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Two sides of the same coin: Information processing style and reverse biases

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Abstract

This paper examines the effect of information processing styles (indexed by the Rational-Experiential Inventory of Pacini & Epstein, 1999) on adherence to bias judgments, and particularly to reverse biases; i.e., when two choice questions that comprise identical normative components are set in different situations and yield seemingly opposite behavioral biases. We found consistent evidence for a negative correlation between rational score and adherence to reverse biases, as well as overall biases, for all three pairs of reverse biases tested. Further, this effect of rational thinking was more pronounced for high experiential individuals, in that high-rational and high-experiential participants committed fewer biases than all other participants. These results lend weight to our claim that low-rational individuals, who are more sensitive to the context, are more prone to utilize some attribute of the provided information when it is uncalled for, but at the same time tend to ignore it or give it too little weight when it is a crucial factor in a normative decision process.

Keywords: Rational-Experiential Inventory, cognitive bias, individual differences.

1 Introduction

One of our colleagues recently complained that he finds the JDM field rather confusing. In his view, each time a new behavioral irregularity is found, JDM researchers classify their findings as a new heuristic. As a case in point, when people exhibit belief in positive recency, researchers tend to assume they have fallen prey to the hot-hand effect (Gilovich, Vallone, & Tversky, 1985). When individuals exhibit belief in negative recency, they are said to be the victim of the gambler's fallacy (Huff, 1959; Kahneman & Tversky, 1972; for a review of these two biases see Ayton & Fisher, 2004). What can be learned from biases which lead in opposite behavioral directions? Do they reflect signal or noise? Behavioral traps or genuine flip sides of the coin in everyday life? How do individual differences shape the direction of a particular bias? Are different individuals prone to biases in different directions?

This paper addresses this puzzle by examining the effect of information processing style on adherence rate to such *reverse biases*, which are said to occur when two choice questions that are made up of identical normative components are set in a different situation and yield seemingly opposite behavioral biases. Typically, two (imperfectly correlated) attributes are involved, such as the number of people affected by a choice option or the proportion of people affected. Each of the two attributes is the normatively relevant one for one judgment. The two biases involve some attention to the normatively irrelevant attribute in each case.

Reverse biases as we define them are thus different from the situation discussed by Baron (2010) and illustrated by ratio bias in opposite directions (Bonner & Newell, 2008), the hot-hand vs. the gambler's fallacy (Ayton & Fisher, 2004; Sundali & Croson, 2006), and action vs. omission bias (Baron, 2010). In these cases, biases in opposite directions can occur in the same task; for example, some people can favor harms caused by omission over lesser harms caused by action, while a few others favor harms of action over lesser harms of omission. Demonstration of such opposite biases requires methods for statistical analysis of individuals (Baron, 2010).

The existence of individual differences in the utilization of heuristic thinking has been demonstrated for a variety of judgmental biases. These include risk perception (Kogan & Wallach, 1967), risk seeking and avoidance (Shaham, Singer, & Schaeffer, 1992), binary guessing (Pruitt, 1961), and variance in heuristic thinking (Kahneman & Tversky, 1972). However, traditional studies of heuristic thinking and biases mainly use group-level statistics to confirm the hypothesis that the number of participants exhibiting cognitive biases in each group cannot be due to chance.

We suggest that an individual who adheres to one direction of bias is not less prone to exhibit its reverse bias. Specifically, we argue that individual differences

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in information processing styles, together with contextual factors, play an important role in determining adherence rate to biases in general and will thus affect both directions of the reverse biases. Previous research has shown the relation of several measures of information processing of thinking style to judgments. For example, Shiloh, Soltan, and Sharabi (2002) reported systematic individual differences in participants' normative-statistical vs. heuristic responses. Normative-statistical responses were found to be positively correlated with a rational thinking style and negatively with an experiential thinking style. Smith and Levin (1996) identified need for cognition as a moderator of framing effects (i.e., the way information is presented). People who are low in need for cognition were more affected by framing effects. Shiloh, Koren and Zakay (2001) found that compensatory decision-making style and need for closure were correlated with the complexity of the representation of a decision task.

Moreover, these individual differences in information processing styles may work in concert with several contextual factors to drive the decision process. For example, two such factors, according to Stanovich and West (2000), are *performance errors*, which reflect momentary and fairly random lapses in ancillary processes such as lack of attention or memory distortions, and *alternative task construal*, where participants perceive and interpret the task in a way that differs from the one implied by the normative point of view or the experimenter's perspective. Thus, the way people process information is dependent on their individual processing style but also on contextual factors which change the priority assigned to the different types of attributes.

In the same vein, Kahneman & Frederick (2002) proposed *attribute substitution* as a processing information model to explain a variety of biases. According to this model, in an attempt to simplify the decision process, individuals replace consideration of complex attributes, although it might be crucial for the choice at hand, with considerations of simpler attributes (which may be correlated with the more relevant ones). The implication of this substitution process is that behavioral biases are often the result of focusing on irrelevant attributes and ignoring crucial normative attributes. For example, when individuals are required to assess the risk level of an investment portfolio, they often tend to ignore crucial normative attributes such as data about the real statistical correlation between funds, and rely instead on irrelevant attributes which comes more readily to mind such as the difference between the funds' names (Ayal & Zakay, 2009; Hedesström, Svedsäter & Gärling, 2006). Thus, subtle manipulations of the contextual factors can change the priority given to each attribute and move the judgmental process in a biased direction.

Based on these notions, we argue that individual information processing styles are likely to determine which attributes or contextual aspects will be emphasized in the judgmental process and which ones will be used as substitutes. Regarding the rational information processing style, the picture seems rather clear. Based on previous research, individuals who are low in rational thinking are assumed to be more prone to commit different types of judgmental biases. Since these people are also more affected by framing (i.e., the way information is presented) (Smith & Levin, 1996) they are more prone to use alternative construal of the tasks. Consequently, they are expected to show seemingly opposite behavioral biases when the identical normative components are set in a different situation. However, the picture is much less clear when we consider experiential thinking. While biased behavior is often considered the result of a low tendency for rational thinking and a high tendency for experiential thinking that replaces relevant attributes with irrelevant attributes (e.g., Kahneman & Frederick, 2002; Shiloh et al., 2002), recent data suggest that in some situations highly intuitive thinking leads to well adjusted judgments that take into account the different attributes according to their importance rather quickly (Ayal & Hochman, 2008; Davis, Staddon, Machado, & Palmer, 1993; Glöckner, 2007; Glöckner & Betsch, 2008a, 2008b; Glöckner & Bröder, 2011; Glöckner & Herbold, 2011; Usher, Russo, Weyers, Brauner, & Zakay, 2011). These more recent studies may shed light on the interplay between the rational and experiential systems. Specifically, highly rational participants tend to engage in active information search which often leads to the selection of more relevant attributes during the decision process (Wilson & Schooler, 1991). Nevertheless, experiential weighting and integrating, which utilizes the most relevant attributes (via high rational thinking), may bear an added value which lead to less biased decisions for individuals high in experiential thinking (Ayal & Hochman, 2009; see also Acker, 2008; Dijksterhuis & Nordgren, 2006). Thus, another goal of the current paper is to examine this proposed connection between experiential thinking and judgment, and to contrast it with the more traditional account which argues that experiential thinking leads to more biased judgments.

1.1 The current study

We identified and tested three novel pairs of reverse biases in which crucial normative attributes are partly ignored and irrelevant attributes are taken into account. In each pair, we matched two different phenomena that were previously reported in different contexts. We hypothesize that individual differences in information processing style as indexed by the Rational-Experiential Inventory (REI; Pacini & Epstein, 1999) will predict the overall propensity toward judgmental biases as well as adherence level

to biases in both directions (i.e., reverse biases). We describe the REI in the Methods section.

1.2 The three pairs of reverse biases

The biases of interest are summarized in Table 1 and described here.

1.2.1 Ratio bias versus proportion dominance

Can people accurately differentiate between relative and absolute risk? According to the ratio bias and proportion dominance, the answer is no. However, the mistakes which lead to these two behavioral phenomena as well as the direction of the final outcome go in opposite directions.

The ratio bias is the tendency to judge a low probability event as more likely when presented as a large-numbered ratio (e.g., 10/100) than as a smaller-numbered but equivalent ratio (e.g., 1/10). This effect is attributed to a tendency to focus on the frequency of the numerator instead of the overall proportion (Piaget & Inhelder, 1951/1975; Kirkpatrick & Epstein, 1992; Miller, Turnbull, & Mcfarland, 1989). Moreover, Denes-Raj and Epstein (1994) showed that individuals sometimes prefer the alternative with the large-numbered ratio even when the small-numbered ratio offered a greater probability of success. Thus, according to the ratio bias, people do not accurately evaluate the risk since they fail to consider overall proportion when it constitutes relevant attribute for the decision process.

In contrast, proportion dominance suggests that people fail to accurately evaluate risk since they consider the irrelevant overall proportion instead of basing their decision on actual frequency or quantity (Slovic, Finucane, Peters, & Mcgregor, 2002). For example, Hsee (1998) found that an overfilled ice cream container with 7 oz. of ice cream was valued more highly (measured by willingness to pay) than an under-filled container with 8 oz. of ice cream. Similarly, the same tendency to neglect actual numbers and consider an irrelevant proportion was found in life-saving interventions studied (Baron, 1997; Fetherstonhaugh et al., 1997; Jenni and Loewenstein, 1997). For example, Fetherstonhaugh et al. showed that people's willingness to intervene to save lives is more greatly affected by the proportion of lives saved than by the actual number of lives that could be saved.

Thus, these two phenomena can be defined as reverse biases since in the ratio-bias people tend to ignore the overall ratio when it is normatively a relevant (and crucial) attribute, whereas in the proportion dominance people use the overall ratio although it is normatively an irrelevant attribute.

1.2.2 Irrational diversification versus debt account aversion

Do people tend to seek more or less variety than the normative solution requires? According to the irrational diversification and the debt account aversion biases, there is more than one answer to this question and biases can emerge in both directions.

A variety of studies have shown a strong tendency toward over-diversification (Hedesström et al., 2006; Galak, Kruger & Loewenstein, 2011; Langer & Fox, 2005; McAlister & Pessemier, 1982; Shin & Ariely, 2004). For example, it has been shown that, when people are required to choose several goods in combination, they usually choose more variety than they end up wanting (Simonson, 1990; Read & Loewenstein, 1995). Indeed, in many situations, the risk level associated with a certain pool is directly associated with the pool's diversity (e.g., stock portfolio). Thus, in these situations the normative solution would suggest to diversify and not to put all the eggs in one basket. However, according to Ayal and Zakay (2009), this *diversification heuristic* yields biased judgments in cases of pseudodiversity, in which the perceived diversity of a pool is enhanced, although this fact does not change the pool's normative values or even decreases its utility. In a series of studies Ayal and Zakay (2009) showed such irrational diversification in the domain of gains (see also Rubinstein, 2002).

In contrast, debt-account aversion (Amar, Ariely, Ayal, Cryder, & Rick, in press) refers to the tendency of multiple debt account holders to primarily be motivated to reduce their total number of outstanding loans, and thus prioritize their payments to low-balance loans even when these loans had a lower associated interest rate than their high-balance loans. In several studies, it was shown that this bias stems from participants' preference for integrated losses over diversified ones.

Thus, these two behavioral tendencies can be defined as reverse biases. On the one hand people rely on irrelevant attributes (i.e., pseudodiversity) and exhibit irrational diversification in their choices (e.g., pension allocations). On the other hand, people ignore crucial statistical attributes (e.g., the interest rate of each loan) and exhibit irrational concentration by preferring to reduce their total number of open debts rather than reducing the objective amount of their total repayment.

1.2.3 Inferential asymmetry versus confusing retrospective and predictive accuracy

How do people compare two opposite conditional probabilities; that is, P(X|Y) vs. P(Y|X)? A review of the literature suggests that these situations could lead to two opposite biases.

Table 1: Predictions for each of the six biases.

Bias	Predicted (biased) response	Normatively relevant attribute	Normatively irrelevant attribute
Pair 1			
Ratio bias	Preferring drawing a marble from the big urn (e.g., 9 out of 200) over the small urn (e.g., 1 out of 20).	The overall proportion of each alternative.	The frequency of the numerator (number of winners).
Proportion dominance	Evaluating the number of lives to be saved according to the proportion. That is, higher in treatment C than in treatment B, and higher in treatment B than in treatment A.	The absolute number of saved lives.	The proportion of saved lives.
Pair 2			
Irrational diversification	Choosing the portfolio with higher perceived diversity but lower expected value.	The actual risk of the portfolio (based on real variance or probability).	The perceived risk (based on perceived diversity).
Debt account aversion	Reducing the total number of outstanding debts, and thus prioritizing payments to low-balance debts over high-interest debts.	The total number of debts.	The interest rate of each debt.
Pair 3			
Inferential asymmetry	Evaluating the prediction of the son's height from the father's height (cause to effect) as more probable that the prediction of the father's height from the son's height.	The interchangeability of cause and effect and the fact that their marginal probabilities are equal, thus P(x|y) = P(y|x).	The direction of the causal schema.
Confusing retrospective and predictive accuracy	Evaluating the probability that the patient's breast mass is indeed malignant as higher than 50%.	Base rate and false alarms.	The biased belief that the conditional probability of an event P (x|y). is always similar to the conditional probability of the event P(y|x).

There are certain situations where "cause" and "effect" are nomologically dependent on each other (i.e., when P(X) = P(Y)), such that normative considerations suggest that P(X|Y) = P(Y|X). However, since people tend to implement a causal schema to reflect the relationship between X and Y, they tend to favor one conditional probability over the other. Inferential asymmetry refers to this inaccurate belief that in these situations the presence of the effect can be inferred from its causes with greater confidence than the presence of a specific cause can be inferred from the effect (Tversky & Kahneman, 1980). To demonstrate this behavioral tendency, Tversky and Kahneman asked participants to state how confident they were with certain predictions. The questions were constructed such that one of the variables was naturally viewed as the cause and the other as the effect but both had the same probability. While from a normative point of view there was no reason to expect a difference in the accuracy with which one variable could be predicted from the other, participants tended to be more confident about prediction of effect from cause (e.g., the prediction of a son's height from his father's height) than cause from effect (e.g., the prediction of the father's height from the son's height). Thus, it seems as though people fail to understand that P(X|Y) = P(Y|X), (where X is the cause and Y is the effect) and instead take into account an assumed but irrelevant casual relationship between the two variables.

In contrast, in many cases P(X) $\neq$ P(Y) but people enforce equality according to which P(X|Y) = P(Y|X). For example, confusing retrospective and predictive accuracy refers to people's failure to take into account relevant attributes (e.g., base rate), and instead consider the two conditional probabilities of P(X|Y) and P(Y|X) as equal. This behavioral tendency can lead to incorrect probabilistic reasoning such as the base rate fallacy (Tversky & Kahneman, 1974; Bar Hillel, 1980) and inaccurate medical decisions (Eddy, 1982). For example, Eddy showed that physicians confuse the probability of cancer when a patient has a positive result on an X-ray with the probability of a positive result on an X-ray in a patient with cancer.

Thus, these two phenomena can be defined as reverse biases since they both result from people's failure to compare two conditional probabilities. On the one hand, when the equality between two opposite conditional probabilities is normatively justified, people tend to neglect this and instead use irrelevant attributes about the causal relationship between the two events (which causes them to violate the normative equality). On the other hand, when the equality between these two opposite conditional probabilities is not justified, people tend to confuse these two probabilities, while neglecting relevant statistical attributes.

1.3 Hypotheses

Based on previous research and the rationale developed above we formulate two main hypotheses in regard to the relationship between a rational scale and biased judgments:

Hypothesis 1: The overall adherence level to biases will be negatively correlated with the rational scale of the REI.

Hypothesis 2: The adherence level to reverse biases—that is, cases in which a subject exhibits both a bias and its reverse—will be negatively correlated with the rational scale of the REI.

In addition, as noted above, the findings concerning experiential processing style are much less consistent. Some previous research has claimed that a high level of experiential thinking induces greater consideration of irrelevant attributes and thus leads to more biases (e.g., Kahneman & Frederick, 2002; Shiloh et al., 2002), whereas other studies have suggested that high intuitive thinking may improve the decision process and thus lead to fewer biases.

Thus, we aim to examine these contradicting hypotheses in regard to the experiential scale and biased judgments in order to provide a decisive test between them:

Hypothesis 3a: The overall adherence level to biases will be positively correlated with the experiential scale of the REI.

Hypothesis 3b: The overall adherence level to biases will be negatively correlated with the experiential scale of the REI.

A similar pair of competing hypotheses can be derived for information processing style and reverse bias adherence:

Hypothesis 4a: The adherence level to reverse biases will be positively correlated with the experiential scale of the REI.

Hypothesis 4b: The adherence level to reverse biases will be negatively correlated with the experiential scale of the REI.

2 Method

Participants. 110 Interdisciplinary Center (IDC) Herzliya Undergraduates (81 females) volunteered to participate in the study in exchange for course credit points. The average age was 24.3 years (SD = 5.98).

Design and procedure. Participants were presented with a Qualtrics web-based questionnaire composed of two blocks (see in full in the appendix). The first block had six prototypical questions adapted from their original papers which were used to measure adherence to each of the six biases: ratio bias (Denes-Raj et al., 1995), proportion dominance (Fetherstonhaugh et al., 1997), irrational diversification (Ayal & Zakay, 2009), debt-account aversion (Amar et al., in press), inferential asymmetry (Tversky & Kahneman, 1980), and confusing retrospective and predictive accuracy (Eddy, 1982). Presentation order was random.

The second block was composed of the short 24-item REI (Pacini & Epstein, 1999) translated into Hebrew. The REI is a self-report inventory that assesses rational and experiential thinking styles. Specifically, the REI consists of two unipolar scales (12 items each) which rank participants on two dimensions of decision making style. The first scale measures engagement in and favorability of cognitive activities and corresponds to rational-analytic thinking. The Rational Scale has been found to be positively associated with openness, conscientiousness and favorable basic beliefs, and negatively associated with neuroticism and conservatism (Pacini & Epstein, 1999). The second scale measures engagement in and favorability of intuitive activities and corresponds to experiential-intuitive thinking. The Experiential Scale has been found to be positively associated with extraversion, agreeableness and emotional expressivity, and negatively associated with categorical thinking and intolerance (Pacini & Epstein, 1999). Previous research has shown that the internal-consistency reliability coefficient for each scale is high (above .85), whereas the correlation between them is small and nonsignificant (Pacini &

Table 2: Adherence rate to each of the six biases and to the reverse biases. RD = ratio bias. PD = proportion dominance. ID = irrational diversification. DAA = debt-account aversion. IA = inferential asymmetry. CR_PA = confusing retrospective and predictive accuracy.

Bias	Adherence rate	Reverse bias adherence
Ratio bias	84%	30%
Proportion dominance	35%	
Irrational diversification	47%	20%
Debt-account aversion	40%	
Inferential asymmetry	54%	31%
Confusing retrospective and predictive accuracy	59%	

Epstein, 1999). Thus, the REI is assumed to support Epstein's (1994) claim of two independent information processing systems. Pacini and Epstein (1999) reported that the Rationality Scale correlated negatively with ratio bias under some conditions, although the results were qualified by several interactions.

The link to the questionnaire was sent by e-mail to participants via the IDC School of Psychology experiments website. This e-mail also included basic instructions and explained the purposes of the questionnaire. We asked participants to answer the questions as best as they could.

3 Results

3.1 Manipulation check

Before we tested our hypotheses, we assessed the reliability and validity of the questionnaire. First, the reliability of the REI Hebrew translation was calculated using Cronbach's alpha coefficient. The internal consistency of the REI was found to be adequate both for the Rational scale (α = 0.88) and the Experiential scale (α = 0.87). The correlation between the two scales was negligible (r = -0.008) and nonsignificant. Second, to examine whether participants exhibited judgment biases, we calculated the adherence rate for each of the six examined biases. This was done by coding each response that was predicted by the corresponding bias as "1", and each response that was normative or not predicted by the bias as "0". (For predictions of the six biases, see Table 1.) This analysis revealed a high adherence rate to all 6 biases (see Table 2). On average, the adherence rate to the ratio bias was 0.84, proportion dominance 0.35, irrational diversification 0.47, debt-account aversion 0.40, inferential asymmetry 0.54, and confusing retrospective and predictive accuracy 0.59.

3.2 Relationship between information processing style and bias adherence

3.2.1 Overall bias adherence

To test the relationship between information processing style and overall bias adherence (Hypotheses 1 and 3a vs. 3b), we used a hierarchical multiple regression analysis. First, we calculated the overall bias adherence level for each participant by averaging the number of biases that each participant adhered to (i.e., the proportion of biases adherence at the individual level). The scale ranged from 0–1, with 0 representing *no biases* and 1 representing *predicted bias responses* in all six tasks. Second, the rational and experiential scales were entered in the first step and an interaction term multiplying the rational scale with the experiential scale was entered in the second step of the regression to assess the effect of these factors on overall bias adherence as a dependent variable. The results of this analysis are summarized in Table 3.

As shown in Table 3, the model that best fit the data is the model that includes the interaction between the rational and experiential scales (R^2 = 0.204, F (3, 106) = 10.106, p < 0.0001). To interpret the interaction effect of these two predictor variables, we computed separate regression lines for individuals one SD below the mean on the predictor experiential scale, at the mean of the predictor experiential scale, and one SD above the mean of the predictor experiential scale (Aiken & West, 1991; Cohen & Cohen, 1983). Then, actual values of the predicted overall bias adherence can be calculated by substituting values of the predictor rational scale. Values are computed for the rational scale at the mean, and one SD above and below the mean. These results are depicted in Figure 1. Thus, the interaction we found between the rational and experiential scales suggests that low rational participants are more prone to judgmental biases, regardless of their experiential level. In contrast, average to high rational participants are less prone to judgmental errors and this tendency decreases even further for average to high experiential participants. Thus, the results support Hypothesis 1, as they show that in general highly rational individuals are less prone to judgmental biases. Moreover, the results also support Hypothesis 3b but not Hypothesis 3a, since they suggest a negative correlation between the overall adherence level to biases and the experiential scale. More specifically, the results show that an average to high experiential level has a further reduction effect on overall bias adherence.

Table 3: Relationship between information processing styles (REI) and overall bias adherence as the dependent variable.

	Model 1			Model 2		
Variables	B	SE B	β	B	SE B	B
Rational Scale	−0.118***	0.025	−0.407	0.078	0.099	0.271
Experiential Scale	−0.061*	0.030	−0.174	0.161	0.112	0.462
Rational X Experiential				−0.086*	0.042	−0.942
Model fit						
Adjusted R^2	0.18			0.204		
F	12.942***			10.293***		
Df	2,107			3,106		

N = 110, * < 0.05 *** < 0.001

Table 4: Relationship between information processing styles (REI) and reverse bias adherence as the dependent variable.

	Model 1			Model 2		
Variables	B	SE B	β	B	SE B	β
Rational Scale	−0.099**	0.033	−0.270	0.143	0.132	0.393
Experiential Scale	−0.073	0.040	−0.167	0.200	0.150	0.456
Rational X Experiential				−0.106*	0.056	−0.923
Model fit						
Adjusted R^2	0.084			0.105		
F	5.967**			5.275**		
Df	2,107			3,106		

N = 110, * < 0.05, **0.001, *** < 0.0001

3.2.2 Reverse bias adherence

To test the relationship between information processing style and adherence level to reverse bias (Hypotheses 2 and 4aVs. 4b), we used a hierarchical multiple regression analysis. First, we calculated reverse bias adherence level for each participant by averaging the number of times in which each participant adhered to the two biases in each of the reverse bias pairs (i.e., the proportion of reverse bias adherence at the individual level). The scale ranged from 0–1, with 0 representing *no reverse biases* and 1 representing *predicted bias responses* in all the three pairs. Second, the rational and experiential scales were entered in the first step and an interaction term multiplying the rational scale with the experiential scale was entered in the second step of the regression to assess the effect of these factors on reverse bias adherence level as a dependent variable. The results of this analysis are summarized in Table 4.[1]

As shown in Table 4, the model that best fit the data is the model that includes the interaction between the rational and experiential scales (R^2 = 0.105, F (3, 106) = 5.275, p < 0.001). The results, analyzed in the same way as for overall bias adherence, are shown in Figure 2. Again, low rational participants are more prone to reverse bias, regardless of their experiential level. In contrast, average to high rational participants are less prone to reverse bias and this tendency decreases even further for average to high experiential participants. Thus, these results support Hypothesis 2, as they show that in general, highly rational individuals are less prone to reverse bias. Moreover, the results also support Hypothesis 4b and not 4a, since they suggest a negative correlation between reverse bias and the experiential scale. Similar to the pattern of results in the overall biases, these results show that average to high experiential level has a further reduction effect on reverse bias adherence.

[1]Logistic regression analysis revealed a similar pattern of results separately for each of the reverse bias pairs (i.e., a significant main effect for the rational scale and a significant interaction effect were obtained,

Figure 1: Overall bias adherence of low (one SD below the average), average and high (one SD above the average) rational individuals as a function of their experiential scale score (low, average and high).

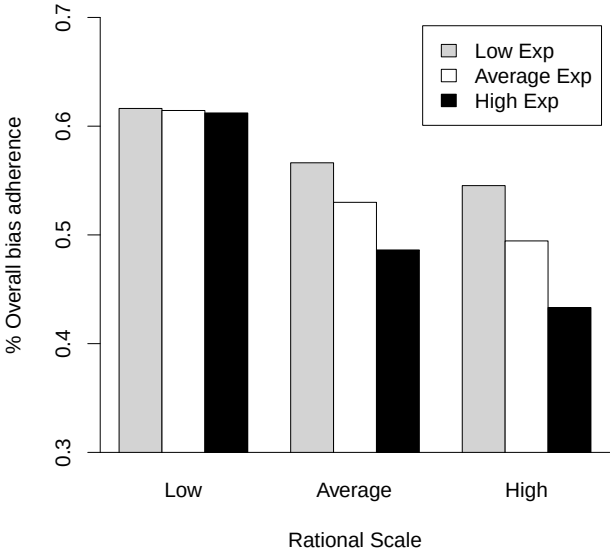
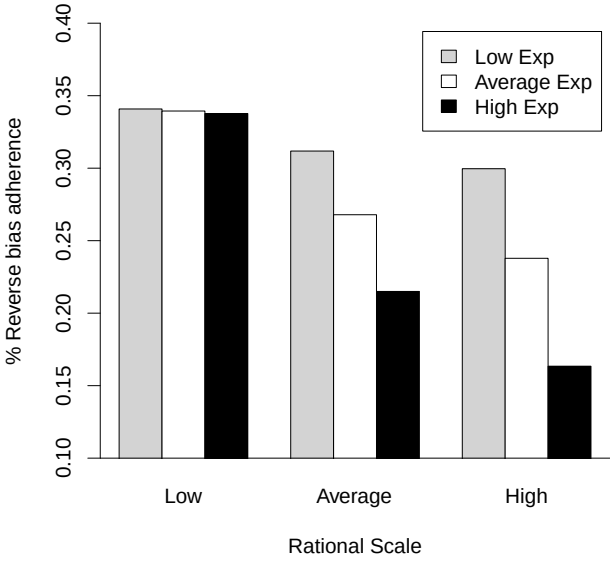


Figure 2: Reverse bias adherence of low (one SD below the average), average and high (one SD above the average) rational individuals as a function of their experiential scale score (low, average and high).



To sum up, the results for the three pairs of biases strongly support Hypotheses 1 and 2 that predicted a negative correlation between overall and reverse biases and rationality score. However, the results also show a clear pattern of negative correlation between experiential score and overall and reverse biases rather than a positive correlation (thus supporting Hypotheses 3b and 4b, but not 3a and 4a). These results demonstrate a high association between rationality and bias adherence, and show that individuals scoring low on rationality are more prone to judgmental biases in general, and specifically to exhibiting reverse biases. Moreover, these results also suggest that high experiential thinking is also an important component in judgment, but its advantages come into play as the level of rationality increases.

4 Discussion

The current paper extends previous work showing a relationship between personality measures and judgmental tasks by highlighting the dominance of information processing style over personal preferences and tastes in effecting the decision process. By demonstrating a reverse bias pattern at the individual level, we showed that rational and intuitive thinking are reliable predictors for biases in general and particularly for the probability to exhibit biases in both directions simultaneously. Across three pairs of reverse biases, we found that on average 27% of the participants adhered to the reverse biases.

Moreover, we showed that rational information processing style (indexed by the REI; Pacini & Epstein, 1999) is strongly associated with the frequency of overall biases in general, and with the reverse bias pattern in particular. Thus, this pattern of results suggests that the ability (and likelihood) to think deliberately and rationally is the main driver of normative judgment. In addition, our results support recent claims suggesting a negative rather than positive association between experiential thinking and biased judgments.

More specifically, previous research also shows that under certain conditions intuitive reasoning may lead to increased normative judgments (e.g., Davis et al., 1993; Glöckner, 2007). Indeed, our data showed that among the average- to high-rational participants, those who were high on the intuitive scale committed fewer overall (62% vs. 43%, $p < 0.001$) and reverse biases (16% vs. 32%, $P<0.001$). This pattern of results suggests that in certain situations rationality may serve as moderator for intuition. Thus, highly intuitive considerations, alongside rational considerations, may be important factors in normative reasoning. Of course, further research is needed to explore this possibility.

The current paper has both theoretical and practical implications. From a theoretical standpoint, our results extend the model proposed by Stanovich and West (2000) and identify yet another factor that might explain indi-

all p's < 0.05 except for an interaction effect for pair 3 in which $p < 0.1$). Therefore, the adherence rate of all three pairs was collapsed to one measure.

vidual differences in human reasoning. Presumably, this factor can act as a moderator for performance error and alternative task construal factors. From a methodological standpoint, the current paper highlights the importance of examining choice behavior at the individual level (Baron, 2010), and suggests that analyzing choice behavior data at the group level must take information processing styles as possible moderators into consideration. Finally, the current results suggest that developing teaching techniques to enhance adequate information processing styles could significantly improve judgment and decision making skills.

To conclude, our colleague's claim might be premature. In fact the existence of reverse biases is not so puzzling and surprising. Our results clearly demonstrate that these biases might seem to reverse, but they nevertheless reflect the same information processing style. Small contextual manipulations change the mental construal of the task at hand, and thus the same individuals, especially those with low rationality, might utilize some attributes (e.g., ratio) when it is uncalled for, and at the same time tend to ignore it or under-weigh it when it is a crucial factor for normative decision processes.

It should be noted, however, that the current research is only a first step toward a more comprehensive understanding of the relationship between information processing styles and biased judgment. Thus, we call for researchers to further pursue this line of research. Future research should aim to reveal and examine more examples of reverse biases, and include a number of examples for each bias to enable a within-subjects analysis to test for bias within each subject, as suggested by Baron (2010). In addition, this line of research should further investigate the interplay between rational and experiential information processing styles and focus on issues such as why low rational people select irrelevant attributes (and which) as a basis for their judgment and how can we educate these people to differentiate between relevant and irrelevant attributes. Successful de-biasing techniques may facilitate the use of experiential inputs to support the main rational system rather than serve as its substitute.

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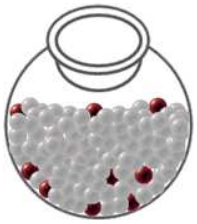
Appendix

Ratio bias (Denes-Raj et al., 1995)

Consider 2 urns filled with marbles:

Urn A



contains 100 marbles, 9 of which are red

Urn B

contains 10 marbles, 1 of which is red

The experimenter will draw a marble from one of the urns. If a red marble is drawn, you will win a monetary prize. Which urn do you choose?

1. Urn A 2. Urn B

Proportion dominance (Fetherstonhaugh et al., 1997)

Imagine that you are the chairperson on the board of "Science For Life", a charitable foundation in charge of distributing large sums of money to research institutions that develop treatments for serious diseases. Medical Institutions (X) [Y] {Z} have developed a treatment for Diseases (A) [B] {C} and now request $10 million from Science For Life. Last year, people with diseases (A) [B] {C} did not have access to this treatment, and (15,000) [160,000] {290,000} died from the diseases.

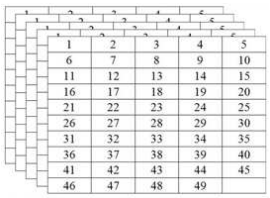
Given Science For Life's shrinking budget, what is the minimum number of lives this treatment would have to save next year in order for Medical Institutions (X) [Y] {Z} to merit funding?

Treatment A____ Treatment B____ Treatment C____

Irrational diversification (Ayal & Zakay, 2009)

Imagine five stacks of lottery tickets. Each ticket has the numbers 1 to 49. A computer will randomly select five different numbers from this range. In order to win a monetary prize, you are required to guess the numbers that will come up. To take part in the bet, please select method A or method B below:

Method A



Pick five tickets and mark five numbers on each of them. If you mark at least one of your tickets with the five numbers that are randomly selected in the lottery, you win.

Method B

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	

Pick one lottery ticket and mark six numbers from the entire range. If you mark the five numbers that are randomly selected in the lottery, you win.

Which of the two methods do you prefer?
1. Method A
2. Method B

Debt account aversion (Amar et al., in press)

Imagine that you have four different credit accounts with different balances, each of which has a different annual percentage rate (APR):

Account	Debt balance	APR
A	$2,830	2.5%
B	$3,476	2%
C	$5,080	3.5%
D	$7,200	3.25%

Suppose that you have just received a $3,000 government stimulus rebate and that you have decided to use the entire rebate to pay off debt. How much would you allocate to each account?

Account A _____
Account B _____
Account C _____
Account D _____

Inferential asymmetry (Tversky & Kahneman, 1980)

In a survey of high-school seniors in a city, the height of boys was compared to the height of their fathers. In which prediction would you have greater confidence?

1. The prediction of the father's height from the son's height
2. The prediction of the son's height from the father's height
3. Equal confidence

Confusing retrospective and predictive accuracy (Eddy, 1982)

Dr. Allen Stewart is an oncologist who specializes in breast cancer. Suppose that Dr. Stewart is examining a patient with a breast mass. Dr. Stewart has had experience with a number of women who are similar, in terms of all the important traits such as age, symptoms, family history, and physical findings, to this particular patient. Based on his experience Dr. Stewart knows that the frequency of cancer in this group is 1 out of 100. Lacking any other information, Dr. Stewart will therefore assign a probability of 1% to the event that this patient has cancer. Still, Dr. Stewart decides to order a mammography. The results turn out positive (i.e., the breast mass was diagnosed as malignant).

Assuming that a mammography correctly identifies malignant breast masses as malignant in 80% of the cases, and that it identifies benign breast masses as malignant in 10% of the cases, what is the probability that the patient's breast mass is indeed malignant?

(The answer should be a number between 1 and 100.)

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