Can Cognitive Biases in Risk Assessment be Improved with a Single Training Intervention?

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Abstract
The assessment of high-impact and low-probability risks poses a major challenge to risk analysts. If their assessments are subjected to biases, such as the bias blind spot or confirmation bias, this can lead to major complications for policy. Therefore, we examine the efficacy of a (single) training as a debiasing intervention to improve judgment and decision-making. Based on previous studies conducted by Scopelliti (2015), Morewedge (2015) and Yoon (2021) we designed a training as a debiasing intervention for students targeting the bias blind spot and confirmation bias. The effect was measured by the completion of a pretest, followed by the training after which participants immediately completed the posttest. We found the debiasing training intervention to be effective in reducing the cognitive biases in judgment for high-impact and low-probability risks.

Keywords: high-impact and low-probability risks, bias blind spot, confirmation bias, debiasing interventions

Introduction

The assessment of high-impact and low-probability risks poses a major challenge to modern states. These types of risks, such as floods, pandemic outbursts, or climate change, either lie far in the future or have a low chance of materialising in any given year (Heerma van Voss & Helsloot, 2021). Nevertheless, the assessment of risk analysts is of great importance to formulate rational and proportional national policies for the prevention and mitigation of these risks. However, states still have great difficulty with the assessment and policy provisions of high-impact and low-probability risks.

A recent event that illustrates how difficult it is for national risk analysts to assess high-impact and low-probability risks is the outburst of the Covid-19 pandemic. Based on the *Epidemic Preparedness Index*, it became clear that most developed countries were not prepared for an outburst with such major implications for society (Oppenheim et al., 2019). In addition, states were also unable to formulate a comprehensive response to control the impact of the virus (Frutos et al., 2021), despite the fact that statistical analyses have shown that outbursts of viruses like influenza happen annually. (Day et al., 2006).

The literature on risk assessment reveals several underlying factors that help explain why it is difficult for states to assess and formulate a rational response regarding these high-impact and low-probability risks. Since the early 2000s the assessment of risk has been done by conducting *National Risk Assessments* (NRA's). This practice became the standard for the OECD in 2009 and four years later for the European Union as well (Vlek, 2013). Because of this, all European Member states and several OECD countries use NRA's for risk assessment (Vlek, 2013; Heerma van Voss & Helsloot, 2021).

Vlek (2013) describes the process of conducting an NRA which in general is done via the charting of national risk scenarios following their estimated likelihood of occurrence and seriousness of the expected impact based on the classical definition of risk: "*probability x effect*". The result is a two-dimensional risk diagram in which major hazards and threats are categorized into four quadrants. Vlek (2013) categorizes the following quadrants: "(1) low likelihood and high impact, (2) high likelihood and high impact, (3) low likelihood and low impact, and (4) high likelihood and low impact" (p.949).

The use of NRA's in the assessment of risk has proven to be a relatively poor supporting tool for the assessment of high-impact and low-probability risks. This is because of the time-consuming information gathering process requiring the cooperation of various experts, which also makes it a really expensive process (Vlek, 2013). Furthermore, Heerma van Voss and Helsloot (2021) state that the far future risk goes uncovered in the NRA's. They add that low likelihood risk will in the long run be underappreciated versus the imminent and imaginable threats (Heerma van Vos & Helsloot, 2021). Helsloot et al. (2010) adds that relying on a "subjective concept of risk, safety perception, or subjective safety becomes a policy goal in itself" . They argue this to be an undesirable broadening of governments' duty, which has no clear relationship with subjective and objective safety (Nas et al., 2021; Helsloot et al., 2010).

Another contributing factor to relatively poor risk assessment is that the assessment of experts is not always based on their expertise concerning a particular safety issue (Nas et al., 2021). Vlek (2013) and Helsloot (2012) have found that experts are often influenced in their assessment. It is not exactly clear whether this is done intentionally or not, or because of the importance

of protecting their status or interest. Helsloot (2012) adds that experts tend to overestimate risks in their own specialist risk area, which results in disproportional (cost-benefit) risk responses.

Moreover, when it comes to identifying and assessing high-impact and low-probability risks, the human mind is notoriously poor (Heerma van Voss & Helsloot, 2021). This is due to the fact that people exhibit cognitive biases that influence their judgment and decision-making (Scopelliti et al., 2015). These cognitive biases are well documented in the literature (e.g. Tversky & Kahneman, 1947) and popularized by Taleb (2007) in *Black Swans* and by Kahneman (2011) in *Thinking fast and slow*. According to Yudkowsky (2008) a wide range of biases are to blame for the relatively poor risk assessment by experts, such as *confirmation-*, *information-*, *selection-*, *availability-*, and bias *blind spot*. Experts tend to have these cognitive biases influence their judgments and decisions, which may have implications for policy outcomes (Tetlock & Gardner, 2015).

Based on the literature on risk assessment, these factors have been identified and help understand the difficulty of assessing high-impact and low-probability risks. In this study, we look at the bias blind spot and confirmation bias because these are the most influential in the assessment of risks, as is made evident by Morewedge et al (2015). Risk analysts have to assess risks with uncertain values, which can be linked to bias blind spot and confirmation bias. Furthermore, risk analysts must infer cause and effect when evaluating past, present and future events, which is also reflected in the confirmation bias. Lastly, risk analysts regularly have to estimate probabilities and evaluate their own analyses, which can be linked to the confirmation bias and bias blind spot. In addition, there are two more practical reasons why these biases were chosen. First, due to the short time frame and taking into account the overcharging of the respondents we could only include these biases. Second, the literature already provides good tests for these biases to determine the effect of a debiasing training intervention. Several studies (e.g. Larrick et al., 1990; Morewedge et al., 2015; Scopelliti & Morewedge, 2019; Yoon et al., 2021) show that training as a debiasing intervention is effective in reducing bias in judgment and decision-making.

Therefore, we examine the efficacy of a (single) training as a debiasing intervention to see whether a training could reduce and improve judgment and decision-making. Effective debiasing training interventions are often based on the four basic strategies proposed by Fischhoff (1982): (1) teaching people about each bias, (2) teaching people the directional influence of each bias in judgment, (3) providing feedback, and (4) providing training with extensive coaching (Morewedge et al., 2015; Yoon et al., 2021). The first three basic strategies were integrated in the experiment. Due to the scope of this research it was not possible to provide subjects with extensive coaching. Effective training is also characterized by raising awareness of information that is normally not considered (Hirt & Markman, 1995; Morewedge et al., 2015) and statistical training (Larrick et al., 1990). In this study, we consider a training to be effective when it reduced the cognitive biases with a significance level of .05. Training as a debiasing intervention proves to be effective in different domains such as education, business, law, medicine, and policy (Nisbett et al., 1987; Yoon et al., 2021).

In an experiment held with students, we examine whether a single training can reduce biases in judgment and decision-making. We predict that the training intervention significantly reduces bias blind spot and confirmation bias and helps to improve judgment and decision-making. The experiment tests the present effect of the debiasing intervention by measuring the extent to which participants are committed to each bias, both before and after the training (Scopelliti et al., 2015; Morewedge et al., 2015). The experiment consists of a pretest, a debiasing training and immediately after a posttest to measure the effect of the training.

Hereafter, key literature on the cognitive biases, bias blind spot and confirmation bias, will be discussed, followed by the literature on debiasing interventions. Then the experiment will be outlined with the findings, and this paper ends with a conclusion.

Heuristics and Biases

People are continuously making decisions. Most decisions are of minor nature, but some are of severe significance. Few people seem to explore whether their decisions are subject to heuristics or biases, or why one option is chosen over another (Pronin et al., 2002). Besides, people are not always fully conscious of how decision-making works (Carmichael, 2020).

Political economy scholars (e.g. Downs, 1957; Simon, 1955; Gowda, 1999) have long recognised that people utilise heuristics when faced with decision-making tasks that require significant processing of information (Gowda, 1999). A heuristic is a mental shortcut that helps the human mind to make quick decisions and judgments without researching and analysing all the information (Carmichael, 2020). A well-known example in political economy that illustrates how heuristics work in decision-making is the 'Downsian voter' by Downs (1957). The concept minimizes information costs and uses heuristics such as party identification in the process of voting (Downs, 1957, Gowda, 1999).

People tend to relay on systematic shortcuts when they make judgments and decisions about the probabilities of events (Gowda, 1999). He states that while the errors caused by using systematic shortcuts can be reduced through education, the effect is limited because of our reliance on past experiences. He continues by explaining that the reason behind this is that people tend to stand by their 'inferior' or 'rational'

choices even after they have been made aware of their mistakes (Gowda, 1999). His perception is that when people make choices, their heuristics are derived from intuition rather than cognition (Gowda, 1999). Tversky and Kahneman (1986) state that while errors in judgment come from correctable mistakes in a person's thought process, errors in choice are caused by wrongly estimating the usefulness of certain decisions.

According to Tversky and Kahneman (1986) and Gowda (1999), this has led to new dimensions that are not traditionally included in rational decision-making models. This is because the primarily focus of research on heuristics and biases was based on the nature of these cognitive biases and how they affect judgment and decision-making in experimental settings (Gowda, 1999). However, in recent years the focus has shifted towards the understanding of why some individuals show persistent heuristics and biases on certain tasks and why others do not outside of experimental settings (West et al., 2012).

This shift in focus has resulted in the identification of a wide range of heuristics and biases in judgment and decision-making by cognitive scientists over the past decades (Blumenthal-Barby, 2016). When cognitive scientists Tversky and Kahneman (1974) published their work on heuristics and biases, they identified three main types of heuristics: the *representativeness* heuristic, the *availability* heuristic and the *adjustment* and *anchoring* heuristic (Tversky and Kahneman, 1974; Blumenthal-Barby, 2016). In their article 'Judgment under Uncertainty' Tversky and Kahneman (1974) state that these heuristics give way to predictable biases and errors in judgment and decision-making. However, after decades of research, the set of heuristics and biases found to operate in human judgment and decision-making has expanded substantially (Blumenthal-Barby, 2016). Besides, these heuristics and biases no longer fit into the classification outlined by Tversky and Kahneman (1974).

Blumenthal-Barby and Krieger (2015) identified nineteen different types of heuristics and biases, based on a review of 214 empirical studies of biases and heuristics in judgment and decision-making. The scope of this study is focused on two of these biases, bias blind spot and confirmation bias. Therefore, the other seventeen heuristics and biases will not be addressed.

Bias Blind Spot

From the literature it is evident that people exhibit numerous systematic biases in judgment and decision-making (Tversky & Kahneman, 1974; Nisbett & Ross, 1980; Kahneman et al., 1982; Scopelliti et al., 2013) and that they are not always accurate and objective at perceiving themselves, their circumstances and those around them (Hastie & Dawes, 2001; Gilovich et al., 2002; Bazerman, 2005; Pronin, 2006). Furthermore, Pronin (2007) argues that people's perceptions can be biased by their beliefs, expectations and context, as well as by their needs, motives and desires. A lack of consciousness about biases has important consequences, as this can compromise the quality of judgment and decision-making (Nisbett & Wilson, 1977; Pronin, 2006; Scopelliti et al., 2015). Commonly mentioned in the literature is that the bias blind spot can cause misunderstandings in communication and outcomes for the intended policies, which can have major complications.

Literature on human judgment and decision-making shows that people recognize the existence, and impact, of many of the biases that affect judgments and inferences of others (Pronin, 2006). However, they seem to lack recognition of the role that these same biases have in shaping their own judgment and inferences (Pronin, 2006; Scopelliti et al., 2015). This is referred to as the bias blind spot. The bias blind spot has been explored by Pronin et al. (2002). In their article 'The blind spot bias: Perceptions of bias in self- versus others', they found that subjects evaluate themselves as having less bias than others (Pronin et al., 2002; West et al., 2012). Pronin et al. (2002) argue that the biases are relatively easy to recognize in the decision of others, but that they are often difficult to detect in one's own judgments and decisions. Scopelliti et al. (2015) add that most people tend to believe, on average, that they are less biased in their judgment and behavior than their peers.

According to Pronin and Kugler (2007), the bias blind spot is attributed to the interplay of two phenomena, namely the *introspection illusion* and *naïve realism*. They argue that "the *introspection illusion* results from differences in the availability and perceived diagnostic values of the introspection when assessing oneself and others" (p. 566). Consequently, they argue that we generally know what we are thinking and feeling, and what we are intending to do and hope to accomplish, better than others know about us. Pronin and Kugler (2007) indicate that this introspective access puts us in a unique position, which might not always be a better one, for understanding our past attitudes and actions and for predicting our future ones (Nisbett & Ross, 1980; Wilson & Brekke, 1994). In addition, Scopelliti et al. (2015) argue that introspection is unlikely to reveal biased thought processes.

Naïve realism involves the belief that one perceives and responds to the world objectively (Ross & Ward, 1996; West et al., 2012). Kruger and Gilovich (2004) show that overreliance on introspective evidence fosters a bias blind spot because of people's false belief that biasing processes can be detected by introspection. They continue with explaining that when introspective efforts fail to detect biasing processes, one may wrongly conclude that they are free of these processes (Kruger & Gilovich, 2004). At the same time, they assume that biasing processes are still common in the other (Kruger & Gilovich, 2004; Williams & Gilovich, 2008; West et al., 2012).

In sum, scholars (e.g. Ross & Ward, 1995; Pronin et al., 2004; Scopelliti et al., 2015) describe naïve realism as the belief that one's perception reflects the true state of the world, which generates a false sense that these charitable self-assessments are genuine rather than positively biased.

According to Scopelliti et al. (2015) the interplay of these two phenomena of the bias blind spot shows that when people evaluate the extent of bias in others, their assessments rely on behavior rather than on private thoughts because the private thoughts of others are not accessible. They add that consequently, the biased behavior of others is not excused by an evidently unbiased thought process. The variety of social and cognitive biases for the blind spot has been observed by Pronin et al. (2004), West et al. (2012) and Scopelliti et al. (2015) and suggest that the sensitivity to the bias blind spot may be a higher-order latent factor underlying the belief that one is less likely to exhibit a variety of specific biases than one's peers (Scopelliti et al., 2015).

Bias Blind Spot and Decision-Making

Scopelliti et al. (2015) clarify the robustness and uniqueness of this bias and examine the relationship with general decision-making ability. They state that a single higher-order construct determines the extent to which people recognize their own bias. They encounter three possible relationships between the bias blind spot and general decision-making.

The first relationship that Scopelliti et al. (2015) detect is that people who are lowest in decision-making ability may not be aware of their own bias. They add that these people may be most likely to exhibit the bias blind spot. The fact that the least skilled are often more prone to this bias was also confirmed by Kruger and Dunning (1999) and is also pointed out in the article by Dunning et al. (2003). Earlier work (Kruger and Dunning, 1999; Dunning et al., 2003) has also pointed out that the least skilled are often more prone to this bias. The bias blind spot should be negatively correlated with decision-making competence, because of the inability to correct for occurring biases.

Second, they argue that "people who believe they are less biased than their peers, may be correct" (Scopelliti et al., 2015, p. 2469). In this case, they state that the bias blind spot may not really reflect vulnerability to a blind spot at all, and there should be a positive correlation between bias blind spot and decision-making competence (Scopelliti et al., 2015).

The third relationship they found is that the bias blind spot may be unrelated to general decision-making ability. Scopelliti et al. (2015) and Bruine de Bruin et al. (2007) argue that people who have not been trained in decision-making and are therefore unaware of common biases in reasoning and judgment show considerable variation in their decision-making competence. They suggest that superior decision-making is a function of calibrated intuitions rather than awareness of appropriate decision-making strategies (Bruine de Bruin et al., 2007; Scopelliti et al., 2015). This suggests, that superior decision-making is a function of calibrated institutions rather than awareness of appropriate decision-making strategies. Research by Nisbett and Wilson (1977) and Wilson and Dunn (2004) shows that people have limited insight into the process by which their judgments and decisions are made.

Having addressed the definition of the bias blind spot and the three relationships we have gained an understanding of how this bias operates in human judgment and decision-making. The next section will go into the confirmation bias.

Confirmation Bias

The second bias addressed in this study is the confirmation bias. According to Lewicka (1998) there are two meanings regarding the confirmation bias in the literature. The first meaning, which is referred to as "Confirmation bias I" (Lewicka, 1998, p. 235), follows from the everyday understanding of the term. This means that there is selective attention to the evidence that may confirm the hypothesis or neglect the data which may disconfirm the hypothesis (Snyder & Swam, 1987; Klayman, 995; Lewicka, 1998). Klayman and Ha (1987) refer to this as 'positive hypothesis testing'. They argue that this tendency's manifestations include favoring or searching for positive evidence which could confirm the hypothesis, and ignoring, distorting or reinterpreting negative evidence (Klayman & Ha, 1987; Lewicka, 1998; Jones & Sugden, 2001).

The second meaning of the confirmation bias distinguished by Lewicka (1998) is the "confirmation bias II" (p.235). Instead of deceptive handling of the evidence, this second type describes a focus on positive instances of a hypothesis, known as confirmatory strategy of hypothesis testing (Lewicka, 1998). Wason (1960) states that this is defined as a way of hypothesis testing on the basis of instances that are predicted by the hypothesis while ignoring instances beyond its scope, and therefore ignoring other outcomes or explanations.

It is of note that both types of confirmation biases lead to different consequences (Snyder, 1980; Snyder & Swann, 1878; Klayman & Ha, 1987; Lewicka, 1998). The difference between the two is that the first type makes it difficult to check whether the hypothetical factor is a good reason for the observed evidence (Lewicka, 1998). On the other hand, in the second confirmation type it is difficult to establish the factor's necessity for the phenome that is observed (ibid., 1998). Evident is that these two types can have serious implications for the judgment and decisions made by risk analysts. For this study we look specifically at the confirmation bias I.

Confirmation Bias and Decision-Making

Lewicka (1998) provides clear examples which show how the confirmation bias affects judgement and decision-making. According to the literature on the first type of confirmation bias, one searches for positive evidence that either confirms their hypothesis or rejects the alternative hypothesis. An example Lewicka (1998) uses to illustrate this is a person that is waiting for the bus. For instance, this person believes that fate is unfair to him, as proven by a series of observations showing that whenever he or she waits for the bus, the bus is always late. The person will then tend to register as evidence only those cases when the bus is late, but not those who were on time. The mechanism that is visible by the confirmation bias I is that it is hard to refute such a hypothesis and can lead to a type I error in judgment and decision-making (Field, 2018).

In addition, Evans (1989) explains that cognitive failure is caused by a selective process in which we gather positive or negative information to match our preferences. This shows that confirmation bias is cognitive rather than a motivational phenomenon in decision-making processes. According to Clark and Clark (1977) it is not due to the lack of willingness to look for disconfirming evidence, but due to the difficulties people experiences while processing negative information. As a result, the outcomes of neglecting either positive or negative information has major consequences for the judgments and decisions that have to be made by risk analysts.

For confirmation bias II, Lewicka (1998) uses the same example about the person waiting for the bus being convinced that the bus this person expects always comes late. This person will be inclined to check only those buses that he or she is waiting for while ignoring the fact that other people waiting for the bus face identical problems. Lewicka (1998) argues that this example shows that the confirmation bias II, in contrast to the first one, is a result of a bias in reasoning rather than the validity of the evidence. Another well-known experiment that illustrates this is the 2-4-6 by Wason (1960). In this experiment, subjects had to discover the rule. They were given the following numbers 2-4-6 and were told that this fit the rule. The aim was not to find numbers but the rule itself (Wason, 1960). They continue to test series of numbers, even after they were highly confident that they discovered the rule they announced it (Wason, 1960).

The results of the experiment showed that only 21% guessed the rule during the first try (Wason, 1960; Yudkowsky, 2018). What became apparent during the experiment is that subject thought the distance between the numbers was two, while the actual rule is that the three numbers must be in ascending order, and that series like 14-28-42 or 50-100-500 also fit the rule (Wason, 1960). The mechanism behind the experiment is that subject try to confirm their hypothesis (confirmation bias) rather than falsifying hypothesis like Propper (1963) would suggest (Wason, 1960; Yudkowsky, 2008).

The consequence associated with this bias for judgment and decision-making is that when the bus arrives on time it can contribute to the idea that the person has sudden luck in his life. However, the person will still be biased, but Lewicka (1998) argues that the bias interpretation will not concern the evidence of the hypothesis but the hypothesis itself.

These two examples by Lewicka (1998) illustrate how reluctant people are to consider alternative hypotheses or explanations. According to Lewicka (1998) there are three factors that contribute to the persistence of neglecting alternative hypotheses. The following three factors show the influence of the confirmation bias on judgment and decision-making and show importance of reducing the bias, namely “the positivity bias”, “the positive test bias”, and “the error minimization hypothesis”.

The first factor, the positivity bias, is illustrated in the first example. The explanation given by Evans (1998) is that the positivity bias is the preference for positive over negative information. Evans (1998) states that it is the failure of the cognitive bias caused by a form of selective processing, in which people think about the positive rather than about the negative information. According to Evans (1998) the confirmation bias is a cognitive phenomenon rather than a normative one. Clark and Clark (1977) add that it is due to the lack of willingness of a person to look for disconfirming evidence, like the person waiting for the bus not registering the times the bus was actually on time and the difficulties experienced during the processing of logically negative material.

The second factor is the positive test strategies. The main point of this factor is that the confirmation bias is not an error but a purposeful strategy of hypothesis testing, in which people tend to generate only positive results and neglect the negative results (Lewicka, 1998).

The last factor, the error minimization hypothesis, is proposed by Lewicka (1985; 1993) and Friedrich (1993). They argue that cognitive processes are, first of all, instruments of actions. According to them, this implies that people outside the laboratory setting are rarely faced with the demand to contemplate reality through certain ways of reasoning, strategies and inference rules. Therefore, Lewicka (1998) states that outcomes that are proven to be beneficial in the past are likely to be chosen again and above other options and explanations.

Debiasing Interventions: Training

It is clear that people exhibit biased judgments and decisions both in their personal and professional lives (Yoon et al., 2021). However, not all people are affected by biases, in their judgment and decisions, in the same way. Morewedge et al. (2015) and Bruine de Bruin et al. (2007) argued that the decision-making ability varies across people and within people across life span. Also, people are often unaware of the extent to which they are biased and have difficulty with

debiasing their judgments and decision-making abilities (Scopelliti et al., 2015; Morewedge et al., 2015). The literature (e.g. Nisbett et al., 1987; Larrick et al., 1995; Morewedge et al., 2015) provides encouraging evidence that a training as debiasing intervention improves human reasoning and can reduce cognitive biases, such as bias blind spot and confirmation bias (Morewedge et al., 2015; Yoon et al., 2021).

Training as a debiasing intervention is commonly used in psychology and medicine studies (e.g. Herman & Freitas, 2010). In a study by Morewedge et al. (2015) they tested whether a single debiasing training intervention could produce long-term reductions in six cognitive biases. The training they provided consisted of instruction videos and educational video games. Their results show that the six cognitive biases in their experiments have been reduced through a training as debiasing intervention (Morewedge et al., 2015). Nevertheless, debiasing training intervention has not received much attention within the field of risk assessment, but could be effective in debiasing the judgment and decision-making ability of risk experts.

Debiasing training interventions typically incorporate some combinations of the four basic strategies proposed by Fischhoff (1982). These four basic strategies are: (1) warning people about the possibility of bias, (2) describing the direction in which bias may influence judgment, (3) providing feedback on judgment and decisions, and (4) providing training with extensive coaching. Fischhoff (1982) argues that 'purely information-based training interventions' (strategy 1 and 2) can be effective. But, the most effective training intervention appears to be incorporate personalised feedback and more extensive forms of coaching and training, such as statistic courses (Yoon et al., 2021).

Effective debiasing training intervention is characterized by the encouragement of information that is likely to be underweighted in intuitive judgment and thus responds to the first basic strategy proposed by Fischhoff (Hirt & Markman, 1995). Another feature of effective training is proposed by Larrick et al. (1995), who argue that it is important to train statistical reasoning and normative rules of which most people are unaware. Overall, training as a debiasing intervention seems to be effective in reducing cognitive biases and improving judgment and decision-making.

In this study, we consider a training as debiasing intervention to be effective when the values of the posttest after training are reduced. This is determined by comparing the means of the pretest and posttest with a significance level of .05.

Experiment Bias Blind Spot and Confirmation Bias and Method

Following the theory summarised above, we will test the following hypotheses during the experiment to see the effects of a training as a debiasing intervention:

H1: *We expect the training to be effective in making the participants aware of their own vulnerability towards the bias blind spot, and improves after training*.

H2: *We expect a training, as a debaising intervention, to be effective in reducing the bias blind spot in judgment and decision-making.*

H3: *We expect a training, as a debiasing intervention, to be effective in reducing the confirmation bias in judgment and decision-making*.

In the experiment, we test whether students become aware of their own sensitivity towards the biases and whether this improves after they become aware of their own weaknesses in judgment and decision-making. In addition, we test whether a training as debiasing intervention could reduce the blind spot bias and confirmation bias, and could improve judgment and decision-making. In cooperation with Irene Scopelliti[1], Carey Morewedge[2], Heawon Yoon[3] and Bas Heerma van Voss[4], I have created a training to see whether this could produce a long-term reduction in cognitive biases affecting risk assessment (Morewedge et al., 2015). We tested the present effect of the training by measuring the extent to which participants are committed to each bias two times: in a pretest before the training, and directly after the training in a posttest.

The setup of the experiment is as follows: the participants are subjected to a pretest, which determined how biased the participants are on the basis of several questions. After completing the first questionnaire they receive a training about cognitive biases and directly after the training participants are immediately subjected to the posttest. These two questionnaires aim to provide insight into the effect of training as a debiasing intervention. To fully understand the workings of the experiment we look gradually at the different elements of the experiment.

Participants. The experiment was conducted with students from three different Dutch universities (Leiden, Enschede and Deventer). All of the students participating in the experiment do courses related to governance of safety. A total of 119 students (56 female students, M_{age}= 26.1, SD=2.09) were subjected to the questionnaires. In all (N=) 111 students successfully completed the pretest and posttest.

Questionnaires. For the experiment, four questionnaires were created based on the previous studies by Scopelliti (2005), Morewedge (2015) and

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Yoon (2021) and the underlying theory by Pronin (2008). To ensure a reliable and stable scale for the analyses an item-generation process was conducted (Scopelliti, 2015). Four versions of the experiment (AC, BD, CA, DB) were created to make sure participants could not consult with each other and were forced to think for themselves, ensuring the measure of the bias would not be affected. The difference between the questionnaires is that for the AC-CA the questions are the same, only ordered differently, BD and DB are similarly comparable to each other, although they do have a slight difference in questions from AC and CA.

To get an idea of the questions, an example will be given for each bias. The questions can also be found in appendix (I). For the bias blind spot, ten questions were formulated in which the participant had to rate the extent to which they exhibit the bias and the extent to which the average person exhibits this bias on a 7-point scale with endpoints, *not at all* (1), and *very much* (7). The questions for this bias were asked on two domains the general- and risk domain. This is best illustrated by the following examples:

- General domain: "*Psychologists have claimed that some people show a tendency to do or believe a thing only because many other people believe or do that thing, in order to feel safer or to avoid conflict*".
  - "To what extent do you think an average person shows this tendency?"
  - "To what extent do you think that you show this tendency?"
- Risk domain: "*Psychologists have claimed that some people show a tendency to do or believe a thing only because many other people believe or do that thing, in order to feel safer or to avoid conflict. Following 9/11, for instance, many analysts heavily overestimated the threat of terrorist attacks because other analysts stated terrorist attacks were likely*".
  - "To what extent do you think an average person shows this tendency?"
  - "To what extent do you think that you show this tendency?"

For the confirmation bias participants were presented with cases about risks, such as floods. We measured the confirmation bias by asking what other information the participants need in addition to the information already given to explain hypotheses. For each question, there were three response options. An example of a case is:

- "*Lucy wonders why her government has reduced investments in preparations for future threats [..]. Lucy thinks that the reduced investments are mostly due to the lack of public support for her government. In which other country should she test her hypothesis?*"

Training intervention. In order to reduce the cognitive biases, we designed a short, 30-minute, training as a debiasing intervention based on the experiences of Scopelliti, Morewedge and Yoon and the previously mentioned three basic strategies by Fischhoff (1982). The training was given by Bas Heerma van Voss and consists of two main parts. The first part of the training focused on the different heuristics and biases and how they influence judgments and decisions (first and second basic strategy by Fischhoff).

The training about the biases was designed by Bas and is based on the literature. The training first addresses the heuristics. A definition and the workings of heuristics were discussed. After that, the biases were addressed. Also, the anchoring bias was treated in the training. This bias was made understandable through information and examples. In the end, tips were given on how to avoid anchoring in judgment and decision-making.

The next part of the training was copied from the debiasing method used by Morewedge, namely the Carter Racing Case by Brittain & Sitkin (1986). This is a case study that is often used in American Business Schools. The Carter Racing Case is about the Carters, who are in charge of a business involved in car racing. They have to decide whether they will participate in the upcoming race. It is an important decision because of the benefits it will bring such as media exposure which is good for business (Brittain & Sitkin, 1986). However, the decision-making process is complicated by a series of factors that represent risks for the team, their careers and their business (Brittain & Sitkin, 1986). Based on the descriptions of the case, the participants have to decide whether they should race or not. This case shows how difficult it is to make certain decisions. In this part of the training, the third strategy of Fischhoff is integrated by giving by giving participants feedback on the decisions they made during the Carter Racing Case. The final part of the training suggested mitigation strategies and ended with a brief summary of the aspects covered in the training.

Bias measures. For the measurement of the biases, two scales were created: one for the bias blind spot (BSB) and one for the confirmation bias (CB). The purpose of this division is to see to what extent the participants were committed to the bias blind spot and confirmation bias. These scales were tested based on Cronbach's alpha ($\alpha > .70$) to ensure reliability and validity. Four versions of questionnaires of each scale were created to measure the biases in the pretest and posttest.

As mentioned before the scale for the bias blind spot was divided into two domains, the risk and the general domain. With the questions, participants were asked to indicate the prevalence of the bias for themselves and others. Based on a precious study by Scopelliti et al. (2015) each question was formulated as a psychological tendency or effect. The scores that emerged from the questionnaires were calculated by subtracting the perceived self from the other to the bias blind. For each participant, the difference between the scores for self and others was used to measure the bias blind spot (Scopelliti et al., 2015).

For the confirmation bias, participants were presented with cases about risks, such as floods, cyber risk and nuclear plants and were asked about what other

information they needed, other than the provided information in the case, to explain or confirm their hypotheses. The measurement is based on the comparison of the mean between the pretest and posttest.

Testing procedure. The experiment was conducted at the universities of the students, in lecture halls. Beforehand, based on the experiment protocol, the setting created separated and private seats to ensure individual answers. The questionnaires were relatively equally disturbed among students. The participants started off with the pretest for which they were given 40 minutes. After the pretest, participants were given a short break of 15 minutes which was followed by the training of 30 minutes. Directly after the training participants had to complete the posttest, for which they had 35 minutes.

Analyses and Results

Before we can look at the effects of the training as a debiasing intervention it is important to address how the scales for the bias blind spot and confirmation bias have emerged and if these scales are reliable. Under the headings *questionnaires* and *bias measure* we have already read that there were ten questions formulated for the bias blind spot and that through subtracting the other from the self the scores were created. This means that we are left with 5-items for the pre-and post-test. For the confirmation bias, we have 7-items. In order to determine if these items can form one latent variable, a factor analysis was conducted.

New variables for the bias blind spot and confirmation bias were created using several tests. First of all, by looking at the correlation which was between .30 and .70. Second, using the KMO test, which was above .50. Third, estimating Kaisers criterion, in which the eigenvalue was 1.0 (Field, 2018). The fourth test was to see whether all items were clearly loaded on one factor. All the items were above .20. The last step is to see whether these new scales are reliable. The reliability of the scales is based on Cronbach's alpha ($\alpha = > .070$). Both the scales for the bias blind spot and the confirmation bias were reliable according to the following values: bias blind spot $\alpha = .81_{pretest}$ and $.83_{posttest}$. For the confirmation bias $\alpha = .67_{pretest}$ and $.78_{posttest.}$

Previous studies on training as a debiasing intervention show that this has a positive effect on reducing cognitive biases and improves judgment and decision-making. Therefore, three hypotheses were formulated in order to establish the effect of the training we designed. In the first hypothesis, we expect the training to be effective in making the participants aware of their own vulnerability toward the bias blind spot, and improves after training. Due to the descriptive nature of the question, a table is presented to gain insight into the respondent's own vulnerability towards the bias blind spot. As mentioned before, the respondents had to rate the extent to which they exhibit the bias compared to the others on a 7-point scale, where 1 is not much and 7 very much. 1 to 7 is shown and shows how often respondents gave this scores for themselves and others. Additionally, this table shows the differences between the indications of the pretest and the posttest.

		Pretest		***Posttest***	
Not at all		Self	Other	Self	Other
	1	43	5	20	2
	2	139	14	93	5
	3	202	65	164	36
	4	330	177	316	169
	5	244	346	214	395
	6	141	406	195	417
	7	44	130	70	156
Very much					

Table 1. Overview bias blind spot self-versus others in pre- and posttest.

Although the table does not generate statistical or significant results, we can observe two small things. First, we see that students are most likely not aware of their own vulnerability while assessing the questions, because the respondents rate themselves less biased than the other. Second, we see that this slightly reduces after training and they become more aware of their own weaknesses in judgment and decision-making. However, the ratings of the other do not change much.

For the second hypothesis, we looked at the effect a training has on the blind spot bias. This bias was tested in two domains, namely the risk domain (α= .76) and the general domain (α=.68). The results show that in both domains the training effectively reduced the blind spot bias, which is also shown in table 3. Looking at the risk domain the values show a reduction of .19 ($1.14_{pretest}$ - $.92_{posttest}$) with a *p*-value of .05. For the general domain, we found a reduction of .22 ($1.29_{pretest}$ – $1.12_{posttest}$) with a *p*-value of .00. Based on these findings we can assume that training as debiasing intervention has a positive effect on the blinds spot bias, and therefore we can accept our hypothesis.

	Mean	Valid *N*	Std. Deviation	Std. Error Mean
Pretest Risk	-1.14	111	.82	.07
Posttest Risk	- .92	111	.95	.08
Pretest General	-1.29	111	.82	.07
Posttest General	-1.12	111	.95	.08

Table 2. Variables bias blind spot

	Mean	Std. Deviation	Std. error Mean	t	Sig.
Pre Risk – Post Risk	-.19	0.86	0.08	-2.7	.00***
Pre General – Post General	-.22	0.95	0.09	-1.97	.05*

$p < .001$***, $p < .010$**, $p<0.050$*

Table 3. Output pre- posttest bias blind spot

For the last hypothesis, we tested whether a training could effectively reduce the confirmation bias

in judgment and decision-making. Here, we also found that the training effectively reduced the confirmation bias with .35 ($1.39_{pretest} - 1.04_{posttest}$) with a *p*-value of .00. This also emerges when looking at tables 4 and 5. Based on these significant results we can accept our third hypothesis and can assume that training as a debiasing intervention is effective in reducing the confirmation bias in judgment and decision-making.

	Mean	Valid *N*	Std. Deviation	Std. Error Mean
Pretest CB	-1.39	111	1.11	.10
Posttest CB	-1.04	111	1.14	.10

Table 4. Variables Confirmation bias

	Mean	Std. Deviation	Std. error Mean	t	Sig.
Pre CB – Post CB	-.35	1.28	.11	-2.92	.00***

$p < .001$***, $p < .010$**, $p<0.050$*

Table 5. Output pre-post test confirmation bias

For all three hypotheses, we found significant values and can assume that training as a debiasing intervention is effective in reducing cognitive biases, blind spot bias, and confirmation bias and improves judgment and decision-making.

Conclusion and Discussion

In this paper, we examined the efficacy of a training as a debiasing intervention for reducing cognitive biases in judgment and decision-making. We looked at the effect the training has on the bias blind spot and confirmation bias to see whether it improved judgment and decision-making. Based on extensive research done in the field of cognitive biases and debiasing intervention (e.g. Fischhoff, 1982; Scopelliti et al., 2015; Morewedge et al., 2015; Yoon et al., 2021) we developed an experiment in which we tested the effect of a training. The experiment was held with 119 students from three Dutch universities.

The results of our experiment show that a training as a debiasing intervention is effective in reducing cognitive biases. If we look at the results we see for all the formulated hypotheses an effective reduction in biases and improvement in judgment and decision-making. Therefore, we can conclude that a training as a debiasing intervention is effective in reducing the bias blind spot and confirmation bias and improving judgment and decision-making.

Although this research shows some caveats such as not yet having tested the experiment with actual risk experts. Or the fact that the values for the pretest confirmation bias scale are slightly below the estimated value of Cronbach's alpha. It does show that risk experts can benefit from following a training to gain insight into their own biases in judgment and decision-making. However, to determine the actual durability of the training as a debiasing intervention, it is necessary to conduct further research on the effect of the term and how long judgments and decisions remain debiased.

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Appendix I

Questionnaire A (pre) Participant #___

Request for consent

The following will provide you with information about the experiment that will help you in deciding whether or not you wish to participate. If you agree to participate, please be aware that you are free to withdraw at any point throughout the duration of the experiment without any penalty.

In this study we will ask you to read and answer several questions regarding large societal risks. The purpose of this study is to improve insight into how states predict societal risks and what can be improved.

All information you provide will remain confidential and will not be associated with your name. The research data will be made anonymous/ pseudonymized and safely stored according to the research data management guidelines of Radboud University and conform General Data Protection Regulation The data will be shared among the researchers involved in the research project. They will not be made public. The data will not be used for other studies, unless we got your explicit permission to do so. For research integrity purposes, the research data will be accessible on request to the academic community for a period of at least 10 years.

If for any reason during this study you do not feel comfortable, you may leave the room without consequence and your information will be discarded. Your participation in this study will require approximately 120 minutes. When this study is complete you will be provided with the results of the experiment if you request them, and you will be free to ask any questions. You can request deletion of all your entries into this study using your participation number up to six weeks after the experiment by sending an email to bas.heermavanvoss@ru.nl.

If you have any further questions concerning this study please feel free to contact us through phone or email: +31 6 2111 3748, bas.heermavanvoss@ru.nl. Should you have any complaints regarding this research, please contact the researcher, contact the confidential Advisors Academic Integrity via email: vertrouwenspersonen@ru.nl or contact the Committee Scientific Integrity of Radboud University. The committee's secretary is mr. M. Steenbergen, (m.steenbergen@bjz.ru.nl or 024 3611578) Executive and Legal Affairs. In case of misuse, you can lodge a complaint at the Autoriteit Persoonsgegevens.

Signing below indicates that

- you have taken note of and you understand this information
- you voluntarily agree to participate
- you are at least 18 years of age

_____ _____

Signature of Participant Bas Heerma van Voss, researcher

Intro

In the following set of questions, you will be assigned a hypothesis about the relationship between two variables. For example, how the mortality rate of a city is related to its proximity to the equator.

In each question, you will see four data points you could investigate. Each data point is related to two pieces of information, but you can only see one piece of information about each data point.

Selecting the data point provides you access to learn about the second piece of information. For example, you might see four cities. One has a high mortality rate, one has a low mortality rate, one is near to the equator, and one is far from the equator.

You would then choose which cities to learn the second piece of information about. If you choose a city with a high or low mortality rate, then you would learn about how close or far it is from the equator. If you choose a city that is close or far from the equator, then you would learn about its mortality rate.

Please choose the item or items for which you think that the second piece of information will be most useful to test the hypothesis stated in the question.

CBRIC4

Your government asks you to assess the reliability of news sources about military attacks in a country without a free press. There are two news stations in the region (news station AAB and news station YYZ).

You have the following pieces of information about four attack reports.

From which nuclear plant(s) should you gather additional information either on distance to the capital or nuclear accident rates. For which report should you gather additional information about either the reliability of the report or which station made it to test the following hypothesis, **"News reports about military attacks by station AAB are reliable"?**

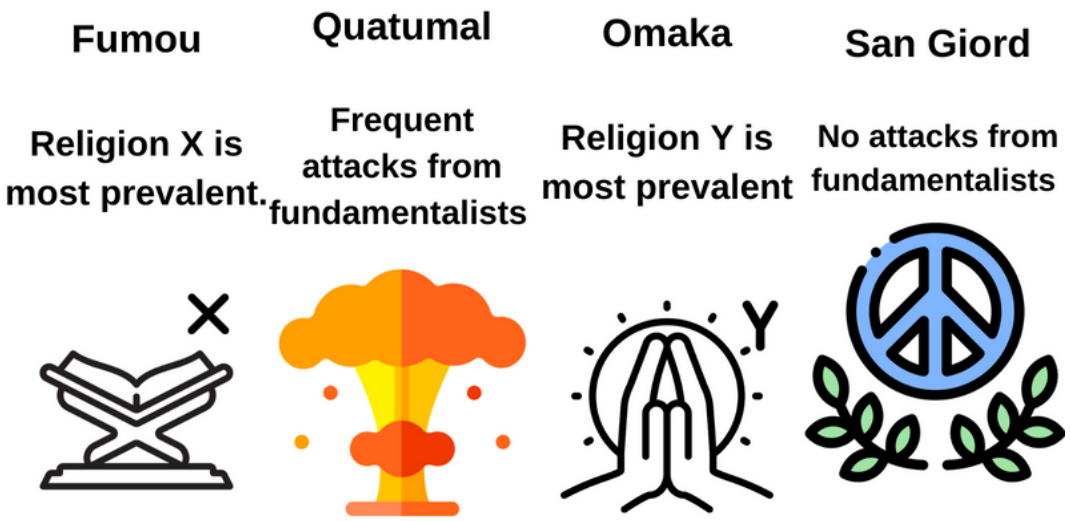
You may select multiple answers.

1) O Attack reported by Station AAB
2) O Attack reported by Station YYZ
3) O A news report about a false attack
4) O A news report about an actual attack

CBRIC5

Your government asks you to assess the risk of a terrorist attack from fundamentalist religious groups in a small group of countries. One of two religions is most prevalent in each of the countries (religion X or religion Y).

You have the following pieces of information about four countries in the area.



From which country (or countries) should you gather additional information on either the most prevalent religion or the frequency of terrorist attacks to test the following hypothesis, **"Countries where religion X is most prevalent are at greater risk of attacks from fundamentalist religious groups"?**

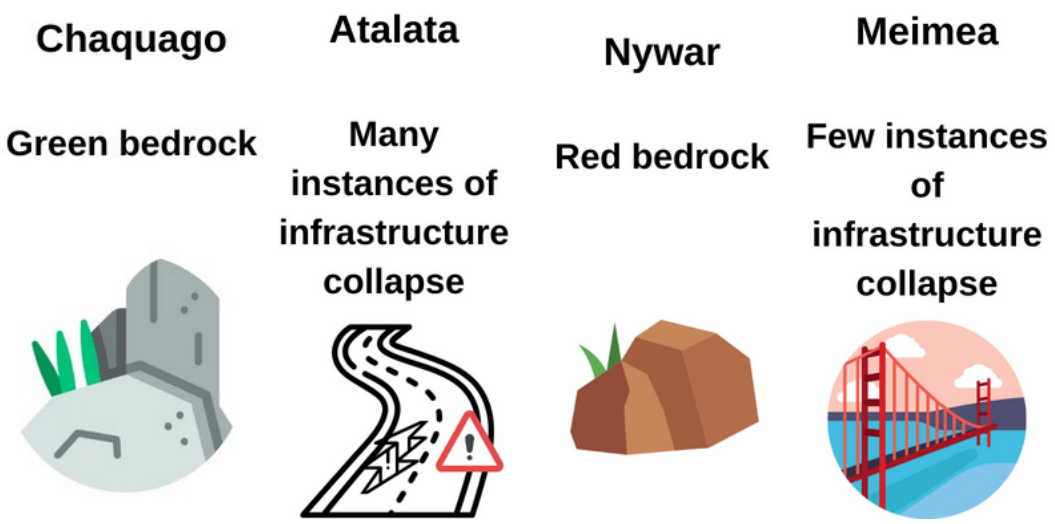
You may select multiple answers.

1) O Quatumal
2) O Omaka
3) O Fumou
4) O San Giord

CBRIC6

Your city government asks you to investigate whether the risk of large infrastructure collapsing, such as bridges or waterworks, is related to specific types of bedrock. There are two types of bedrock in the region (green and red bedrock).

You have the following pieces of information about four cities in the region.



From which city (or cities) should you gather information about either the type of bedrock or the frequency of infrastructure collapse to test the following hypothesis, **"Cities with a green bedrock experience more instances of infrastructural collapse"?**

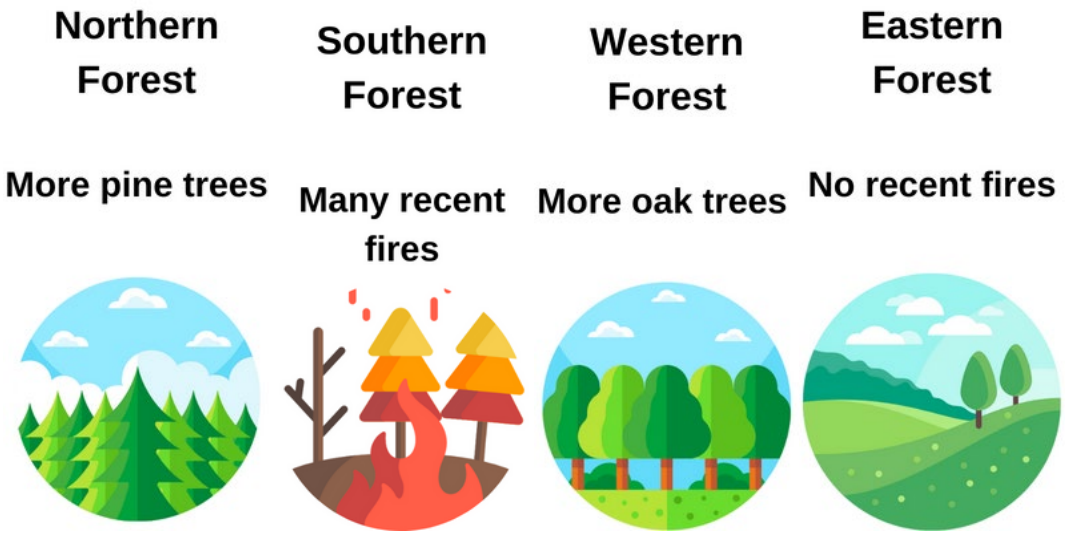
You may select multiple answers.

1) O Nywar
2) O Meimea
3) O Chaquago
4) O Atalata

CBRIC7

Your government asks you to investigate whether the risk of forest fires is related to the dominant type of tree in your country's forests. Forests in your county largely consist of two types of trees (pine trees and oak trees).

You have the following pieces of information about four forests in your country.



From which forest (or forests) should you gather additional information about either the dominant type of tree or the incidence of recent fires to test the following hypothesis, **"Forest that have more pine trees experience more forest fires"?**

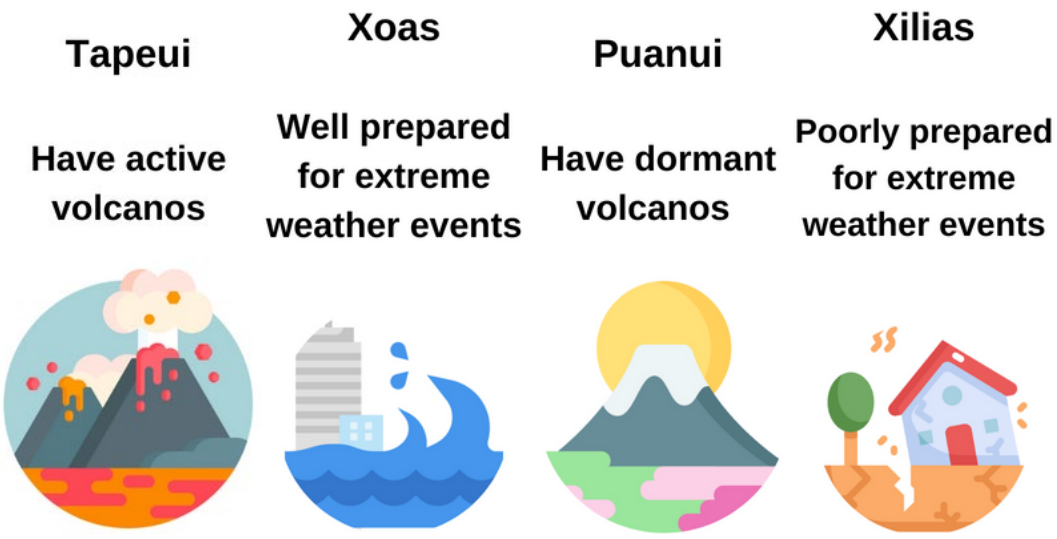
You may select multiple answers.

1) O Western Forest
2) O Southern Forest
3) O Northern Forest
4) O Eastern Forest

CBRIC8

Your government asks you to examine whether the preparedness for extreme weather is related to the presence of active volcanos in the region.

You have the following pieces of information about four regions.



From which region (or regions) should you gather additional information on either the presence of active volcanos or the preparedness for extreme weather to test the following hypothesis, **"Regions which have experienced volcanic eruptions in their recent past are better prepared for extreme weather events"?**

You may select multiple answers.

1) O Tapeui
2) O Xilias
3) O Xoas
4) O Puanui

CBRIC9

Your government asks you to examine the effect of a country being surrounded by plains or high mountains on its likelihood of being at war.

You have the following pieces of information about four countries.

From which country (or countries) should you gather additional information on either their surroundings or whether they experienced wars to test the following hypothesis, **"Nations surrounded by plains experience more wars"?**

You may select multiple answers.

1) O Gnuok
2) O Chiwok
3) O Kuunb
4) O Gokpi

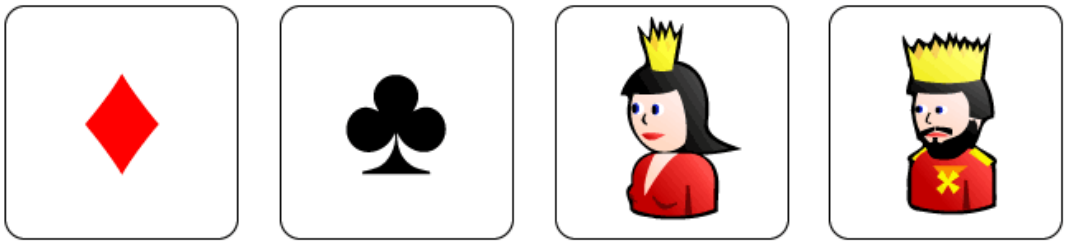
RIC1

Four playing cards are placed on a table before you. Each card has either diamonds or clubs on one side, and has either a queen or a king on the other side.

The visible faces of the cards show diamonds, clubs, a queen, and a king.

Which card(s) should you turn over to test the following hypothesis: "**If a card has clubs on one side, then it has a queen on the other side**"? You may select multiple answers.

1) O The card with one diamond.
2) O The card with one club.
3) O The card with the king.
4) O The card with the queen.



RIC3

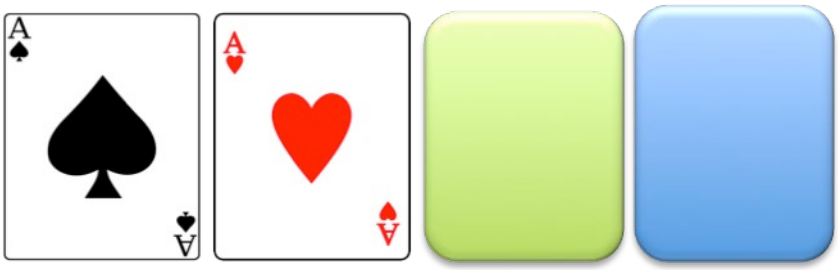
Four playing cards are placed on a table before you. Each card has either spades or hearts on one side, and is either green or blue on the other side.

The visible faces of the cards show spades, hearts, green, and blue.

Which card(s) would you turn over in order to test the hypothesis "**if a card has spades on one side, then it is green on the other side**"?

You may select multiple answers.

1) O The green card.
2) O The blue card.
3) O The card with a heart.
4) O The card with a spade.



RIC4

Four napkins are set before you. The front side displays a pattern of stripes or polka dots. The back side is either white or red.

Which napkin(s) would you turn over to test the hypothesis: "**If the front of the napkin displays a pattern of stripes, then the back side is white**"?

You may select multiple answers.

1) O The napkin with stripes.
2) O The napkin with polka dots.
3) O The red napkin.
4) O The white napkin.

AHT Questions

Note, for the following items, only one answer should be selected!

AHT1_R

Jenny noticed an increase in forest fires in her country in recent years.

Several factors could contribute to this trend: a new disease has spread among trees that lowers their water content, there have been budget cuts in the forestry management department, and replanting efforts have doubled the land cover of forests in the country.

Jenny thinks that the new disease is causing the increase in forest fires in her country.

Which of the following groups of countries should she research to test if her hypothesis about the increase in forest fires is correct?

1) O Countries that have experienced other types of diseases, that have experienced recent social unrest, and in which a new tree species has recently been introduced that is known to be vulnerable to forest fires.
2) O Countries where the disease has been prevalent, that have a history of extreme weather events, and in which wind patterns have changed as well.

3) O Countries that have experienced recent social unrest, in which there have been budget cuts in the forestry management department, and replanting efforts have doubled the land cover of forests.

AHT2_R

Alan noticed a decrease in biodiversity in the coastal areas of his country where desalination plants (plants that remove salt from water) have been installed. The plants take the salt out of water from the sea to produce drinking water.

To build these desalination plants, steel pipes are laid underground. Traffic has also increased around the plants because of the workers. The plants also create loud noise.

Alan thinks the loud noise created by the plants has caused the loss of biodiversity.

Which of the nearby industrial installations should Alan check to see whether his hypothesis about the loss of biodiversity is correct?

1) O Nearby installations where deforestation has reduced shade, pipes run above and below ground, and traffic is comprised of light rail and occasional high speed trains.
2) O Nearby installations with loud noise, high winds, and no traffic.
3) O Nearby installations that are quiet, where there has been an increase in traffic, and steel pipes have been laid underground.

AHT4_R

Martha works at her country's secret services. She noticed that the quality of their intelligence has improved drastically this year.

Three possible developments may explain this. Firstly, new hackers were added to the team. Secondly, new foreign intelligence agents were added to the team. Third, Martha's country began exchanging intelligence with neighbouring countries.

Martha thinks the new hackers are the factor improving her service's intelligence.

Which other secret services of allied countries should Martha compare recent performance to see whether she is right?

1) O A secret service that increased its supporting staff, that started gathering intelligence from different parts of the world and that recently changed its organizational form in response to an external review.
2) O A secret service that has hired new hackers, installed new satellites, and which uses new algorithms for filtering potentially relevant data.
3) O A secret service that uses a new algorithm form filtering potentially relevant data, to which new foreign intelligence agents were added, and that recently began exchanging intelligence with neighbouring countries.

AHT5_R

Jacob is researching a recent surge in the number of accidents at nuclear plants in his country.

There are several factors that could have contributed to this surge. The plants are relatively old, rules for oversight have been relaxed recently, and their usage has increased sharply because coal plants in the region have shut down.

Jacob thinks that the surge in accidents is due to the age of the nuclear plants.

Which bordering country's nuclear plants should he research to test if his idea on the surge in accidents is correct?

1) O A country where rules for oversight have been relaxed recently, where the usage of the plant has increased heavily, and where the budget for safety measures near the plants has been reduced.
2) O A country where floods have occurred near nuclear plants, the budget for safety measures has been reduced, and where an abundance of renewable energy has made the electricity grid less stable.
3) O A country which has relatively old nuclear plants, where floods have occurred, and where a recent financial crisis has led to lower investments in the plants.

AHT6_R

Martin is investigating why several large infrastructural structures in his province have collapsed recently.

Several developments may explain why this has happened. Recent floods may have weakened the structures, a reduction in inspections may have caused dangerous situations to go undetected, and increased traffic in the region may have exhausted the carrying capacity of the infrastructure.

Martin thinks that the increase in collapses is due to the recent floods.

In which other regions should he check for infrastructure collapses to see if he is correct?

1) O Regions with a drier climate, with a relatively old infrastructure, and where a recent invasive species of bacteria has led to erosion of concrete structures.
2) O Regions which have recently experienced floods, in which infrastructure is known to have been designed poorly in the past, and which have experienced a seismic swarm.
3) O Regions where there has been a reduction in the total amount of inspections, where there has been an increase in traffic, and which have had a drier climate.

AHT8_R

Laura is looking at why her country is less often targeted by state-led cyber attacks.

Three factors could play a role. First, her country has a strong protective digital infrastructure. Second, her country carefully avoids putting sensitive information online. Third, her country has signed a military defense pact with surrounding countries that rules out cyber-attacks against one another.

Laura thinks her country's protective digital infrastructure is the reason why her country is less often targeted by state-led cyber-attacks.

Which other country should she check to see whether her explanation for the low incidence of state-led cyber attacks is correct?

1) O A country with a strong protective digital infrastructure, of which it is known that it never engages in cyber-attacks itself, and which is internationally known for its neutral stance.
2) O A country with an intelligence service which is very sophisticated in analyzing threats, which is internationally known for its neutral stance, and which rarely engages in cyber-attacks itself.
3) O A country which carefully avoids putting sensitive information online, which has signed a military defense pact with surrounding countries that rules out cyber attacks against one another, and which does not have a strong protective digital infrastructure.

AHT9_R

Lucy wonders why her government has reduced investment in preparations for future threats.

She sees three potential causes. First, her government does not have strong public support, and therefore prefers to avoid investments that lack immediate economic benefits for voters. Second, there have been few disasters in recent years, so people may not see the need. Third, it could also be that the governmental unit concerned with countering risk has been moved out of the prime minister's office and into a much less central body of government, leading to reduced investments.

Lucy thinks that the reduced investments are mostly due to the lack of public support for her government.

In which other country should she test her hypothesis?

1) O A country where government has low support, with a very populist government, and where governmental budgets are highly constrained because of a recent economic crisis.
2) O A country where there were few recent disasters, where the governmental unit concerned with countering risk has moved to a less influential place in government, and where the government has very strong support.
3) O A which has recently seen a rise in crises in recent years, where a corruption scandal has reduced trust in government, and which has recently experienced an economic crisis.

AHT1

Jenny noticed that her hair has become frizzier. She thinks that it might be due to a special ingredient in her new shampoo. Her new shampoo contains peppermint, green-tea extract, and lemon balm. Jenny thinks the peppermint is making her hair frizzy.

Which shampoo should she use to test if her intuition is correct?

1) O Shampoo with eucalyptus, green-tea extract, and lemon balm.
2) O Shampoo with eucalyptus, coconut oil, and honey.
3) O Shampoo with peppermint, coconut oil, and honey.

AHT2

Alan noticed that his dog has been lacking energy recently. He thinks that his dog's low energy levels may be the result of an ingredient in its new food. The dog food contains beef, noodles, and spinach. Alan thinks the noodles are responsible for his dog's low energy.

Which food should he feed his dog to test if his intuition is correct?

1) O Dog food with beef, rice, and spinach.
2) O Dog food with chicken, noodles, and carrots.
3) O Dog food with chicken, rice, and carrots.

AHT4

Martha is on her college's track team. She noticed that her race times have gotten worse over the last 3 weeks. Martha thinks that this might be due to a vitamin in the new smoothie that she drinks before training. The smoothie contains vitamins A, B6, and C. Martha thinks Vitamin C is causing her to run slower.

Which of the following smoothies should she drink to test if her intuition is correct?

1) O A smoothie that contains vitamins B1, A, and B6.
2) O A smoothie that contains vitamins B1, E, and K1.
3) O A smoothie that contains vitamins C, E, and K1.

A1. Psychologists have claimed that some people show a tendency to follow their peer group in estimating that something will or will not happen, to feel safer or to avoid conflict. Following 9/11, for instance, many analysts heavily overestimated the threat of terrorist attacks because other analysts stated terrorist attacks were likely.

To what extent do you think that an average person shows this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you think that you show this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A2. Many psychological studies have shown that people react to counterevidence by actually strengthening their beliefs. For example, when exposed to evidence that a country is not developing weapons of mass destruction, intelligence analysts who believe the country is developing WMD's implicitly counterargued against that evidence, therefore strengthening their initial conclusions about the country's weapons programs (that it was developing WMD's).

To what extent do you believe an average person shows this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you believe you show this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A3. Psychologists have claimed that some people show a "disconfirmation" tendency in the way they evaluate research about potentially dangerous habits. That is, they are more critical and skeptical in evaluating evidence that an activity is dangerous when they engage in that activity than when they do not. Policy makers who play sports, for example, are less likely to consider sports to be a dangerous activity during a pandemic.

To what extent do you think an average person shows the "disconfirmation" tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you think you show the "disconfirmation" tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A4. Psychologists have claimed that some people show a "halo" effect in the way they form impressions of attractive people. For instance, when it comes to assessing a politician, people tend to judge an attractive politician more positively than he or she deserves.

To what extent do you believe that an average person shows this effect?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you believe that you show this effect?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A5. Psychologists have identified a tendency called the "ostrich effect," an aversion to learning about potential losses. For example, people may respond too late to an emerging environmental crisis by ignoring it. The name comes from the common (but false) legend that ostriches bury their heads in the sand to avoid danger.

How often do you think an average person has shown this tendency in his or her life?

Very rarely						Very often
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

How often have you shown this tendency in your life?

Very rarely						Very often
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A6. Psychologists have claimed that some people show a tendency to do or believe a thing only because many other people believe or do that thing, in order to feel safer or to avoid conflict.

To what extent do you think that an average person shows this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you think that you show this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A7. Many psychological studies have shown that people react to counterevidence by actually strengthening their beliefs. For example, when exposed to negative evidence about their favorite political candidate, people tend to implicitly counterargue against that evidence, therefore strengthening their favorable feelings toward the candidate.

To what extent do you believe an average person shows this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you believe you show this tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A8. Psychologists have claimed that some people show a "disconfirmation" tendency in the way they evaluate research about potentially dangerous habits. That is, they are more critical and skeptical in evaluating evidence that an activity is dangerous when they engage in that activity than when they do not.

To what extent do you think an average person shows the "disconfirmation" tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you think you show the "disconfirmation" tendency?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A9. Psychologists have claimed that some people show a "halo" effect in the way they form impressions of attractive people. For instance, when it comes to assessing how nice, interesting, or able someone is, people tend to judge an attractive person more positively than he or she deserves.

To what extent do you believe that an average person shows this effect?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

To what extent do you believe that you show this effect?

Not at all						Very much
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

A10. Psychologists have identified a tendency called the "ostrich effect," an aversion to learning about potential losses. For example, people may try to avoid bad news by ignoring it. The name comes from the common (but false) legend that ostriches bury their heads in the sand to avoid danger.

How often do you think an average person has shown this tendency in his or her life?

Very rarely						Very often
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

How often have you shown this tendency in your life?

Very rarely						Very often
(1)	(2)	(3)	(4)	(5)	(6)	(7)
◯	◯	◯	◯	◯	◯	◯

Appendix II

Bias Blind Spot Items / Risk Domain

Version A.

	Area	Paradigm	Item wording
1	General	Action-inaction bias	Some people show a tendency to judge a harmful action as worse than an equally harmful inaction. For example, this tendency leads to thinking it is worse to falsely testify in court that someone is guilty, than not to testify that someone is innocent.
1	Risk	Action-inaction bias	Some people show a tendency to judge a harmful action as worse than an equally harmful inaction. For example, this tendency leads to thinking it is worse to mistakenly kill five civilians who were believed to be terrorists, than it is to mistakenly allow terrorists to kill five civilians.
2	General	Bandwagon effect	Psychologists have claimed that some people show a tendency to do or believe a thing only because many other people believe or do that thing, in order to feel safer or to avoid conflict.
2	Risk	Bandwagon effect	Psychologists have claimed that some people show a tendency to follow their peer group in estimating that something will or will not happen, to feel safer or to avoid conflict. Following 9/11, for instance, many analysts heavily overestimated the threat of terrorist attacks because other analysts stated terrorist attacks were likely.

3	General	Confirmation bias	Many psychological studies have shown that people react to counterevidence by actually strengthening their beliefs. For example, when exposed to negative evidence about their favorite political candidate, people tend to implicitly counterargue against that evidence, therefore strengthening their favorable feelings toward the candidate.
3	Risk	Confirmation bias	Many psychological studies have shown that people react to counterevidence by actually strengthening their beliefs. For example, when exposed to evidence that a country is not developing weapons of mass destruction, intelligence analysts who believe the country is developing WMD's implicitly counterargued against that evidence, therefore strengthening their initial conclusions about the country's weapons programs (that it was developing WMD's).
5	General	Disconfirmation tendency	Psychologists have claimed that some people show a “disconfirmation” tendency in the way they evaluate research about potentially dangerous habits. That is, they are more critical and skeptical in evaluating evidence that an activity is dangerous when they engage in that activity than when they do not.
5	Risk	Disconfirmation tendency	Psychologists have claimed that some people show a "disconfirmation" tendency in the way they evaluate research about potentially dangerous habits. That is, they are more critical and skeptical in evaluating evidence that an activity is dangerous when they engage in that activity than when they do not. Policy makers who play sports, for example, are less likely to consider sports to be a dangerous activity during a pandemic.
8	General	Halo effect	Psychologists have claimed that some people show a “halo” effect in the way they form impressions of attractive people. For instance, when it comes to assessing how nice, interesting, or able someone is, people tend to judge an attractive person more positively than he or she deserves.
8	Risk	Halo effect	Psychologists have claimed that some people show a "halo" effect in the way they form impressions of heath risks. For instance, when modified tobacco products like electronic cigarettes advertise a lower exposure to one carcinogen than regular cigarettes (e.g., carbon monoxide), people infer that that the product also reduces their exposure to other carcinogens (e.g., formaldehyde).

10	General	Ostrich effect	Psychologists have identified a tendency called the "ostrich effect," an aversion to learning about potential losses. For example, people may try to avoid bad news by ignoring it. The name comes from the common (but false) legend that ostriches bury their heads in the sand to avoid danger.
10	Risk	Ostrich effect	Psychologists have identified a tendency called the "ostrich effect," an aversion to learning about potential losses. For example, people may respond too late to an emerging environmental crisis by ignoring it. The name comes from the common (but false) legend that ostriches bury their heads in the sand to avoid danger.
13	General	Self-serving tendency	Psychologists have claimed that some people show a “self-serving” tendency in the way they view their academic or job performance. That is, they tend to take credit for success but deny responsibility for failure. They see their successes as the result of personal qualities, like drive or ability, but their failures as the result of external factors, like unreasonable work requirements or inadequate instructions.
13	Risk	Self-serving tendency	Psychologists have claimed that some people show a "self-serving" tendency in the way they view their job performance. That is, they tend to take credit for success but deny responsibility for failure. They see risk analysts’ accurate predictions as the result of personal qualities, like drive or ability, but their failures as the result of external factors, like unreasonable work requirements or inadequate instructions.

Version B.

	Area	Bias measured	Item wording
4	General	Diffusion of responsibility	Psychologists have identified an effect called "diffusion of responsibility," where people tend not to help in an emergency situation when other people are present. This happens because as the number of bystanders increases, a bystander who sees other people standing around is less likely to interpret the incident as a problem, and also is less likely to feel individually responsible for taking action.

4	Risk	Diffusion of responsibility	Psychologists have identified an effect called "diffusion of responsibility," where people tend not to help in an emergency situation when other people are present. This happens because as the number of bystanders increases, a bystander who sees other people standing around is less likely to interpret the incident as a problem, and also is less likely to feel individually responsible for taking action. In the case of a wildfire, for instance, it may be identified too late because analysts who saw risks assumed others would have called attention to them if the risks were significant.
6	General	Escalation of commitment	Research has found that people will make irrational decisions to justify actions they have already taken. For example, when two people engage in a bidding war for an object, they can end up paying much more than the object is worth to justify the initial expenses associated with bidding.
6	Risk	Escalation of commitment	Research has found that people will make irrational decisions to justify actions they have already taken. For example, when a country commits to engage in an ‘arms race’ with another country, it can maintain a high defense budget , even when the threat turns out to be smaller than originally thought and lower spending will also suffice to achieve the necessary security.
7	General	Fundamental attribution error	Psychologists have claimed that some people show a tendency to make “overly dispositional inferences” in the way they view victims of assault crimes. That is, they are overly inclined to view the victim’s plight as one he or she brought on by carelessness, foolishness, misbehavior, or naiveté.
7	Risk	Fundamental attribution error	Psychologists have claimed that some people show a tendency to make "overly dispositional inferences" in the way they view victims from hurricanes. That is, they are overly inclined to view victims as having exhibited risky behaviour or not having taken the right precautions, such as the construction of shelters in their houses.
9	General	Intergroup bias	Extensive psychological research has shown that people possess an unconscious, automatic tendency to be less generous to people of a different race than to people of their race. This tendency has been shown to affect the behavior of everyone from doctors to taxi drivers.

9	Risk	Intergroup bias	Extensive psychological research has shown that people possess an unconscious, automatic tendency to be less generous to people of a different race than to people of their race. This tendency has been shown to affect the behavior of everyone from bankers to terrorism analysts.
11	General	Projection bias	Many psychological studies have found that people have the tendency to underestimate the impact or the strength of another person's feelings. For example, people who have not been victims of discrimination do not really understand a victim's social suffering and the emotional effects of discrimination.
11	Risk	Projection bias	Many psychological studies have found that people have the tendency to underestimate the impact of events or the strength of another person's feelings. For example, people who have not been victims of a flood do not really understand a victim's loss and trauma from the event.
12	General	Self-interest bias	Psychologists have claimed that some people show a 'self-interest' effect in the way they view political candidates. That is, people's assessments of qualifications, and their judgments about the extent to which particular candidates would pursue policies good for the people of that country as a whole, are influenced by their feelings about whether the candidates' policies would serve their own particular interests.
12	Risk	Self-interest bias	Psychologists have claimed that some people show a "self-interest" effect in the way they view political candidates. That is, people's assessments of qualifications, and their judgments about the extent to which particular candidates would pursue policies good for the people of that country as a whole, are influenced by their feelings about whether the candidates' policies would serve their own particular interests. Risk analysts therefore tend to vote for risk-oriented politicians that consider their line of work to be more important.
14	General	Stereotyping	Psychologists have argued that gender biases lead people to associate men with technology and women with housework.

14	Risk	Stereotyping	Psychologists have argued that racial stereotyping lead analysts to associate Muslims with potential terrorist threats in Western countries.

Responses (DV)

***General**

Two 7-pt scales: 1 = Not at all, 7 = Very much; "average person" & "you"

you less biased than "average person"

***Risk**

Two 7-pt scales: 1 = Not at all, 7 = Very much; "average analyst" & "you"

you less biased than "average analyst"

Appendix III

Syntax

```
RELIABILITY
/variables PR1 PR2 PR3 PR4 PR5
/scale('all variables') all
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE scale
/SUMMARY=TOTAL.

COMPUTE PreRisk= Mean (PR1, PR2, PR3, PR4, PR5).
EXECUTE.

FACTOR
  /VARIABLES PR1 PR2 PR3 PR4 PR5
  /MISSING LISTWISE
  /ANALYSIS PR1 PR2 PR3 PR4 PR5
  /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25) DELTA(0)
  /ROTATION OBLIMIN
  /METHOD=CORRELATION.
RELIABILITY
/variables PR1 PR2 PR3 PR4 PR5
/scale('all variables') all
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE scale
/SUMMARY=TOTAL.

FACTOR
  /VARIABLES POR1 POR2 POR3 POR4 POR5
  /MISSING LISTWISE
  /ANALYSIS POR1 POR2 POR3 POR4 POR5
  /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25) DELTA(0)
  /ROTATION OBLIMIN
  /METHOD=CORRELATION.

RELIABILITY
/variables POR1 POR2 POR3 POR4 POR5
/scale('all variables') all
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE scale
/SUMMARY=TOTAL.

Compute valid=1.
exe.
if missing(PR1) or missing(PR2) or missing(PR3) or missing(PR4) or missing(PR5) or missing(POR1) or missing(POR2) or missing(POR3) or missing(POR4) or missing(POR5)
exe.
filter by valid.

descriptive PR1 PR2 PR3 PR4 PR5 POR1 POR2 POR3 POR4 POR5.

FACTOR
  /VARIABLES PR1 PR2 PR3 PR4 PR5
  /MISSING LISTWISE
  /ANALYSIS PR1 PR2 PR3 PR4 PR5
```

```
  /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25) DELTA(0)
  /ROTATION OBLIMIN
  /METHOD=CORRELATION.

RELIABILITY
/variables PR1 PR2 PR3 PR4 PR5
/scale('all variables') all
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE scale
/SUMMARY=TOTAL.

COMPUTE PreRisk1= Mean (PR1, PR2, PR3, PR4, PR5).
EXECUTE.

FACTOR
  /VARIABLES POR1 POR2 POR3 POR4 POR5
  /MISSING LISTWISE
  /ANALYSIS POR1 POR2 POR3 POR4 POR5
  /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25) DELTA(0)
  /ROTATION OBLIMIN
  /METHOD=CORRELATION.

RELIABILITY
/variables POR1 POR2 POR3 POR4 POR5
/scale('all variables') all
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE scale
/SUMMARY=TOTAL.

COMPUTE PostRisk1= Mean (POR1, POR2, POR3, POR4, POR5).
EXECUTE.

Compute valid=1.
exe.
if missing(PG1) or missing(PG2) or missing(PG3) or missing(PG4) or missing(PG5) or missing(POG1) or
missing(POG2) or missing(POG3) or missing(POG4) or missing(POG5) valid=0.
exe.
filter by valid.

Descriptives PG1 PG2 PG3 PG4 PG5 POG1 POG2 POG3 POG4 POG5.

FACTOR
  /VARIABLES PG1 PG2 PG3 PG4 PG5
  /MISSING LISTWISE
  /ANALYSIS PG1 PG2 PG3 PG4 PG5
  /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25) DELTA(0)
  /ROTATION OBLIMIN
  /METHOD=CORRELATION.

RELIABILITY
/variables PG1 PG2 PG3 PG4 PG5
```

```
/scale('all variables') all
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE scale
/SUMMARY=TOTAL.

COMPUTE PreGeneral= Mean (PG1, PG2, PG3, PG4, PG5).
EXECUTE.

FACTOR
  /VARIABLES  POG2 POG3 POG4 POG5
  /MISSING LISTWISE
  /ANALYSIS POG2 POG3 POG4 POG5
  /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION PC
  /CRITERIA ITERATE(25) DELTA(0)
  /ROTATION OBLIMIN
  /METHOD=CORRELATION.

RELIABILITY
/variables POG2 POG3 POG4
/scale('all variables') all
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE scale
/SUMMARY=TOTAL.


COMPUTE ProstGeneral= Mean (POG2, POG3, POG4).
EXECUTE.

DESCRIPTIVES PR1 PR2 PR3 PR4 PR5 POR1 POR2 POR3 POR4 POR5 PG1 PG2 PG3 PG4 PG5 POG1 POG2
POG3 POG4 POG5.

Descriptives PG1 PG2 PG3 PG4 PG5 POG1 POG2 POG3 POG4 POG5.
```