A Study on Five Cognitive Biases

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Abstract

Traditionally, the studies examining heuristics and biases in decision-making have used experimental designs to demonstrate violations of rationality. The objective of this study was to perform the replication of five classic cognitive biases with an alternative form of measurement. The problems and the response scales were adapted from the experimental tasks performed by Stanovich and West (2008) to measure five cognitive biases: base-rate, conjunction, framing, anchoring, and outcome. It is a quantitative study with a cross-sectional experimental design. The set of problems was applied to a sample of 440 participants, 72% of women (*M* age = 21.3, *SD* = 4.05). The comparison of

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the average scores of each pair of problems yielded a response form compatible with the predictions inferred from the theory of cognitive biases. In addition, it was possible to replicate the results of the experimental procedures on which this study was based. Future research should aim to determine personal and situational variables associated with different thinking biases and to develop interventions for eliminating these biases, thus optimizing performance in areas where the cost of errors may be too high.

Key words: *cognitive biases, heuristics, thinking biases*

1. Introduction

In science, phenomena are accepted after a series of studies by different researchers have obtained the same results (Allen et al., 2023). However, a number of results from replication studies in psychology have put this science in a crisis of confidence, related to the so-called replication crisis (Allen et al., 2023; Derksen & Morawski, 2022; Fabrigar et al., 2020).

Replications can be classified into two types: direct and conceptual. The latter attempt to test the same phenomena using different experimental designs, participants, or conditions compared to the original research, while the former attempt to duplicate the original experiment without modification (Allen et al., 2023; Derksen & Morawski, 2022). There are opposing views on the desirability of each type of replication: some researchers argue that exact or direct replications are more important, while others consider conceptual replications superior (Crandall & Sherman, 2016). Regardless of their type, replication studies are necessary because they are the foundation of science (Allen et al., 2023).

The study of biases in the performance of cognitive tasks has recently been considered of interest in the field of scientific research on the human decision-making process (Bruine de Bruin et al., 2007; Toplak et al.,

2007). Research on human judgments in the face of risk and uncertainty was transformed in 1970, when Kahneman and Tversky introduced their approach to heuristics and biases, challenging the dominant, strictly rational models. The psychology of thought had been focused on exploring the performance of reasoning tests, in particular intelligence tests (Sá et al., 1999). The prevailing belief was that the human being was generally rational, and thus the study of intuition was left aside (Sá et al., 1999). Kahneman and Tversky's studies contributed to the understanding that intuitive thinking can cause deviations in reasoning that lead to cognitive biases (Ariely 2009; Kahneman et al., 1982; Kahneman & Tversky, 1982).

Heuristics consist of mental shortcuts or alternative ways to make quick decisions, but they may miss some aspects that are relevant to the decision at hand. When these heuristics lead to systematic errors, they are called biases, thinking biases or cognitive biases (Kahneman, 2013; Stanovich & West, 2000; Yudkowsky, 2008).

Kahneman et al. (1982) considered that it is not always feasible to make rational, or even desirable, choices for several reasons: (a) it takes time and effort to collect and ponder all the evidence needed to solve a problem, (b) it requires investing many cognitive resources that could be used for other purposes, and (c) approximating the best solution to a problem may be good enough, while working to obtain the most optimal solution may not be worth it, given the extra resources that the person must implement. Therefore, the mind uses heuristics, or mental shortcuts, to find a solution in a faster and satisfactory enough way, thereby minimizing the effort.

The literature on heuristics and biases has produced a wide collection of experimental tasks to demonstrate the systematic deviation of thought from rational and statistically normative parameters. These bias-assessment tasks are often used in the study of human judgment and decision-making (Kahneman et al., 1982). This substantial collection of biases, errors, and violations of the rational choice challenge the classical

theory of utility maximization. From a rational perspective, different authors have considered these phenomena as errors or defects inherent to mental development, which must be detected and corrected (Haselton & Funder, 2006). However, other theoretical approaches argue that much of the research on cognitive biases can be reformulated and understood in evolutionarily functional terms. This perspective posits that the mind is remarkably well designed and has enabled humans to survive in complex and constantly changing environments (Cosmides & Tooby, 2005).

In this framework, the human mind is described using the concept of adaptive rationality in contrast to the traditional rationality (Haselton & Funder, 2006; Haselton et al., 2009). Adaptive rationality means that the mind shows evidence of a design for dealing with various survival problems faced by our ancestors throughout evolutionary history. These mechanisms are limited and sometimes imprecise but are nevertheless the product of the natural selection process and they evince functionality in an evolutionary sense (Haselton et al., 2009). This definition contrasts with the concept of traditional rationality, whereby the mind must optimize precision, truth, well-being, or adherence to the abstract rules of logic (Haselton et al., 2009). However useful it may be to evaluate human beings according to these standards, which the modern world probably wishes to maximize, it is questionable to assume that all deviations from these standards mean that the human mind is defective or poorly designed (Haselton et al., 2009; Haselton & Buss, 2000).

The error management theory posits that human cognition has developed in a direction that minimizes the adaptive costs of an error, favoring those heuristics or cognitive biases that are frequently correct and represent a lower cost for survival (Haselton & Buss, 2000; Haselton & Nettle, 2006; Johnson et al., 2013).

Assuming the existence of evolutionary rationality legitimizes the question about whether the traditional concept of intelligence considers

all the relevant aspects that determine decision-making (Stanovich, 2012), or whether the study of human thought deserves further theoretical and empirical developments that also consider cognitive biases (Stanovich et al., 2011). Indeed, empirical evidence suggests that some variability in the performance of human decision-making is relatively independent of cognitive skills and rational intelligence (Stanovich, 1999; Stanovich & West, 2008).

Experimental research has documented several cognitive biases, including 1) base-rate neglect (Kahneman & Tversky, 1973); 2) conjunction effect (Kahneman & Tversky, 1983); 3) framing effect (Tversky & Kahneman, 1981); 4) anchoring bias (Tversky & Kahneman, 1974); and 5) outcome bias (Baron & Hershey, 1988). Consistently, Stanovich and West (2008) study have examined empirical evidence suggesting that people may have cognitive biases that can interfere with their logical and critical reasoning. The authors argue that these cognitive biases can be especially problematic in situations where decisions have significant implications. The authors present a conceptual framework to understand the different cognitive biases that can affect reasoning and decision making. Their study has included the aforementioned five classical biases. To assess them, they carried out between-subject experiments and observe the differences between groups that receive different problems. Although this study confirms the existence of these phenomena, the between-subject design of their study does not make it possible to analyse the individual tendency to commit certain types of biases, which would be useful to identify their relationship with other personal attributes such as decision-making and personality, among others. The five classical cognitive biases are described below.

1.1 Base-Rate Neglect

The base-rate bias occurs when general information is presented with specific information and the mind tends to ignore the general information

and pays attention only to the specific information (Hammerton, 1973; Kahneman & Tversky, 1973). This is reflected in exercises based on Bayes' theorem, in which the probability of A given B is related to the probability of B given A. Kahneman and Tversky (1973) evaluated the probability of exhibiting this bias using the lawyer/engineer problem. They used two identical versions, except that the base rates given to engineers and lawyers were exchanged and treated as a between-subject variable (30 engineers and 70 lawyers in Form A and 70 engineers and 30 lawyers in Form B). One group of subjects answered Form A, while a different group of subjects answered Form B, by estimating the probability that the focal individual was one of the engineers. Kahneman and Tversky (1982) pointed out that, due to the representativeness heuristic, people usually respond to this problem by choosing the most representative profession of the information provided about the character, neglecting the data about the minority proportion of this profession. Stanovich and West (2008) replicated this problem and also found the presence of this bias because the average probability estimated by the participants that the focal individual was a lawyer was lower in Form A than in Form B.

1.2 Conjunction Fallacy

Tversky and Kanehman (1983) define the conjunction bias as the belief that the probability that two events will occur simultaneously is higher than the probability that each event will occur separately. If the subject responds by following the logic dictated by the laws of probability, he or she will consider that the occurrence of a single event is more likely than the conjunction of the two events. However, as shown in the task proposed by Tversky and Kahneman, the second event in the conjunction is representative of the information provided in the character description, and therefore, the option that includes this event is more frequently chosen, in contrast to what the law of probability dictates.

Stanovich and West (2008) tested the description of bias postulated by Tversky and Kahneman (1983) by asking participants to read a vignette about a woman named Linda, aged 31, described as single, sociable, and very bright. The authors also mentioned that Linda specialized in philosophy and that, as a student, she was very concerned with issues of discrimination and social justice, having also participated in anti-nuclear demonstrations. Subsequently, the participants were divided into two groups and asked to read three statements about Linda and indicate on a six-point Likert scale how likely it was that the statements were true. The first two statements (one simple and one with conjunction) were the same for both groups: 1) Linda is a primary school teacher; 2) Linda works in a bookstore and takes yoga classes. The third statement was different for each group. Group A was presented with a statement without conjunction: 3a) Linda is a bank teller. In contrast, group B was presented with a statement with conjunction: 3b) Linda is a bank teller and an active member of a feminist movement. The results showed that most group B participants displayed the conjunction bias by assuming that Linda was more likely to be a bank teller and a feminist than only a bank teller, that is, the probability assigned to Group A.

1.3 Framing Effect

The framing bias concerns the subject's tendency to respond to a problematic situation differently, depending on the context in which the options or scenarios are proposed. Tversky and Kahneman (1981) proposed a vignette in two versions. A positive version emphasized the lives that would be saved in the context of an Asian epidemic. It required the subject to decide between making sure to save 200 lives (Plan A) and having a one-third probability that 600 people will be saved and a two-thirds probability that no one will be saved (Plan B). A negative version emphasized the lives that would be lost in the same context. It required the subject to

decide between the certain death of 400 people (Plan C) and a one-third probability of nobody dying and a two-thirds probability of 600 people dying (Plan D). In the positive version of the problem, a clear majority of the respondents preferred the safe option of saving 200 lives (Plan A) to the option that offered a one-third probability of saving 600 lives and a two-thirds probability of no one being saved (Plan B). On the other hand, in the negative version of the problem, most participants preferred the option offering a one-third probability of no one dying and a two-thirds probability of everyone dying (Plan D) to the certain death of 400 people.

From a formal point of view, options A and B of the first version of the problem are indistinguishable from options C and D of the second version. In the four options, 200 people survive (Plans A and C) or 200 people are expected to survive (Plans B and D) for risky options. Therefore, there should be no systematic preference. However, the result of the experiment shows a general tendency to risk aversion in problems with a positive context and a general tendency to seek risk in problems with a negative context. These trends constitute "framing effects" (Kühberger, 1998). Stanovich and West (2008) replicated this experiment and found similar results.

1.4 Anchoring Effect

According to Tversky and Kahneman (1974), anchoring bias occurs when people estimate values based on a starting figure and adjust them conveniently enough to make estimates that they consider correct. This initial reference value is known as an anchor. The authors argue that the starting figure often conditions the final estimate and, as a result, the subject displays the anchoring cognitive bias. To prove the existence of this bias, Tversky and Kahneman conducted an experiment in which different individuals were asked to estimate the percentage of African nations within the United Nations, after spinning a wheel of fortune with

numbers between 0 and 100. The participants were first asked to say if they considered that the percentage was greater or lower than the number that the wheel had delivered and then estimate the required percentage, by making adjustments to this number. In this way, the value shown by the wheel of fortune had an anchoring effect on the participants. The results supported the authors' premise because those participants who obtained low numbers from the wheel of fortune (such as 10) estimated an average value of 25%, while those who obtained high numbers (such as 65) estimated an average value of 45%.

According to Wilson et al. (1996), the anchoring effect is more likely to occur when two conditions are met: (1) when people pay attention to the external anchor (wheel of fortune) and (2) when they perceive that the anchor and the value to be estimated are compatible. When the authors asked the participants if the anchor might have influenced their final estimate, the participants said it had not. Furthermore, the authors concluded that the anchor influences the decision or estimate even when the participant is asked not to take it into account.

Stanovich and West (2008) made an experiment in which the participants were first asked to estimate a particular value and then to answer a question that contained a small or large value anchor. The questions asked were 1a) Do you think that there are more or fewer than 65 [12] African countries in the United Nations? 1b) How many African countries do you think there are in the United Nations? Subsequently, they were also asked: 2a) Is the tallest redwood in the world more or less than 85 [1000] feet tall? 2b) How tall do you think the world's tallest redwood tree is?. The results explained the anchoring bias in both questions because the participants presented with a large anchor estimated a higher number of African countries (sample mean 42.6) compared to the participants presented with a small anchor, who reported a much smaller number of African countries (sample mean 14.9). Results were similar for the redwood question. Both groups showed the

expected anchoring effect: the large anchor resulted in higher estimates of the redwood height (sample mean 989 feet) than the small anchor (sample mean 127.4 feet).

1.5 Outcome Bias

The outcome bias is defined by the tendency to evaluate decisions based on outcomes rather than on the decision-making process itself. Thus, the person will judge the quality of a decision as good when the outcome was good or as bad when the outcome was not satisfactory (Baron & Hershey, 1988). The person will display outcome bias when deciding based only on the outcome of an event, thus neglecting other objective information, processes, or behaviors involved.

Based on Baron and Hershey's work (1988), Stanovich and West (2008) conducted an experiment to prove the existence of outcome bias. They randomly divided the participants into two groups. One group received Form A and the other group received Form B. After reading both Forms (depending on the group), the participants were asked to evaluate a doctor's decision to perform surgery based on a written situation and a seven-option Likert scale ranging from a completely incorrect to a completely correct decision. In Form A, the situation involved a positive outcome, with a 55-year-old man who had a heart condition and whose surgery had been successful. By contrast, Form B depicted a situation with a negative outcome, designed in such a way that the decision to perform surgery was the best choice, although the man died after the surgery. As expected, the decision based on the positive outcome was rated as a better decision than that based on the negative outcome, even though the latter was objectively better.

Several of these biases have been evaluated independently of each other and between subjects in the different studies cited above. However, it would be important to detect the predominant cognitive biases in people to

determine whether they affect other psychological phenomena. Along these lines, research on phenomena such as anxiety (Gotlib et al., 1988; MacLeod et al., 1986), depression (Dobson & Breiter, 1983; Hollon & Kendall, 1980; Krantz & Hammen, 1979; Mogg et al., 1991) and eating disorders (Langner et al., 2010; Williamson et al., 2000) developed instruments whose content focuses on the characteristic features of these problems, but it could not be determined whether deviations of thought (understood as abstract deviations) are possible explanatory factors of the disorders under study.

1.6 Differences between United States and Argentina

Conceptual replications involve several differences between the original study and the new studies. One difference may be in the population sample. Our replication study includes a population sample from Argentina, whereas the population sample used in the original study by Stanovich and West (2008) was from the United States. There are some differences between Argentina and the United States in different areas, ranging from general differences such as language, social composition, ethnic groups, values and culture (Bornstein, 2022; Garza et al., 2017), to specific differences such as mother-child interaction (Bornstein et al., 1992, 2020) and organizational leadership styles (Aimar & Stough, 2007).

1.7 Objectives and Hypotheses

Objective: To conceptually replicate the five classic cognitive biases used in the experiments by Stanovich and West (2008) with a within-subject design, participants from Argentina, a Spanish alternative version of text and Likert-type response format. Hypothesis: Similar results will be found between the original version and the new version of the experiment.

2. Method

2.1 Study Type and Design

The study involved a quantitative methodology and a cross-sectional experimental design. We used a within-subject design compared to the study by Stanovich and West (2008), who randomly divided their sample into two independent groups. Specific and review studies have shown that researchers studied the biases we selected for this study with both within- and between-subject designs (Birnbaum, 1983; Chapman & Johnson, 1999; Damnjanović et al., 2019; Kahneman & Tversky, 1996; Koehler, 1996; Li et al., 2020; Mellers et al., 2001; Piñon & Gambara, 2005; Stolarz-Fantino & Fantino, 1990; Tentori & Crupi, 2012; Vives et al., 2018). The within-subject designs have drawbacks, like to increase the likelihood participants will discover what the experiment is about and to remember their answers for later scenarios (Liaw et al., 2019). However, Baron and Hershey (1988) used a similar design to our approach in their seminal study on outcome bias. They have indicated within-subject designs have certain advantages, e.g., that it is easier to detect small effect sizes.

In our design, the same participants had to go through all the problems. It could be an advantage compared to other studies that only focused on one problem or task at a time, as in within-subject design, the same participants function as their own controls. Despite the disadvantages associated with within-subject designs, we have taken some measures to minimize its influence. We have maintained a maximum distance between the original version of the problem and the other version of the same problem. By maximizing the distance between pairs of stimuli, we mean the two presentations of each problem were placed in positions on the problem list that were separated by five items, which is the maximum distance possible while keeping the two problem version equidistant for all individuals in our investigation. This circumstance also leads to an increase in time between

a problem and the other problem version of the same bias. Consistently, this distance was set up to reduce the possibility of participants recalling their own responses and to prevent them from discovering the purpose of our research. A within-subject design allows us to show that the bias occurs even when the same participants receive both presentations of each problem.

2.2 Participants

The sample consisted of 440 participants, with 72% women and 28% men (*M* age = 21.3, *SD* = 4.05) from Argentina. They were all university students whose gender and age characteristics were similar to those of the sample studied by the reference authors. All the participants signed a consent, where they were also informed about the confidential use of the data.

We determined the required sample size based on the previous study by Stanovich and West (2008) and the expected variability in participants' responses because of the known weaknesses of using within-subject design. Therefore, in order to increase the likelihood of detecting the phenomena we studied, we used a sample size that was approximately twice the size of each sample in the study by Stanovich and West (2008). Considering the responses to each pair of problems of the same type in the within-subject design, an effect size of 0.5, a significance level of .05, and a group of 440 individuals, the statistical power calculation is 1 with *df* of 439.

2.3 Development of the Problem List

As described in the Introduction, Stanovich and West (2008) used a between-subjects experimental design and quantified the bias effects by comparing the scores obtained by groups A and B.

In the present study, the problems were designed based on the experimental tasks performed by Stanovich and West (2008) to measure

five cognitive biases: base-rate, conjunction, framing, anchoring, and outcome. To evaluate each bias, two problems were written and formatted like the instructions of groups A and B in the aforementioned study, but our problem questions differed in that they were answered by the same person. The list consisted of 10 problems (two for each bias), which were evaluated using a 7-point Likert-type scale.

In order to adjust the problems to the local sample, a direct translation of the problems into Spanish was made and adapted into a more general style (validated by experts), so that it could be suitable for different types of samples (see Appendix A). For example, the proper name "Linda" in the conjunction bias was replaced by "a woman", the proper name "Jack" by "a man", the word "redwood" by "a petrified prehistoric tree", among others. In this way, the instructions were modified in Forms A and B proposed for each of the groups in Stanovich and West's experimental designs. A pilot study was performed with university students who did not participate in the central study; the results showed that the problems were understood and that the options in the Likert scale presented clear variability.

2.4 Description of the problems in each bias

Base-rate bias

We evaluated the bias through problems number 1 and 6 of the total problem list. This evaluation was conducted in the following manner.

Problem 1 (Form A: 30 engineers). A panel of psychologists interviewed 30 engineers and 70 lawyers, all of whom were very successful in their profession. Based on those interviews, the psychologists made brief descriptions of each of the 30 engineers and 70 lawyers. Later, you will read one of these descriptions, which was chosen at random from the 100 descriptions made by the panel of psychologists. Please, when you read the description, indicate the probability that the person described is an engineer

or a lawyer. The psychologists were extremely accurate in assigning probabilities to each of the descriptions, so we ask you to do your best to give an estimate of the probability that best approximates that made by the psychologists: 45-year-old man, married with 4 children. He is conservative, careful, and ambitious. He is not interested in political or social issues, but rather spends most of his free time enjoying his many hobbies, including home carpentry, sailing, and puzzles. After reading the description, the participant was asked to indicate the probability that this man was one of the 30 engineers (relative to the sample of 100 descriptions).

Problem 6 (Form B: 70 engineers). This problem was identical to problem 1 except that, in the beginning, the participant was told that the panel of psychologists interviewed 70 engineers and 30 lawyers (the numbers were inverted in relation to problem 1). After reading the description, the participant was also asked to indicate the probability that this man was one of the 70 engineers (relative to the sample of 100 descriptions).

Framing bias

We evaluated the bias through problems number 2 and 7 of the total problem list. This evaluation was conducted in the following manner.

Problem 2 (Form A: Gain). Imagine that our country is preparing for the outbreak of a very rare disease and 600 people are expected to die. Only two alternative intervention plans were proposed to deal with this disease. Scientists accurately estimated that the consequences of applying these plans are as follows: (a) If Plan “A” is applied, 200 people will be saved; b) If plan “B” is applied, there is a one-third probability that 600 people will be saved and a two-thirds probability that no one will be saved. Which plan seems better to you?

Problem 7 (Form B: Loss). The same situation as in problem 2 was presented, except that, in this case, two different intervention plans were proposed: a) If plan “A” is applied, 400 people will die; b) If plan “B” is

applied, there will be a one-third probability that no one will die or a two-thirds probability that 600 people will die.

Conjunction bias

We evaluated the bias through problems number 3 and 8 of the total problem list. This evaluation was conducted in the following manner.

Problem 3 (Form A: Cashier). A 31-year-old single, honest, and very bright woman studied philosophy. As a student, she was very concerned about issues of discrimination and social justice, and also participated in protests against the use of nuclear energy. After reading this description, the participant was asked to indicate the probability that this woman was a bank teller.

Problem 8 (Form B: Cashier and a feminist). An identical description to that of problem 3 was presented, but the participant was asked to indicate the probability that the woman, in addition to being a bank teller, was also a feminist activist.

Outcome bias

We evaluated the bias through problems number 4 and 9 of the total problem list. This evaluation was conducted in the following manner.

Problem 4 (Form A: Positive outcome). A 55-year-old man suffered from heart disease. He had to stop working because of chest pain. He enjoyed his job very much and did not want to stop working. His pain also hindered other activities, such as travel and leisure tasks. A cardiac bypass surgery would ease his pain and increase his life expectancy from 65 to 70 years. However, 8% of the patients who undergo this surgery die as a result of it. His doctor decided to perform the surgery. The surgery was a complete success. Subsequently, the participant was asked to evaluate the doctor's decision to perform the surgery.

Problem 9 (Form B: Negative outcome). The same situation as in problem

4 was proposed to the participant, but this problem differed in that the percentage of people who died as a result of the surgery was much lower (2%), although the outcome was the death of the patient. Subsequently, the participant was asked to evaluate the doctor's decision to perform the surgery.

Anchorage bias

We evaluated the bias through problems number 5 and 10 of the total problem list. This evaluation was conducted in the following manner.

Problem 5 (Form A: 2 Meters). In a recent expedition, scientists discovered a strange prehistoric tree petrified in a forest. The respondent was asked: What do you think? Could the petrified tree be more or less than 2 meters tall? How tall do you think the prehistoric tree is?

Problem 10 (Form B: 6 Meters). The statement was identical to that in problem 5, but a greater number of meters was indicated as an anchor: What do you think? Could the petrified tree be more or less than 6 meters tall? How tall do you think the prehistoric tree is?

3. Results

For data analysis, *t*-tests were performed for repeated measures using the R software (R Core Team, 2018). Table 1 shows the average score and standard deviation corresponding to each of the problems for each of the biases (Form A vs. Form B). In addition, the t value of repeated measures is indicated with their corresponding significance and the effect size, performed on Forms A and B of the problems corresponding to each bias.

Table 1. Results for Each Bias

Bias	*t*	*d*	Form A	Form B
			M (SD)	*M (SD)*
			30 engineers	70 engineers
Base-Rate	-10.16***	.48	4.38 (2.14)	4.38 (2.14)
			Gain	Loss
Framing	-4.71***	.22	3.84 (1.78)	4.21 (1.73)
			Bank teller	BT & feminist
Conjunction	-8.61***	.41	3.94 (1.49)	4.50 (1.46)
			Positive	Negative
Outcome	4.82***	.23	5.80 (1.26)	5.34 (1.36)
			2 meters	6 meters
Anchoring	-4.20***	.20	3.34 (2.11)	3.67 (2.11)

Note. t = repeated measures t-tests. d = effect size. BT = Bank teller. ***$p < .001$

The first analysis in Table 1 indicates a significant base-rate effect on the engineer/lawyer problem. Besides, the representation heuristic was observed with respect to problem A, given that the mean of the participants was greater than the probability of 30%, according to the absolute frequencies proposed.

The following analysis in Table 1 corresponds to the assessment of the framing bias in solving the problem known as “the Asian disease”. The average scores for both forms of the problem were compared and the expected framing effect was found: the loss problem yielded a greater preference for the risky plan and the gain problem yielded a greater preference for the safe plan.

The following comparison in Table 1 corresponds to the conjunction bias (also known as “Linda's problem”). The comparison between the means of the scores for both forms of the problem (cashier vs. cashier and feminist) evinced the presence of a significant effect of the conjunction bias. Participants judged that the woman was more likely to be both a feminist

and a bank teller than only a bank teller.

The next analysis shown corresponds to the outcome bias. The comparison between the average scores for both forms of the problem (positive outcome vs. negative outcome) showed the effect of the outcome bias: the decision for the problem with a positive outcome was evaluated by the sample as better than the decision taken for the problem with a negative outcome, despite the latter being objectively better. The effect of the outcome bias was significant.

The remaining analysis in Table 1 comprises the anchoring bias problem. The comparison between the average scores on both forms of the problem (2 meters vs. 6 meters) showed the effect of anchoring bias. The problem that included the 6-meter anchor in its description resulted in a higher average estimate of the petrified tree height relative to the estimate for the same tree corresponding to the problem with the 2-meter anchor. Therefore, the effect of anchoring bias was also significant.

In sum, comparing the average scores of each pair of problems on the total list for each bias evaluated allowed us to corroborate a form of response compatible with the predictions inferred from the theory of cognitive biases. Likewise, the measurement of the effect of cognitive biases through the problems used on this total list replicated the results obtained by the between-subjects experimental procedures performed by Stanovich and West (2008).

4. Discussion

The main goal of the present work was to evaluate whether the traditional cognitive biases conducted by Stanovich and West (2008) could also be observed with an alternative version of the bias text. In this sense, the methodological convergence between the measurement of cognitive biases was studied through the within-subjects comparison of the scores of the list

of problems and the experimental reference procedures. The final version of the problems involved the Spanish translation and adaptation to any situation of Forms A and B of the instructions for each group designed by Stanovich and West (2008). The comparison of the average scores of each pair of problems exhibited a response pattern among the participants evaluated that is consistent with the predictions inferred from the theory of cognitive biases (Kahneman et al., 1982).

Future studies will be conducted to determine the variables associated with different thinking biases and to evaluate the effectiveness of interventions aimed at eliminating these biases, in an attempt to optimize performance in areas where the cost of an error may be too high. Under this premise, this study is part of a broader research plan that contributes to the research on the human decision process and, in particular, to those decisions made in emergency and uncertain situations.

In the future, we will validate a cognitive bias instrument through confirmatory factor analysis to ensure thematic coherence between its items. We expect to elucidate whether the responses of the subjects fit with a theoretical model of unifactorial or multifactorial biases in line with the traditional definitions of the different heuristics. By using an alternative instrument to explore a wide range of biases will make it possible a) to study the existence of individual differences in cognitive biases; b) to assess how susceptible a person is to display cognitive biases in different situations; c) to detect whether there are individual factors (personality traits, impulsiveness, risk tendency, self-esteem, etc.) related to a certain profile with a tendency to display certain biases over others and; d) to study the effectiveness of interventions aimed at modifying and eliminating such biased decisions in areas where making errors may lead to highly negative consequences.

Furthermore, although this study is cross-sectional, it would be relevant in the future to conduct a longitudinal investigation that analyzes the stability

of individual biases over time. Likewise, since the present study sampled university students, we hope to expand the sample in future works and extend the results to the general population.

As a conclusion, we believe that the results of this conceptual replication study provide additional empirical support for the notion that biases are psychological phenomena. Cognitive bias is an essential aspect of the human mind.

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Declarations

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Appendix A

Problems

Gender: ……..……..

Age: …...

Instructions

Please solve the set of problems stated below. We are interested in you solving each problem in a completely independent way. All problems are different, and no two problems are completely alike, although some problems may be very similar to each other. Please, once you begin to respond, do not review your own previous responses. Do not ask anyone for help or consult the internet to solve these problems. We are very interested in your own individual answers to each problem.
Your participation is completely voluntary, and all responses are treated as anonymous and will be used for the sole purpose of scientific research in Psychology. There is no feedback on these problems because the data are not analyzed individually, and there are no correct answers.
By starting to solve these problems, you are giving your explicit informed consent to voluntary participation in the research.

PLEASE DO NOT LEAVE ANY QUESTIONS UNANSWERED

(Base-rate A)

Problem 1. A panel of psychologists interviewed 30 engineers and 70 lawyers, all of whom were very successful in their profession. After the interviews, the psychologists made brief descriptions of each of the 30 engineers and 70 lawyers.
You will read one of these descriptions later, which was chosen at random from the 100 descriptions made by the panel of psychologists. Please, when you read the description, indicate the probability that the person described is an engineer or a lawyer.
The psychologists were extremely accurate in giving probabilities to each of the

descriptions, so we ask you to do your best to estimate the probability that best approximates that made by the psychologists.
The description is as follows:
45-year-old man, married with 4 children. He is conservative, careful, and ambitious. He is not interested in political or social issues, but rather spends most of his free time enjoying his many hobbies, including home carpentry, sailing, and puzzles.
The probability that this man is one of the 30 engineers in the sample of 100 is in the range from
20% to 29%
30% to 39%
40% to 49%
50% to 59%
60% to 69%
70% to 79%
80% to 89%

(Framing A)

Problem 2. Imagine that our country is preparing for the outbreak of a very rare disease for which 600 people are expected to die. Only two alternative intervention plans were proposed to deal with this disease. Suppose the most accurate scientific estimates of the consequences of applying these plans are as follows:
a) If plan "A" is applied, 200 people will be saved.
b) If plan "B" is applied, there is a one-third probability that 600 people will be saved and a two-thirds probability that no one will be saved.
Which plan seems better to you?
I am completely in favor of plan A
I am in favor of plan A
I am a little in favor of plan A
I am not in favor of any plan
I am a little in favor of plan B
I am in favor of plan B
I am completely in favor of plan B

(Conjunction A)

Problem 3. A 31-year-old single, honest, and very bright woman studied philosophy. As a student, she was very concerned about issues of discrimination

and social justice, and also participated in protests against the use of nuclear energy. That this woman is a bank teller is:
completely probable
mostly probable
a little probable
neither probable nor improbable
a little probable
mostly probable
completely probable

(Outcome A)

Problem 4. A 55-year-old man had heart disease. He had to stop working because of chest pain. He enjoyed his job very much and did not want to stop working. His pain also interfered with other activities, such as travel and leisure tasks. A cardiac bypass surgery would ease his pain and increase his life expectancy from 65 to 70 years. However, 8% of people who undergo this surgery die as a result of it. His doctor decided to perform the surgery. The surgery was a complete success.
Evaluate the doctor's decision to perform the surgery.
completely incorrect
very incorrect
somewhat incorrect
neither correct nor incorrect
somewhat correct
very correct
completely correct

(Anchoring A)

Problem 5. In a recent scientific expedition, a strange petrified prehistoric tree was discovered in a forest. What do you think? Could the petrified tree be more or less than 2 meters tall? How tall do you think the prehistoric tree is?
from 1 to 1.9 meters
from 2 to 2.9 meters
from 3 to 3.9 meters
from 4 to 4.9 meters
from 5 to 5.9 meters
from 6 to 6.9 meters
from 7 to 7.9 meters

(Base-Rate B)

Problem 6. A panel of psychologists interviewed 70 engineers and 30 lawyers, all very successful in their profession. Based on those interviews, the psychologists made brief descriptions of each of the 70 engineers and 30 lawyers.
You will read one of these descriptions later, which was chosen at random from the 100 descriptions made by the panel of psychologists. Please, when you read the description, indicate the probability that the person described is an engineer or a lawyer.
The psychologists were extremely accurate in giving probabilities to each of the descriptions, we ask you to do your best to give an estimate of the probability that best approximates that made by the psychologists.
The description is as follows:
45-year-old man, married with 4 children. He is conservative, careful, and ambitious. He is not interested in political or social issues, but rather spends most of his free time enjoying his many hobbies, including home carpentry, sailing, and puzzles.
The probability that this man is one of the 70 engineers in the sample of 100 is in the range from
20% to 29%
30% to 39%
40% to 49%
50% to 59%
60% to 69%
70% to 79%
80% to 89%

(Framing B)

Problem 7. Imagine that our country is preparing for the outbreak of a very rare disease for which 600 people are expected to die. Only two alternative intervention plans were proposed to deal with this disease. Suppose the most accurate scientific estimates of the consequences of applying these plans are as follows:
a) If Plan “A” is applied, 400 people will die.
b) If plan “B” is applied, there will be a one-third probability that no one will die or a two-thirds probability that 600 people will die.
Which plan seems better to you?
I am completely in favor of plan A
I am in favor of plan A
I am a little in favor of plan A

I am not in favor of any plan
I am a little in favor of plan B
I am in favor of plan B
I am completely in favor of plan B

(Conjunction B)

Problem 8. A 31-year-old single, honest, and very bright woman studied philosophy. As a student, she was very concerned about issues of discrimination and social justice, and also participated in protests against the use of nuclear energy. That the woman is a bank teller and a feminist activist is:
completely improbable
mostly improbable
a little improbable
neither probable nor improbable
a little probable
mostly probable
completely probable

(Outcome B)

Problem 9. A 55-year-old man had heart disease. He had to stop working because of chest pain. He enjoyed his job very much and did not want to stop working. His pain also interfered with other activities, such as travel and leisure tasks. A cardiac bypass surgery would ease his pain and increase his life expectancy from 65 years to 75 years. However, 2% of people who have this surgery die as a result of it. His doctor decided to perform the surgery. The surgery failed and the man died.
Evaluate the doctor's decision to perform the surgery.
completely incorrect
very incorrect
somewhat incorrect
neither correct nor incorrect
somewhat correct
very correct
completely correct

(Anchor B)

Problem 10. In a recent scientific expedition, a strange petrified prehistoric tree was discovered in a forest. What do you think? Could the petrified tree be more or less

than 6 meters tall? How tall do you think the prehistoric tree is?
from 1 to 1.9 meters
from 2 to 2.9 meters
from 3 to 3.9 meters
from 4 to 4.9 meters
from 5 to 5.9 meters
from 6 to 6.9 meters
from 7 to 7.9 meters