposed to the "negative framing" of problem C.

The unprocessed and reduced-form versions of the two problems were presented to the subjects in distinct sessions. The unprocessed versions were presented at the first session and the reduced-form versions were presented one week later. The median bids are disclosed on Table 1. Again, the bids for the unprocessed version are significantly lower/higher than the bids for the reduced-form lotteries in cases of negative/positive framing, respectively. Sign-tests and Wilcoxon signed-rank tests confirm that the anchoring-to-frame effect is statistically significant at $p < 0.001$ in each of the comparisons, but as in the case of problems A and B, the z-statistic is about 50% smaller for the case of positive framing. As in example I, we use the sum d(C) + d(D) to test the significance of the asymmetry. The mean value of d(C) + d(D) equals −7.9 and the hypothesis d(C) + d(D) = 0 is strongly rejected in Wilcoxon signed-rank test ($z = -2.11$; $p < 0.05$). Again, the representation effect appears significantly stronger on the negative side.

3.3 Example III

The classic literature on bounded rationality (Simon 1955) suggests that decision procedures are simplified when decisions become more complex. Increase in complexity may also increase the noise in the decision process (e.g., Mazzotta and Opaluch 1995). In problems E and F, we utilize the construct of example II to test if the asymmetric anchoring effect still reflects, when (a) reduction-rules are more complicated and (b) the (mean) payoff-level in the unprocessed frame is closer to the expected-payoff on the reduced-form lottery. The unprocessed versions of two problems used the same collection of binary lotteries *L1–L3* as problems C and D above, but the reduction rules now employed a weighted average of the maximal and minimal draws. The reduction-rule for problem E is described in italics below:

Let M denotes the maximal prize drawn in the 3 lotteries; i.e., $M = \max\{x, y, z\}$.
Let N denotes the minimal prize drawn in the 3 lotteries; i.e., $N = \min\{x, y, z\}$.
The payoff of the current lottery-ticket is $\frac{2M+N}{3}$.

The reduction-rule for problem F is described next:

Let M denotes the maximal prize drawn in the 3 lotteries; i.e., $M = \max\{x, y, z\}$.
Let N denotes the minimal prize drawn in the 3 lotteries; i.e., $N = \min\{x, y, z\}$.
The payoff of the current lottery-ticket is $\frac{M+2N}{3}$.

Direct calculations reveal that the mean (actual) payoff in case E is 89.25, while the mean actual-payoff in case F is 71.[12] Since the mean-payoff on lotteries *L1–L3* is

[12] The reduced-form of E pays 101 with probability 25%; 92 with probability 50% and 72 with probability 25%; the reduced-form of F pays 87 with probability 25%; 69 with probability 50% and 59 with probability 25%.

80, anchoring-to-frame implies that the WTP for the unprocessed version of E will be lower than the WTP for the reduced-form version, while the WTP for the unprocessed version of F will be higher than the WTP for the parallel reduced-form lottery. The median bids for the unprocessed and reduced-form versions of the problems together with the Wilcoxon statistics are provided in Table 1. Again, the anchoring hypothesis is confirmed on the aggregate, as the bids for the unprocessed version are higher on average than the bids for the reduced-form version in the case of problem E and the direction is reversed in the case of problem F. The Wilcoxon tests suggest that the differences are statistically significant in the case of problem E ($p < 0.01$) but do not reach significance in the case of problem F. Again, the bias therefore appears stronger on the "negative side" and in fact—does not appear statistically significant on the "positive side." The median distance $\mathrm{d(E)} + \mathrm{d(F)}$ is equal to -5 and the hypothesis $\mathrm{d(E)} + \mathrm{d(F)} = 0$ is rejected in a signed-rank test ($z = -2$; $p < 0.05$).

3.4 Analysis

The anchor-to-frame hypothesis obtains additional support in joint examination for the six sets of problems A–F. While 42% of the participants exhibit the anchoring bias in at least four sets of problems, none of the subjects complies with the "contrast affect" as often. None of the 55 subjects is thus characterized as consistently complying with the contrast hypothesis. Summarizing over all 6 problems, we find that individual bidding conforms with anchoring in 202 cases, while the contrast affect is only supported in 42 comparisons. The bids for the unprocessed and reduced-form versions are equal in the remaining 86 cases, but only one subject has complied with reduction in more than 3 problems. This unique "rational" subject is the only one that has formally derived the reduced-form versions before placing his bids for the unprocessed uncertainties; his bids for the unprocessed and reduced-form versions were equal in 5 of 6 cases.

Most of the subjects did not provide any trails for the method by which they constructed their bids for the unprocessed problems. Closer examinations reveal that 17.9% of the bids for the unprocessed risks (59 bids of 330) are equal to one of the figures in the "unprocessed" payoff-matrix. The corresponding proportion for the reduced-form lotteries is only 7.6% (25 bids of 330). While 61.8% of the bids for the reduced-form lotteries are placed within a distance of 10 NIS from the expected-payoff, only 40% of the bids for the corresponding unprocessed risks are located within a 10 NIS margin from the reduced-form mean. The distributions of bids for the reduced-form lotteries appears approximately normal (Kolmogorov–Smirnov tests for normality; $p < 0.01$ for each of the reduced-form problems), while the corresponding distributions for the unprocessed versions are multi-modal and skewed in the direction implied by the anchoring bias. The questionnaires did not ask subjects to disclose their method of valuation since our goal was to examine "intuitive bidding" for unprocessed frames avoiding the hazards of experimenter bias. However, casual debriefing suggests that subjects used the payoffs in the unprocessed frame to calculate arbitrary statistics (e.g., some "representative payoff" in the unprocessed frame or an average of some representative payoffs) which were adjusted upward or downward intuitively to construct the bid. The asymmetry in bias therefore suggests that the sorting procedures employed by the subjects in the process of forming their WTP may vary with the type of framing and reflect "rational" principles like loss or regret-aversion when applicable.

The asymmetry in anchoring bias is summarized in ad hoc estimation as follows: let Z denote an unprocessed risk and use $r(Z)$ to represent the reduced-form version; $V(Z)$ and $V(r(Z))$, then, denote the values of unprocessed and reduced-form versions, respectively; $E(Z)$ accordingly denotes the mean-payoff in the unprocessed frame, while $E(r(Z))$ represents the expected-payoff on the reduce-form lottery. For the estimation assume that $V(Z) = [E(Z)/E(r(Z))]^{\beta} \cdot V(r(Z))$, so that the value of the reduced-form lottery is inflated/deflated in cases of positive/negative frames, respectively. The coefficient $\beta > 0$ summarizes the impact of anchoring-to-frame; $\beta = 0$ represents the benchmark of rational frame-consistent valuation. In order to distinguish between cases of positive and negative framing, let β^{+} denote the value of β in cases of positive framing (where $E(Z) > E(r(Z))$), while β^{-} would denote the value of β in cases of negative framing (where $E(Z) < E(r(Z))$). Nonlinear least-squares estimation of the two parameters gives the results $\beta^{+} = 0.1186$ ($t = 1.97$), while $\beta^{-} = 0.5547$ ($t = 9.2$) which nicely reflects the framing asymmetry.[13] The estimation, for example, suggests that when the payoff-level in the unprocessed frame is 30% lower than actual expected-payoff, the WTP for the unprocessed version would be 18% lower than the WTP for the reduced-form lottery. When, on the opposite, the payoff-level in the unprocessed frame is 30% higher than the actual expected-payoff, the WTP for the unprocessed version would only be 3% higher than the WTP for the reduced-form lottery.

4 Complexity aversion

Experimental studies (e.g., Neilson 1992; Huck and Weizsäcker 1999; Sonsino and Mandelbaum 2001) suggest that decision-makers penalize lotteries for complexity. In the current design, complexity aversion may decrease the WTP for unprocessed uncertainties relatively to the WTP for corresponding reduced-form lotteries. Aversion to unprocessed frames provides an alternative explanation to the asymmetry in anchoring bias. If subjects "anchor-to-frame" but the WTP for the unprocessed versions is generally lower, then the differences in WTP for unprocessed and reduced-form versions will be magnified in cases of negative framing and decreased in cases of positive framing.[14] In order to check if, subjects exhibit aversion to unprocessed frames, we use an additional problem G where the mean-payoff in the unprocessed

[13] An asymptotic F-test suggests significance at $p < 0.001$; similar results are obtained in individual OLS estimation, where the parameters are separately estimated for each subject; the median value of β^{+} is 0.158, while the median value of β^{-} is 0.47.

[14] Assuming that the anchoring and complexity effects are separable and additive, the argument can be sketched as follows: let $V(Z)$ denotes the value of unprocessed risk Z before deducting a reduction cost/complexity penalty K; If $E(Z) < E(r(Z))$ then anchoring-to-frame implies that $V(Z) < V(r(Z))$; the subtraction of a reduction-cost K would thus increase the difference between the values of unprocessed and reduced-form versions. If, on the other hand, $E(Z) > E(r(Z))$ then anchoring-to-frame implies that $V(Z) > V(r(Z))$ and the reduction-cost K shrinks the difference between the two values.

frame is equal to the expected-payoff on the reduced-form lottery. The unprocessed version of problem G referred to the same collection of underlying lotteries *L1–L3* (see Fig. 1), but subjects were told that their actual-payoff would be equal the average draw $(x+y+z)/3$. As, in the preceding examples, the reduced-form version presented the corresponding payoff in the form of a simple lottery. Since the mean-payoff in the unprocessed frame (80) is equal to the expected-payoff on the reduced-form lottery in this example, "anchoring-to-frame" does not imply any specific bias. If subjects, however, penalize unprocessed risks for complexity, the WTP for the unprocessed version would be lower than the WTP for the reduced-form lottery. Comparison of the bids for the 2 versions of the problem reveals that subjects price the unprocessed version slightly lower but the differences are not statistically significant. The median bid for the unprocessed version of the problem is 74, while the median bid for the reduced-form version is 75. A Wilcoxon signed-rank test ($z = 1.75$; $p = 0.08$) and a sign-test ($z = 1.29$, $p = 0.19$) could not reject the hypothesis of equality.

The alternative claim that subjects exhibit stronger attention in cases of negative framing, obtains additional support in comparison of the effect of changes in reduction-rules within the unprocessed frame. In particular, compare the effect of shifting from unprocessed frame C to unprocessed frame E to the effect of moving from frame D to frame F (recall the data on Table 1). While the WTP for the unprocessed version of problem C was not significantly different from the WTP for the unprocessed version of problem E (Wilcoxon signed-rank test $z = 1.4$; $p = 0.16$), the WTP for the unprocessed version of D was significantly lower from the WTP for problem F ($z = 4.5$; $p < 0.01$). Subjects' response to parallel changes in reduction-rules thus appear statistically significant in cases of positive framing (problems D and F) while the response is not significant in cases of negative framing (problems C and E).[15] The asymmetry in anchoring-to-frame, therefore, also reflects in comparison of bidding patterns across unprocessed problems. This provides additional support to the claim that the asymmetry follows from careful response to "positive frames" compared to "negative frames."

5 Choice experiment

In order to examine the robustness of results, we have presented 5 binary-choice problems to 89 undergraduate engineering students that did not participate in the pricing experiment. In each of the 5 problems, subjects were asked to choose between (a) an unprocessed risk and (b) the expected-payoff on the reduced-form version.[16] The unprocessed risks were similar to those used in problems C–G above with slight

[15] Note that the distance in mean actual-payoff between C and E is similar to the distance between D and F (see Table 1). Note also that the bids for the reduced-form versions of problems C and E were significantly different (Wilcoxon signed-rank test; $z = 4.86$; $p < 0.001$). The same holds for the reduced-form versions of problems D and F ($z = 5.3$; $p < 0.001$).

[16] An alternative design where subjects are asked to choose between the unprocessed frame and the reduced-form lottery (or a close variation) could direct the subjects to unravel the relation between the two versions.

changes in payoffs.[17] We have copied the MAX, MIN, (2*MAX + MIN)/3, and (MAX + 2*MIN)/3 reduction-rules from problems C–F but instead of using the average-payoff rule (of problem G), we now used a weighted-product rule: $(x \cdot y \cdot z)/6000$. The instructions (see supplementary appendix) explained that 1 of the 5 problems would be randomly selected to determine the final-payoff of each participant and 35 subjects would receive a check in the corresponding amount. The average payout of the 35 winners was 75 NIS (approximately 15.5 dollars).

Table 2 presents the distribution of choices in the 5 problems; The row titled "Prop(b)" presents the proportion of subjects that chose the risk-free payoff (alternative b) in each problem. Note that if subjects are risk-averse and comply with reduction they should choose the risk-free alternative (b) in all 5 problems. Similarly, risk-seeking subjects that comply with reduction must choose (a) in all 5 cases. In fact, only 5 of the 89 subjects chose the same alternative (b) in all 5 problems. In order to characterize the response of the other subjects, we adapt the definitions of "anchoring-to-frame" and "contrast affect" as follows. Say that the subject exhibits "anchoring-to-frame" if she prefers the safe alternative (b) in cases of negative framing, but chooses the unprocessed option (a) in cases of positive framing. Say that the subject exhibits a "contrast affect" if choices are reversed.[18] The choices in problems C′ and D′ then strongly support the anchoring hypothesis. While 74.16% of the subjects preferred taking no-risk in the negative frame of problem C′; 64.05% of the subjects chose the unprocessed version in the positive frame of problem D′. Binomial tests confirm that the observed choice-frequencies are significantly different from 50% in each of the problems (see the bottom row of Table 2). Individual level comparisons reveal that 44 subjects chose the no-risk alternative in problem C′, while preferring the unprocessed lottery in problem D′ and only 10 subjects chose the lottery in C′ and the certain payoff in D′. The "contrast affect" is, therefore, strongly rejected for the anchoring alternative in a sign-test ($p < 0.001$).

Interestingly, however, we find that the choice patterns for problems E′ and F′ strongly contradict the anchor-to-frame. Only 33.71% of the subjects chose the no-risk alternative in the negative frame of problem E′, while 62.92% of the participants marked alternative (b) in the positive frame of problem F′. Individual-level comparisons confirm that the choices of 38 subjects conformed with the "contrast affect," while only 12 subjects exhibit "anchor-to-frame" in these 2 problems (sign-test; $p < 0.001$). Our intuitive explanation is that the safe payoff in option (b) is close to the mean-payoff in the unprocessed frame (80) in these 2 problems (this is not the case in problems C′ and D′). Since the two options are similar in the payoff-level dimension, subjects focus on the reduction-rule and a contrast affect emerges where subjects prefer the

[17] Since the possibility that subjects recognized the reduced-form version from the unprocessed version (see discussion in Sect. 2) is irrelevant in the binary-choice design we have "rounded the numbers" as follows: Lottery *L1* paid 40 or 120, lottery *L20* paid 40 or 80, and lottery *L3* paid 80 or 120.

[18] These definitions are not equivalent to those used in the pricing experiment: for example, anchoring-to-frame in the sense of Sect. 2 implies that the WTP for the unprocessed version would be higher than the WTP for the reduced-form version in cases of positive framing. Yet, if the subject is risk-averse and the effect of risk-aversion is stronger than anchoring-to-frame than he might still prefer the safe option (b) on the unprocessed version in binary-choice. Since our main concern is the characterization of inconsistent choices in positive/negative frames, the definitions are adapted accordingly.

Table 2 Binary-choice problems

Problem	C′	D′	E′	F′	G′
Type of frame	Negative	Positive	Negative	Positive	–
Reduction-rule (a)	Max	Min	(2*max + min)/3	(max + 2*min/3)	$(x \cdot y \cdot z)/6000$
Expected-payoff (b)	110	50	90	70	80
Prop (b)	74.2%	35.9%	33.7%	62.9%	60.7%
Binomial test	$p<0.001$	$p<0.01$	$p<0.01$	$p=0.04$	$p=0.11$

unprocessed risk when the reduction rule is closer to the max, while preferring the safe option when the reduction rule is closer to the min.[19]

6 Discussion

The unprocessed frames introduced in the note are motivated by the suggestion that decision-makers, in reality, may not reduce risks to simple lotteries before making choices. The valuation of professional training, for example, may be based on the mean job prospects at the end of training, even when the decision-maker expects to obtain one of the best, or worst, realized jobs. Then, our results suggest that anchoring to mean-payoff-possibilities might lead to inefficient decision. Decision-makers that expect to obtain the best realized payoffs may refuse a training opportunity offered at a price lower than their rational WTP, while agents who are expected to end-up with the lowest realized payoffs might agree to take such courses at prices higher than their true WTP for the reduced-form payoff. In general, the efficient self-selection into professional training or other type of investment may be disrupted by anchoring to mean or representative payoff-levels when risks are evaluated in unprocessed frames.[20]

Our valuation experiment did not attempt to document the procedure by which subjects construct their bids for unprocessed risks. The goal of the main experiment was to elicit the WTP for unprocessed frames in competitive setting with minimal experimental intervention. Examination of experimental questionnaires and casual debriefing suggest that subjects have used the payoffs in the unprocessed frame to calculate arbitrary statistics (e.g., some “representative payoff” in the unprocessed frame or an average of some representative payoffs) that were adjusted upward or downward intuitively to construct the bid. The bids for unprocessed problems, for example, are equal to one of the payoffs in the unprocessed frame in 17.9% of the cases. The asymmetry in bias, then, suggests that loss-aversion (or other forms of “negativity bias”) may affect the sorting method or other aspects of the informal procedure by which subjects construct their bids. While our subjects anchor their WTP for unprocessed

[19] The explanation is inspired by Rubinstein (1998) similarity-based choice procedure.

[20] Wilcox (1993) demonstrates that increased incentives may push complex decision closer to rational benchmarks. The actual payout in our in-class experiment was generous relatively to the small number of bidding tasks; we speculate that stronger monetary incentives may decrease the bias quantitatively but would not change the qualitative results.

risks to the payoff-level in the unprocessed frame, their bids are significantly closer to the rational, reduced-from benchmark in cases of positive framing. The results, therefore, demonstrate that established attributes of empirical/rational choice may reflect in cases of "unprocessed" biased decision. Principles like loss or regret aversion may reflect in field insurance or portfolio decision although choices are run intuitively in unprocessed frames and violate the rational standard of framing-invariance.

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