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# Effects of personal characteristics, mental state and external factors on susceptibility to bias: a literature study

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# Summary

*Issue*
As part of comprehensive conflict intervention, military operations are focused on changing the behaviour of actors (involved) in the conflict. Key to military operations is thus to influence the behaviour of actors[1] through the conduct of military activities. The behaviour of an actor can be influenced in different ways. An actor can be engaged physically: for example, by taking away its resources, or the actor himself (e.g., by ‘kill’ or ‘capture’). But the actor can also be engaged psychologically: changing his behaviour by inducing a certain psychological state (e.g., anxious, motivated, indifferent, distracted).

Being able to recognise the possible engagement points of an actor and influence these, requires structured knowledge of human behaviour. Human behaviour is guided and influenced more by emotions and subconscious processes than by explicit, ‘formal’ information and the rational weighing of arguments and facts.
In order to be ‘better influencers’, we need to know and understand how these subconscious processes work. At the same time, this can also enable us to better shield ourselves from being influenced by others and to improve our own decision making.

The goal of this project was therefore to acquire further insight into heuristic judgement and decision making processes (that are influenced by intuitions, emotions, biases, or associations) and to investigate whether biased thinking depends on the characteristics of individuals and the situations they are in. If there are indeed psychological and environmental characteristics that modulate biased thinking, this knowledge could in principle effectively be used to either mitigate or induce biased thinking in a military context.

*Approach*
The literature study reported here contributes to this goal by identifying
- characteristics of individuals (e.g., cognitive abilities, expertise, personality, cultural background),
- mental states (e.g., mood, emotions, stress, attention, expectations), and
- external factors (e.g., information availability, time constraints, physical discomfort)

which may predict a person’s susceptibility to cognitive biases, and in particular those leading to decision and judgement biases.

We performed a literature study to investigate whether these personal characteristics, mental states and external factors influence the occurrence of cognitive biases.

[1] An actor can be an individual, a group, an organisation, a community or society, a government, a state.

To unify and understand the findings of our study we adopted the dual-process heuristic-deliberate theory of human decision making as a framework[2].
*Outcome*
The results of the literature study indicate that both personal characteristics and external factors can affect cognitive biases under certain conditions:

- Cognition: Personal characteristics like cognitive ability and a deliberate thinking style may mitigate various cognitive biases. Emotional intelligence may also reduce some biases. Cognitive ability by itself does not prevent the occurrence of biases, but may help to prevent or reduce their effects on a person's behaviour, such as risk taking, overconfidence or sunk cost bias.
- Expertise affects sensitivity to biases, because expertise largely determines thinking style and contextual information processing. Experts are less likely to misinterpret the context than novices. They are therefore more likely to select the thinking style appropriate for the context and are subsequently less prone to bias than non-experts.
- Personality affects the way people weigh and processes information, which in turn affects the susceptibility to certain (but not all) biases. However, the nature and strength of the relationship between personality and susceptibility to cognitive bias is not fully clear. Predicting the occurrence and direction of cognitive bias based on personality traits is therefore (still) difficult.
- Culture. Only a few studies have investigated the effects of culture on bias. There are arguments to assume that culture affects susceptibility to cognitive bias. Some studies indeed show that culture exerts an effect through culturally determined differences in preferred thinking styles or levels of self-efficacy. However, other studies show no effects. All in all, strong conclusions cannot be drawn from this small and contradicting body of research.
- Mental states like mood, emotions, stress and attention are known to affect and drive behaviour. It can therefore be expected that mental states may also cause biased thinking. The literature shows that subliminal presentation of affective stimuli can shift appraisal of subsequent stimuli in the corresponding affectively congruent direction (priming). Emotions reflect an individual's appraisal of a situation (reference) and thus affect risk taking behaviour. A number of studies show that negative emotions and feelings of uncertainty invoke a deeper level of information processing. In contrast, positive emotions and feelings of certainty promote a more superficial and faster level of processing.
- External factors. Variables like the availability and clarity of information, and the available processing time are known to affect an individual's decision making strategy by shifting it towards either a more rational (when information and time are sufficiently available) or a more heuristic mode (when there is not enough time and the available information is either insufficient, ambiguous or too complex). Heuristics can lead to biases when they are used in an inappropriate context, but may (perhaps counter-intuitively) be effective when they are used in complex and unreliable problem contexts.

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[2] Dual-process heuristic-deliberate theories postulate the existence of fast, intuitive, emotionally charged and error-prone decision processes (heuristic or 'Type 1 system' ), next to slow, conscious and analytic decision processes (deliberate or 'Type 2 system').

*Impact*
Studies on cognitive biases in military decision making are scarce. The findings reviewed in this study mostly result from laboratory studies involving simplified tests that have specially been designed to induce cognitive biases.
It is therefore not clear how these results translate into real-life military practice. However, the current findings may stimulate reflection on designing the military decision making process in such a way that it will improve the quality of military judgment, and will help commanders to prevent bias in their decision making. In addition, the fact that the effects of cognitive biases on decision making are not completely fixed within and between individuals suggests opportunities to apply this knowledge not only for influencing target audiences, but also for selecting and training of personnel.

The knowledge gained in this project can be used to enable the Royal Netherlands Armed Forces to operate effectively amidst the complex and ambiguous environments they face in current operations, by:

- Enhancing the understanding of cognitive biases, and their influence on decision making and behaviour:
  - People are susceptible to cognitive biases; making them vulnerable to behavioural influence. The knowledge on these cognitive processes and biases can be used in the engagement of relevant (targeted) actors in the conflict environment (both on a strategic level as part of a doctrine and operationally in the field).
  - The same goes for our own forces. Military professionals are expected to make critical decisions under conditions of uncertainty, ambiguity and time constraints. Under such circumstances, people may be more susceptible to make predictable errors in decisions and judgments caused by cognitive biases. Understanding these biases can reduce the susceptibility to biases and ameliorate their effects on for instance the military Decision Making Process (DMP).
- Being input for doctrine, selection procedures (e.g., develop tests that estimate an individual's susceptibility to biases), education and training.

The general picture that arises is that bias susceptibility and the occurrence of biases depend on thinking style (heuristic versus deliberate), where thinking style is associated with an individual's personal characteristics, mental state and external factors. In general, biases are reduced when a deliberate (analytical) thinking style is applied. However, whether a specific (heuristic or deliberate) thinking style actually reduces or enhances a given type of bias also depends on the context.

*Debiasing*
Although there are currently no generally accepted techniques to prevent decision biases, there are a few debiasing strategies that have received empirical support. Most of these techniques try to shift people from intuitive to deliberate thinking. One of these techniques is the 'Critical Thinking' strategy that has been developed for application in practical (military) settings. TNO developed Critical Thinking training programs for the Netherlands military forces, fostering the development and application critical thinking skills. The premise is that awareness, collaboration, and critical thinking can prevent learners from falling prey to judgment biases.
Both laboratory and field results show that critical thinking training had positive effects on the process of tactical command (i.e., better argumentation for situation assessment) as well as on the outcomes (i.e., more and better contingency plans).

# Contents

# 1 Background

People constantly make judgments and decisions, either conscious or subconscious. In addition, most decisions are made without knowing for sure what the effects of the decision will be. For example, decisions to invest in shares on the stock market, to undergo a medical operation, or to initiate a military tactical manoeuvre are generally being made without knowing in advance whether the stock prices will go up, whether the operation will succeed, or whether the tactical move will win the battle. Making decisions in uncertainty is based upon at least two factors: the desirability and the likelihood of the outcome. Decision theory studies the development of algorithms that, for a given problem and likelihoods, produce the best outcome. Decision theory can thus, in principle, provide recommendations how to best make decisions. However, in real life people often make decisions that deviate from the (rationally) best solution (Haselton et al., 2005).These deviations are the outcome of systematic distortions in human judgment and reasoning.

These distortions are the result of the influence that emotions have on our reasoning process. Subjective estimations play an important role in our lives.
The decisions that we make, the conclusions that we draw, and the explanations that we accept are based upon our *beliefs* about the likelihood of uncertain events, not the likelihood *in reality*. So our behaviour is much more instinctive (driven by emotions), than it is rational (driven by facts). For example, the decision to stay away from a particular neighbourhood is not driven by the *factual* likelihood of being robbed, but by our *perception* of the likelihood of being robbed. The important conclusion of an immense body of research on decision making is that people do not follow the laws of probability, but instead use relatively simple rules (heuristics). These heuristics often perform well, but under certain conditions may lead to systematic and serious errors. The distortion of human judgment and decision making is called ‘cognitive bias’, or shortly ‘bias’.
Human behaviour can be seen as (the result of) a decision: a decision about if and how to act, or react to a certain stimulus[3]. This decision can be made consciously, but also subconsciously. Human behaviour is the result of a decision cycle, which is, as explained above, much more guided and influenced by emotions and subconscious processes than we may think.

## 1.1 Aim of the study

Military operations are aimed at changing the behaviour of actors (involved) in conflict. When violence is used or human rights are violated in conflicts in or between societies, intervention is deemed necessary. Such an intervention is always focused on changing the (unacceptable) behaviour of the actors involved in the conflict; whether it is about combatants (rebellious parties, terrorists, etc.), or crime, corruption, abuse of power, or the use of violence against specific populations.

[3] The stimulus is any type of information, which can be either external or internal information. External (outside of the actor) are for instance ‘things’ in the environment such as buildings, people, nature, animals, etc.; information sources such as written text, or spoken words, sounds, etc.; but also events, and the behaviour of other actors: verbal, non-verbal, expressions and intonation, etcetera. Internal (from inside the actor) are for instance feeling your heart racing, your palms sweating; your ‘gut feeling’; but also thoughts, ideas or desires.

As part of comprehensive conflict intervention, the military element is therefore focused on changing the behaviour of the actors (involved) in the conflict. Key to military operations is thus to influence the behaviour of actors[4], through the conduct of military activities. The behaviour of an actor can be influenced in different ways. An actor can be engaged physically: for example, by taking away its resources, or the actor himself (e.g. by 'kill' or 'capture'). But the actor can also be engaged psychologically: changing his behaviour by inducing a certain psychological state (e.g. anxious, motivated, indifferent, distracted).

Being able to recognise the possible engagement points of an actor and influence these, requires structured knowledge of human behaviour. And if human behaviour is guided and influenced by emotions and subconscious processes (instead of explicit, 'formal' information and the rational weighing of arguments and facts), this means that knowing and understanding how these subconscious processes work, can enable us to use this to be a better influencer. At the same time, it can also enable us to better shield ourselves from being influenced by others and to improve our own decision making.

The study reported here was performed as part of the research programme V1522 "Military behavioural influence in integrated operations". The aim of programme V1522 is to develop knowledge about methods that can be used to influence behaviour of actors by integrated operations and to support military forces to effectively operate in the psychological domain. Important in this context is the significant role that automatic, emotional, heuristic thought processes play in the judgement of situations, generation of decisions and the causation of behaviour (Ogilvie & Carruthers, 2014). Part of this is to acquire further insight into biased (pre-cognitive, automatic, heuristic) judgement and decision processes (that are influenced by intuitions, emotions, biases, or associations) and to investigate whether biased thinking depends on the characteristics of individuals and the situations they are in. If there are indeed psychological and environmental characteristics that modulate biased thinking, this knowledge could in principle effectively be used to either mitigate or induce biased thinking in a military context. The literature study reported here contributes to this goal by identifying characteristics of individuals (e.g., cognitive abilities, expertise, personality, cultural background), mental states (e.g., mood, emotions, stress, attention, expectations) and external factors (e.g., information availability, time constraints, physical discomfort) that may predict a person's susceptibility to cognitive biases, and in particular those leading to decision and judgement biases.

This knowledge can be used to enable the Royal Netherlands Armed Forces to operate effectively amidst the complex and ambiguous environments they face in current operations, by:

- Enhancing the understanding of cognitive biases, and their influence on decision making and behaviour:
  - People are susceptible to cognitive biases; making them vulnerable to behavioural influence. The knowledge on these cognitive processes and biases can be used in the engagement of relevant (targeted) actors in the conflict environment (both on a strategic level as part of a doctrine and operationally in the field).

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[4] An actor can be an individual, a group, an organisation, a community or society, a government, a state.

  - The same goes for our own forces. Military professionals are expected to make critical decisions under conditions of uncertainty, ambiguity and time constraints. Under such circumstances, people may be more susceptible to make predictable errors in decisions and judgments caused by cognitive biases (Williams, 2010). Understanding these biases can reduce the susceptibility to biases and ameliorate their effects on for instance the military Decision Making Process (DMP).
- Being input for doctrine, selection procedures (e.g., develop tests that estimate an individual's susceptibility to biases), education and training.

## 1.2 Report structure

We will start this report by shortly discussing the origins of human decision biases (Section 2). The underlying mechanisms of bias are reported separately in TNO report R11707 "Neurowetenschappelijke mechanismen van cognitieve bias" (2015). Section 3 presents the literature review on the internal factors (characteristics of the individual and mental state) and external factors that predict an individual's susceptibility to judgment and decision bias, and some methods that may be deployed to mitigate the effects of biasing (cognitive debiasing techniques). Finally, in Section 4 we will present the conclusions of this study.

This report may trigger several research questions or ideas which are relevant for the military practice but which have not been explicitly addressed in the text, simply because these issues have not been reported in the literature. We marked these issues by small lightbulb icons in the text. The numbers in the icons refer to the corresponding items in Table 1 in the section named 'Food for thought'.

# 2 Short introduction to cognitive biases

## 2.1 Cognitive biases and their origin

The human mind is limited in its capacity to render judgments in a way that is perfectly rational and fully informed.  While rational thinking serves well to solve decision problems that allow comprehensive analysis, it may fail in complex real life situations, where it is often very difficult to have access to every relevant piece of information, and where a decision often has to be made quickly. Even if such access were possible, our brains do not operate like computer algorithms, capable of complex and multiple calculations in order to reach logically sound conclusions – not to mention that we hardly have time to perform such rigorous analysis for every judgment that we make. As a result, the brain has developed ‘shortcuts’: a variety of simple decision rules that can be executed quickly. These rules are called heuristics. Oftentimes, heuristics produce judgements and decisions that are ‘good enough’ when measured against an acceptable cognitive load and/or have been experienced to be effective in previous similar situations. However, heuristics can also lead to errors in decisions, for instance when the chosen heuristic wasn’t appropriate for that specific situation. When a heuristic has ‘gone wrong’, it is called ‘cognitive bias’. This is most likely to occur in complex situations (when relevant information is ignored and/or irrelevant information interferes) or in situations that are mistakenly perceived as familiar while they are actually unknown (see Appendix A for a list of the cognitive biases discussed in this report together with their definitions). Cognitive biases are pervasive in human reasoning and have important practical implications on human behaviour.

Dual-process heuristic-deliberate  theories postulate a distinction between:
- fast, intuitive, automatic, heuristic, emotionally charged and error-prone decision processes (heuristic or ‘Type 1’ ), versus


- slow, conscious, controlled, deliberate and analytic decision processes (deliberate or ‘Type 2’) (e.g., Evans, 2006; Kahneman, 2003; Kahneman & Frederick, 2002; Sloman, 1996).

When fast responses are required and there is either  insufficient, ambiguous or simply too much information,  performance is based on low-effort heuristic processes (type 1). Deliberate processes (type 2) monitor and revise the output of this heuristic system. In this view, biases occur when deliberate processing either (1) fails to successfully engage (Kahneman, 2003) or (2) fails to override the biased heuristic response (De Neys, 2012).The slower deliberate processes rely on time- and resource-consuming serial operations and are constrained by the limited capacity of central working memory. Conversely, heuristic processes do not demand executive working memory resources and operate implicitly and in parallel (De Neys, 2006).The literature posits that heuristic processes (activated immediately when engaging in reasoning tasks) may lead to biased outcomes, unless the analytical system intervenes (Evans, 1984; Evans, 1989). In this study we adopt this dual-process heuristic-deliberate theory of human decision making as a framework to unify and understand our current findings.



Intuitive (heuristic) decision-making produces quick solutions based on general heuristics (the Fast and Frugal view: Gigerenzer & Gaissmaier, 2010) or on experience-based (pattern- matching) evaluations (Naturalistic Decision Making:

Klein, 1993; see e.g. Kahneman & Klein, 2009; Klein, 2015 and Davis et al., 2005 for a discussion on the differences and similarities between both views).
This allows access to information that would not be accessible through deliberate thinking (Hogarth, 2010).

However, intuition cannot be used to generalize beyond a specific context, does not involve the acquisition of external information, and suffers from various biases (Dane & Pratt, 2007; Kahneman & Frederick, 2002; Tversky & Kahneman, 1974) that could lead to potentially dangerous inaccurate perceptions of reality.

Deliberation offers advantages over intuitive decision-making, such as the use of abstract thinking and generalizations, as well as the inclusion of additional information in the decision-making process (Söllner et al., 2013).This is particularly beneficial if the task requires the application of complex rules (Kahneman & Frederick, 2002). In the real world, decision makers often have to deal with three critical constraints that limit their opportunities for deliberation: (1) limited access to information, (2) cognitive limitations inherent in the human mind, and (3) limited time. These constraints result in 'bounded rationality' (Simon, 1972). Deliberation is costly with regard to both time and cognitive effort. Since cognitive resources are limited, deliberation requires resources that cannot be assigned elsewhere (Kurzban et al., 2013). Decision-makers will, therefore, have a tendency to avoid deliberate reasoning if intuition appears sufficient to make a good decision.

From a behavioural standpoint cognitive biases may be seen as systematic errors in rational reasoning (Tversky & Kahneman, 1974). However, many cognitive biases that appear irrational from the perspective of rational choice theory may in fact be quite rational from the perspective of evolutionary biology (Santos & Rosati, 2015). They may optimize decision making in a given environment (context) by optimally using the available information (ecological rationality: Goldstein & Gigerenzer, 2002). However, decision rules that are completely adapted to a given (natural) environment may of course lead to maladaptive ('biased') behaviour in different settings (Fawcett et al., 2014).

## 2.2 Hypotheses concerning factors that affect human cognitive bias

From a military viewpoint, it would be useful to understand the factors that predict or influence the occurrence of cognitive biases, as addressed in paragraph 1.1.
This literature review addresses the question whether characteristics of individuals, mental state and external factors affect susceptibility to cognitive biases. The dual-process heuristic-deliberate theory of human decision making (described above) is adopted as a framework to unify and understand our current findings. This theory states that individuals are less prone to biases if they apply the thinking style (deliberate or heuristic) that is most appropriate for the problem context. Furthermore, an individual's tendency to make biased judgments and decisions may be related to personal characteristics (e.g., cognitive ability, expertise, personality, culture), the mental state of the individual (e.g. mood, emotions, stress, attention, expectations), and on the characteristics of the environment (e.g., availability of information; stress-inducing features). However, it may also be that these factors have little or no influence on cognitive biases, and that biases occur inevitably.

# 3 Which factors affect human cognitive bias?

In this section we report the results of a literature study that was performed to investigate whether susceptibility to cognitive bias is affected by:
- an individual's characteristics (personality, intelligence, skills, expertise);
- mental state (mood, emotions, stress, attention, expectations);
- external (situational or environmental) factors.

Since literature on biased thinking in military contexts is scarce[5] most of the references used are from cognitive and social psychology or behavioural economics, while some are from medical decision making. The biases that are discussed are listed and explained in Appendix A, and the detailed search methodology that was used is described in Appendix B.

## 3.1 Do individual characteristics modulate cognitive bias?

### *3.1.1 Cognitive ability*

People differ in their cognitive abilities like intelligence, training (level of expertise), and thinking styles. The literature on cognitive ability typically distinguishes between
- *fluid intelligence,* which refers to an individual's capacity to think logically and solve problems in novel situations, independent of acquired knowledge (Cattell, 1987), and
- *crystallised intelligence*, which refers to the ability to use skills, knowledge, and experience.

Studies investigating the correlation between measures of intelligence and a wide range of different cognitive biases have shown that cognitive ability (both fluid and crystalized intelligence) does not predict bias-proneness in general (Stanovich & West, 2008; Teovanovic et al., 2015). In other words, *intelligent people are typically just as prone to cognitive bias as less intelligent people*. However, highly intelligent people are more able than less intelligent people to avoid cognitive bias once they have been warned about the bias in advance and are instructed how to avoid it (Stanovich & West, 2008).

Significant negative correlations have been observed between fluid intelligence and several biases. In other words, *people with high reflective abilities and a high fluid intelligence are less prone to some cognitive biases*. The Cognitive Reflection Test (CRT) is a widely used tool to assess individual differences in intuitive–analytic cognitive styles (Frederick, 2005). Higher scores on the CRT have been found to correspond to less sunk cost bias, less belief bias and less base rate neglect (Teovanovic et al., 2015).

The literature shows mixed results on the relation between analytic intelligence and proneness to the anchoring bias (for a review see: Furnham & Boo, 2011).
While some studies found that individuals with higher cognitive abilities are less susceptible to anchoring (Bergman et al., 2010), others observed no - or even the opposite - effect (Oechssler et al., 2009).

[5] What is there, can be found in for instance Davis et al., 2005; Human Dimension Capabilities Development Task Force, 2015; Janser, 2007; Keller & Katsikopoulos, 2015.

There is evidence that an individual's susceptibility to bias relates to structures and emotional processes in the brain. Two key brain structures mediating emotional information processing are the amygdala and the orbitofrontal cortex (OFC) (e.g., Kim & Hamann, 2007; Zald, 2003). The amygdala can be seen as a primitive structure linking immediate threat with rapid survival responses (Sander et al., 2003). The OFC is associated with deliberate thinking and has the function to gather and update information and use it to predict possible outcomes of, and to steer, human behaviour (Rolls, 2004; Rolls & Grabenhorst, 2008). De Martino et al. (De Martino et al., 2006) examined the neural basis of both the framing effect and the ability to control it. While placed inside an fMRI scanner their participants performed a financial decision making task. In accordance with the dual-process assumption (i.e., the view that choices are often guided by an initial emotional evaluation involving heuristic thinking; see Kahneman & Frederick, 2007) this brain imaging study revealed greater amygdala activation when participants demonstrated a typical framing bias when making financial decisions. In addition, they found that subjects who acted more rationally also exhibited stronger OFC activation. In other words, *subjects who were in an emotional thinking mode showed more framing bias while those in a more rational thinking mode were less prone to framing*. Interestingly, their findings also showed a strong inter-individual variability regarding susceptibility to framing, which was not predicted by amygdala activity. Instead, their data revealed a positive correlation between an individual's ability to control framing bias and activation of the OFC: enhanced orbital and medial prefrontal cortex activity predicted a reduced susceptibility to the framing effect (De Martino et al., 2006). Although enhanced OFC activity does not necessarily imply the inhibition of emotional processes (Aron, 2007), this result agrees with the view that controlling decision (and therefore also framing) bias generally depends on engagement of deliberate, rational thinking.

People who score high on the *Need for Cognition* (NFC: an individual's propensity to enjoy and engage in thought: Cacioppo & Petty, 1982) are just as likely to be 'framed' as anyone else. However, compared to people scoring low on NFC, they are more consistent across different frames of a problem. In other words, *the decisions made by people scoring high on NFC are less affected by the way a problem is presented (framed)*.

In accordance with the abovementioned results from brain research, the magnitude of the framing effect is significantly reduced when decision makers are encouraged to reflect on the options and to provide a rationale for their choice (Miller & Fagley, 1991; Sieck & Yates, 1997; Takemura, 1993). For people who score high on the *Need for Cognition* this manipulation even eliminates the framing effect altogether (Simon et al., 2004). NFC has also been found to moderate hindsight bias: hindsight bias is found for persons with low and medium NFC scores, but not for people with high NFC scores (Verplanken & Pieters, 1988).

An individual's thinking style has often been associated with proneness to bias. An individual's preference for an analytic-rational (deliberate processing) or an intuitive-experiential (heuristic processing) thinking style can be assessed using the Rational-Experiential Inventory (REI: Epstein et al., 1996). Several studies have investigated the relationship between thinking style and various biases.

Persons that dominantly use an analytic/rational thinking style tend to be less susceptible to the base rate neglect bias than people using an intuitive/experiential thinking style (Ohlert & Weißenberger, 2015). There seems to be no relation between thinking style and susceptibility to the conjunction fallacy (Lu, 2015). There appears to be a clear link between thinking style and belief bias: in contrast to people with an intuitive-experiential thinking style, people with an analytic-rational thinking style show no signs of belief bias (Svedholm-Häkkinen, 2015).


A specific cognitive ability that appears to be linked with thinking style is *numeracy*: the ability to process basic probability and numerical concepts (Peters et al., 2006). An individual's numeracy-competency is determined by (1) the degree of information processing (heuristic or deep elaborative processing), (2) affective numerical intuition (e.g., framing); and (3) intuitive understanding (e.g., gist-based, or comprehensive and intuitive, representation and reasoning; see Ghazal et al., 2014). Low numeracy is typically linked with intuitive (heuristic) thinking, whereas high numeracy is typically linked with deliberate (analytical) processing (Brust-Renck et al., 2014). In this view people with high numeracy are less susceptible to biases because they show an analytical thinking style and information seeking behaviour (Ghazal et al., 2014). Numeracy has indeed been found to be relevant for decision making quality across a wide range of tasks (Sinayev & Peters, 2015). For instance, people with high numeracy are less susceptible to framing bias (Gamliel et al., 2015; Peters et al., 2006) and conjunctions fallacies (Sinayev & Peters, 2015), are less over/under confident about their decisions (Sinayev & Peters, 2015), and take less risks (Jasper et al., 2013). The more numerate people are much better than the less numerate ones at extracting the precise affective 'gist' of a problem and use it to determine the quality of a particular choice (Jasper et al., 2013). These findings cannot be attributed to differences in general intelligence (Peters et al., 2006).

Somewhat in contrast, people using a combination of thinking styles (high deliberate/high heuristic (also called 'complementary thinking') and low deliberate/low heuristic (also called 'poor thinking') are found to be more susceptible to framing than those using a dominant (either rational or intuitive) thinking style (Shiloh et al., 2002). Thus, it seems that people with one clearly dominant thinking style are more resistant to framing than people with a less dominant style, or people using a combination of styles.

This may be because both decision styles have strong *internal* guides, either logical or experiential, upon which they rely in processing information. However, people with a non-differentiated thinking style (either 'complementary' or 'poor') tend to rely more on coincidental *external* cues within the situation, like the exact formulation (framing) of information, when processing information.

Individuals with high emotional intelligence (the ability to recognise one's own and other people's emotions, to discriminate between different feelings and to identify their causes) are able to reduce (or even eliminate) the effects of cognitive bias by recognizing that the emotions they experience (for instance anxiety: Yip & Côté, 2013) are irrelevant for the decisions they have to make.

For example, military officers with high emotional intelligence showed better tactical decisions under stressful conditions because they are able to maintain a higher state of attentiveness for social cues and perform a more exhaustive (deliberate) analysis of situational cues (Fallon et al., 2014).

Summarizing, several types of cognitive ability, as well as the ability to engage in deliberate information processing at appropriate times, seem to protect an individual from several cognitive biases (in particular, the sunk cost bias, the base rate fallacy, the over-confidence bias, the belief bias, and framing). For anchoring and conjunction bias the evidence is mixed. Emotional intelligence has been found to reduce the likelihood of falling prey to decision bias. In general it can be concluded that cognitive ability does not safeguard an individual against bias, but it may in some cases help in deploying countering mechanisms that reduce or prevent subsequent behavioural effects such as sunk cost bias, overconfidence or risk seeking.

### *3.1.2 Expertise*

Whether people deploy a heuristic or a more deliberate decision making mode depends for a large part on the decision-maker’s expertise (Fuchs et al., 2015). An expert is an individual who has achieved exceptional skills in one particular domain (Chi et al., 1988). The primary distinction that separates experts from novices appears to be both the breadth and depth of their domain-specific knowledge (Chi et al., 1988). Less experienced decision-makers respond to subjective complexity with an increase in deliberation and tend to follow their preferred (either heuristic or deliberate) decision style. In addition, the thoroughness of their information processing is affected by their mood: a happy mood leads to more superficial (heuristic) processing, while a sad mood leads to more thorough (deliberate) processing (Englich & Soder, 2009). In contrast, more experienced decision makers show a constant use of deliberation independent of their decision preferences, subjective environmental complexity or mood (Englich & Soder, 2009; Fuchs et al., 2015). Also, experts are found to rely more on intuition than on deliberation. They can probably do so because they have learned to recognize patterns of conditions for which particular tools or strategies will most likely work (similar to chess players: Sauter, 1999). For example, expert handball players are more intuitive than non-experts and tend to rely on their first intuitively generated decision option (Raab & Laborde, 2011).

Expertise generally does not significantly reduce the anchoring bias effect (for a review see: Furnham & Boo, 2011). However, expertise in a specific estimation context/task may reduce susceptibility to anchoring: participants became less susceptible to anchoring with increasing experience in a card game (Welsh et al., 2014). This implies that expertise within a particular field of interest should be clearly defined before being able to assess whether ‘experts’ are less affected by anchors than ‘non-experts’. Individual differences in various traits may be more useful for predicting the rate of increase in expertise, while it is the level of expertise that indirectly reduces susceptibility to anchoring, rather than direct susceptibility to biases (Welsh et al., 2014).

Summarizing, expertise affects sensitivity to biases since it determines thinking style and the way that information is processed in combination with its context. Expertise can stimulate both deliberate and heuristic thinking. When the context is not appropriate, the latter may lead to biases. Experts are less likely to misinterpret the context than novices. They are therefore more likely to select the thinking style appropriate for the context, and are subsequently less prone to bias than non-experts.

### *3.1.3 Personality*

Personality is often defined in terms of five main personality traits (the ‘Big Five’: John & Srivastava, 1999): openness, conscientiousness, extraversion, agreeableness, and neuroticism. These traits are characterised as follows:

- *Openness to experience*: Appreciation for art, emotion, adventure, unusual ideas, curiosity, and variety of experience.
- *Conscientiousness*: A tendency to be organized and dependable, show self-discipline, act dutifully, aim for achievement, and prefer planned rather than spontaneous behaviour.
- *Extraversion*: Energy, positive emotions, surgency, assertiveness, sociability and the tendency to seek stimulation in the company of others, and talkativeness.
- *Agreeableness*: A tendency to be compassionate and cooperative rather than suspicious and antagonistic towards others.
- *Neuroticism*: The tendency to experience unpleasant emotions easily, such as anger, anxiety, depression, and vulnerability.

The literature shows that individuals with high conscientiousness, agreeableness and openness to experience or with low extraversion are more susceptible to the anchoring bias (Caputo, 2014; Eroglu & Croxton, 2010; McElroy & Dowd, 2007; Teovanovic et al., 2015). It has been suggested that because individuals with high conscientiousness engage in more deliberate thinking when making decisions, they are more likely to perform a confirmatory search for anchor consistent information. Individuals with high agreeableness tend to be more affected by anchors than less agreeable persons. This is probably because individuals with high openness to experience easily ‘adjust’ their beliefs when considering situational information.

There are some indications that introverts are more susceptible to anchoring bias than extraverts (Eroglu & Croxton, 2010; Furnham et al., 2012), but this relation is not robust (Furnham et al., 2012).

It has been suggested that low extraversion may be associated with negative affect (Eroglu & Croxton, 2010), which may stimulate more deliberate thinking and thereby activate a confirmatory search for anchor consistent information (Bodenhausen et al., 2000; Englich & Soder, 2009).


People scoring high on trait optimism (people who tend to hold positive expectancies for their future) (Scheier et al., 1994) were found to be less likely to update their judgments in response to undesirable than to desirable information, and this to a greater extent for judgments concerning themselves than others (Kuzmanovic et al., 2015). In other words, people with high trait optimism show a pronounced self-specific optimism bias.


It has been argued that the evolution of the healthy mind to (optimistically) mis-predict future occurrences has led to an increased resilience, improved coping behaviour and reduced anxiety, resulting in overall improvements of both physical and mental health (Dolcos et al., 2015; Sharot, 2011). Optimism bias may sometimes even lead to better outcomes than do unbiased beliefs (Sharot, 2011). Recent brain studies have identified the orbitofrontal cortex to be associated with trait optimism: higher OFC gray matter volume (GMV) was associated with increased optimism, which in turn was associated with reduced anxiety (Dolcos et al., 2015).

Despite the hypotheses suggested above, it is not easy to determine the mechanisms underlying the relationships between personality traits and susceptibility to cognitive bias. On a general level it can be said that personality appears to relate to bias susceptibility because it determines how people weigh and process information.

#### *3.1.4 Culture*

Members of different social cultures may have different ways of thinking, because they have been socialized from birth into different world views. Some researchers hypothesize that these cultural differences affect an individual's susceptibility for bias. For instance, East Asians are believed to have a holistic world view, attending more to contextual factors and assigning causality to them, making relatively little use of categories and formal logic, and relying on 'dialectical' reasoning. Westerners, on the other hand, are believed to be more analytic, paying attention primarily to the object of interest and the categories to which it belongs and using rules, including formal logic, to understand its behaviour (Nisbett et al., 2001; Strutton & Carter, 2013). As a result, East Asians may for instance be less susceptible to attribution errors, since they see behaviour primarily as a product of external factors and not merely of the actor's dispositions. For the same reason, they may be more susceptible to hindsight bias because they are readily able to find some explanation for a given event since everything is connected in their world view (Choi & Nisbett, 2000; Yama et al., 2010). Following this line of thinking, Westerners may be better able to withstand the hindsight bias because they have a more rule-based thinking style.

Only a few studies address the influence of culture on bias susceptibility. Studies on the effects of culture on hindsight bias show mixed results: while some studies confirmed the abovementioned hypotheses (Choi & Nisbett, 2000; Yama et al., 2010) others found no cultural differences in the sensitivity to hindsight bias (Pohl et al., 2002).


One study (Scott et al., 1998) found evidence for the hypothesis that self-centred Westerners, with their personal desire to be correct and to fortify one's choices, are more susceptible to the sunk cost bias than collectivist East Asians who are more focused on optimizing outcomes for the group. However, other studies found opposite results (Yoder et al., 2014). They propose that East Asians may also be prone to sunk cost bias because they are more concerned about saving face, resulting in more commitment to prior decisions.

A recent study on choice framing (Haerem et al., 2011) compared military decision makers with business students (difference in organizational cultures).
While business students showed the classic framing bias (risk aversion in the gain frame an risk seeking behaviour in the loss frame: Tversky & Kahneman, 1981), military decision makers  consistently showed a risk-seeking tendency, independent of choice framing. Consistent with a cultural explanation, military officers had significantly higher levels of self-efficacy than civil business school students, and self-efficacy predicted risk seeking in the military sample, but not in the civil sample. This result is in line with the finding that individuals with little belief in their own competence prefer not to gamble (Heath & Tversky, 1991). Military decision makers, on the other hand, may have such strong beliefs in their own abilities that they believe that they can beat the odds (over-confidence).

Summarizing, while it is possible that culture affects sensitivity to bias (e.g., as a result of different preferred thinking styles or levels of self-efficacy), only a few studies on this topic have been conducted and their results are mixed. So not much or ‘heavy’ conclusions can be drawn with regards to this topic.

## 3.2 Do mental states modulate cognitive bias?

This section  explores whether mental states (e.g., mood, emotions, stress, attention, expectations) affect the occurrence and impact of bias.

Emotions have a big impact on people’s lives in general, and impact the decisions we make. Such effects may either be small or large, depending on the situation and the type of emotion that is experienced. Similarly, mood can also affect someone’s judgment and decisions. Emotions and mood are closely related. Emotions are aroused in people by some specific objects or situations, and tend to be relatively short-lived. Mood tends to be less situation-specific and persists for a longer period of time. Sometimes situations may be so taxing that people experience stress.

The effects of affect, mood and stress on cognitive biases are broad and currently not fully understood (Phelps et al., 2014; Raglan & Schulkin, 2014; see Schiebener & Brand, 2015 for a recent neuro-cognitive model of cognitive and affective decision making). Several effects have been reported, with varying explanations on how the effect of emotions bring about the observed biases.

Firstly, the mere presence of emotional cues can bias human decision making and behaviour (affective priming), even when the cues themselves are not consciously perceived (Winkielman et al., 1997; Winkielman & Berridge, 2004; Winkielman et al., 2005).

For instance, the subliminal perception of faces with negative or positive expressions shifts the appraisal of subsequently perceived stimuli in an affect congruent way (i.e., stimuli are judged more positive after subliminal perception of positive facial expressions and as more negative after subliminal perception of negative facial expressions: Winkielman et al., 1997). Also, consumption behaviour can be influenced in this way (subliminally perceived smiles caused thirsty participants to consume more beverage and increased their willingness to pay more, while frowning faces had the opposite effect: Winkielman et al., 2005).

Secondly, people sometimes base their decisions on their mood or gut feeling ('the affect as information theory'; Clore & Storbeck, 2001). Rather than considering the actual information about a situation, they may ask themselves "*How do I feel about it*?" In such a way, people may make affect biased decisions by misattributing their core affect (i.e., the neurophysiological state underlying their feelings of pleasure
8 and arousal) to unrelated persons or situations. Affect also biases an individual's attention to mood-congruent cues, thus leading to mood-consistent judgments. In addition, inferences drawn from emotion expressed by others can bias interpersonal relationships (Van Kleef, 2009). In other words*, people base their judgements on their current mood and selectively pay attention to social and physical cues in their environment that are in line with their own mood.*

Thirdly, affect biases risk taking (Slovic & Peters, 2006), possibly through weighing or perceiving probabilities and possible outcomes differently. Mood and emotion have been suggested to induce bias through affecting thinking style. A sad mood typically biases preferences toward taking high-risk options, whereas an anxious mood is more likely to induce low-risk options (Raghunathan & Pham, 1999). Positive moods induce loss aversion (the tendency to overweigh losses relative to gains: Isen et al., 1988). Anger reduces the bias for anchors provided by others, but enhances this bias for self-generated anchors (Jung & Young, 2012). Fear reduces
9 risk-seeking behaviour while anger results in more risk-seeking (Lerner & Keltner, 2001). Acute stress enhances the framing effect (people make riskier decisions both when options are presented in terms of loss: Porcelli & Delgado, 2009) whereas sustained stress reduces this bias (people make only somewhat less risky decisions in the loss domain while risk taking behaviour does not change in the gain domain: Pabst et al., 2013).

Several explanations for the above findings have been suggested in the literature. On the one hand, positive moods have been reported to lead to:
– more superficial processing of incoming information (i.e., to a reliance on global knowledge and heuristics, with less attention to detail: Clore & Huntsinger, 2007; Schwarz, 1998; Schwarz, 2002),
– increased flexibility and creativity, and
– decreased anchoring biases (Estrada et al., 1997; for a review see Cohen et al., 2008).

Negative moods generally trigger a more thorough processing of incoming information (i.e., to the use of a systematic, data-driven strategy of information processing, with considerable attention to detail) resulting in a reduced susceptibility
10 to both attribution errors and halo effects. Negative affect narrows attentional focus while positive affect broadens the attentional span (for a review see Loewenstein & Lerner, 2003).

This suggests that people in a positive mood are typically more susceptible to heuristic bias when making decisions than people in a neutral or negative mood. Accordingly, people in a negative mood are more susceptible to the heuristic bias of anchoring than people in a neutral or positive mood. This is probably because a negative mood stimulates more thorough information processing, allowing the anchor to exercise its influence on this search (Bodenhausen et al., 2000; Englich & Soder, 2009). For novices and non-experts, a positive mood has been found to significantly reduce or even eliminate the anchoring effect: happy non-experts are not or hardly affected by anchors. This is probably because non-experts in a positive mood are more likely to ignore irrelevant information (Biss & Hasher, 2011; McConnell & Shore, 2011). In contrast, experts are robustly influenced by anchors, probably because their information processing mode (pattern recognition) is not affected by their mood.

Similarly, the provision of a pleasant emotional context can eliminate the framing effect: framing susceptibility disappeared after the induction of a task-irrelevant subtle positive emotional context  (viewing positive emotional images: Cassotti et al., 2012).

A possible explanation for the idea that mood affects information processing (based on the affect as information theory hypothesis) would be that a negative mood signals a situation that is problematic and therefore needs a more vigilant form of processing, while a positive mood signals that a situation that is benign and therefore allows a more nonchalant form of processing (Schwarz, 2002).
However, recent studies suggest that it may be the sense of certainty associated with a given emotion, rather than its valence, that drives the depth of information processing. Emotions characterized by a sense of certainty (e.g., happiness, anger, disgust) lead decision makers to rely on heuristic thinking, while emotions characterized by a sense of uncertainty (e.g., worry or surprise) lead them to scrutinize information more carefully (deliberate thinking: Tiedens & Linton, 2001; for reviews see Cohen et al., 2008; Lerner et al., 2015; Loewenstein & Lerner, 2003).This fits with the findings that negative emotions like anger (Coleman, 2010) and anxiety (Moon et al., 2003) also exacerbate the sunk cost effect. The feelings of high certainty and personal control that are associated with these emotions may cause individuals to become optimistic (overconfident) about their chances of success.

Summarizing, several effects of mental state (mood, emotions, stress, attention) on decision bias have been reported. While it is uncertain whether it is related to actually experiencing emotions, subliminal presentation of affective stimuli can shift appraisal of subsequent stimuli in the corresponding affectively congruent direction (priming), at least in the lab. Emotions affect risk taking behaviour and can be used as a source of information to appraise a situation itself. A number of studies are consistent with emotions affecting information processing, which in turn affects the likelihood of biased decisions: negative emotions and feelings of uncertainty invoke a deeper level of information processing, therefore reducing biased decisions. Positive emotions and feelings of certainty, in contrast, promote a more superficial and faster level of processing, thereby enhancing the risk of biased decisions.

### 3.3 Do external factors modulate cognitive bias?

People tend to apply a deliberate decision making mode in tasks that are relatively easy, where critical information is available and where there is plenty of time available. They tend to deploy a heuristic mode (efficient rules of thumb) in relatively difficult tasks, with lacking or ambiguous information, and where little time is available (Klein et al., 2010).Thus, the mode of decision making (rational vs heuristic) is determined by (1) the availability of information (too much or lacking), (2) the quality of information (clear and relevant information versus ambiguous and uncertain information), and (3) the time constraints. In addition, physical discomfort resulting from the environment (e.g., heat, loud noise) may cause changes in an individual's mental state, such as an increase in stress and anxiety, which is known to make bias more likely, and its effect more severe (see previous section).

In difficult, complex and stressing conditions, people tend to rely on multiple simple heuristics, rather than on one general-purpose calculus of rationality (e.g., Bröder & Schiffer, 2003; Gigerenzer, 2007). This means that they can be led to use particular heuristics in inappropriate environments and consequently make errors (Tversky & Kahneman, 1974).


Whether a given heuristic succeeds in a given situation depends on the uncertainty, redundancy, sample size and cue weight distribution in that condition (Todd & Gigerenzer, 2012). In challenging environments with high variability, low predictability, and little opportunity for learning, good decisions may nonetheless be made more often by simple decision rules rather than by complex ones (Todd & Gigerenzer, 2007). An example is the Less-is-More effect: there are situations in which the use of less information results in more accurate decisions (Gigerenzer & Gaissmaier, 2010; Goldstein & Gigerenzer, 2002). For example, 62% of American students tested could correctly state that San Diego has a higher population than San Antonio, but 100% of German students tested could do so (Goldstein & Gigerenzer, 1999). The argument here is that the American students were forced to consider multiple different, often unreliable, cues to size in making their judgment, whereas the German students simply needed to consider whether they had ever heard of the city: a more reliable size cue.

Summarizing, external factors can shift an individual's decision making strategy towards either a more rational or a more heuristic mode. Heuristics can lead to biases when they are used in an inappropriate context, but may – perhaps counter-intuitively - be effective when they are used in complex and unreliable problem contexts.

### 3.4 Debiasing techniques

While the literature on cognitive bias is extensive, the literature on debiasing is much more limited (Lilienfeld et al., 2009). It appears that there are currently no generally accepted techniques to prevent decision biases (Leddy et al., 2013). There are, however, a few strategies that are empirically supported (see Larrick, 2004 for a review). Most of these techniques try to shift people from intuitive to deliberate thinking.

Strategies that promote deeper information processing and thereby stimulate the recruitment of the medial and lateral orbitofrontal cortex (regions associated with the integration of affective and contextual information in decision making) may constrain decision bias (Hughes & Zaki, 2015). Such strategies typically involve the consideration of alternative reasons or viewpoints through training and meditation.

The cognitive debiasing strategy that is best attested in the literature is '*consider the opposite*' or '*consider an alternative*' (e.g., Hirt & Markman, 1995; Mussweiler et al., 2000) which requires the reasoner to generate reasons for the contrary position, or to explain an alternative outcome. This strategy has been found effective in reducing hindsight bias, as well as over-confidence bias and anchoring effects (Mussweiler et al., 2000). A similar strategy is '*perspective taking'*, which requires the reasoner to imagine what it would be like to be another person in a given scenario (Galinsky & Ku, 2004). This technique can effectively reduce prejudice (Galinsky & Ku, 2004), automatic expressions of racial biases (Todd et al., 2011) and the fundamental attribution error (Hooper et al., 2015). Hence, in a given context it depends on the bias that is most likely to occur which debiasing strategy should be applied.


Both with *considering the opposite* and *perspective taking*, the reasoner is forced to make sense of another perspective, rather than merely enumerating the reasons to support his own views. This '*distance taking'* can also be achieved by presenting the available options in a different tongue: for instance, the framing effect disappears when choices are presented in a foreign language (Keysar et al., 2012). Since a foreign language is typically processed less automatically than a native tongue, this may lead to more deliberate processing, which generally helps to reduce bias effects.

Based on the above strategies Cohen and colleagues developed the 'Critical Thinking' strategy for application in practical (military) settings (Cohen et al., 1998). Critical Thinking is a dynamic and iterative problem-solving approach for new and unfamiliar situations, that involves asking and answering questions about alternative possibilities in order to better achieve an objective. TNO developed Critical Thinking training programs for the Netherlands military forces, fostering the development and application critical thinking skills (van den Bosch & de Beer, 2007).The premise is that awareness, collaboration, and critical thinking can prevent learners from falling prey to judgment biases. Effects of training were studied in laboratory and field studies. Results show that critical thinking training had positive effects on the process of tactical command (i.e., better argumentation for situation assessment) as well as on the outcomes (i.e., more and better contingency plans; Helsdingen et al., 2010; van den Bosch & de Beer, 2007; van den Bosch & van Ingen, 2002).
Based on the same principles, TNO also developed and evaluated the Critical Thinking Tool to help crisis management personnel avoid tunnel vision and confirmation bias. The tool proved successful in countering these biases, primarily by making competing hypotheses and presenting the evidence supporting them (Schraagen et al., 2008).

Computer games that immerse the user into bias-invoking situations that provide the experience to identify cognitive bias and to practice mitigation strategies, may also serve as debiasing tools. It has been shown that these types of “serious games” can provide an effective method to train adults how to recognize and mitigate cognitive biases (confirmation, attribution and blind spot) (Clegg et al., 2015; Dunbar et al., 2014; Symborski et al., 2014).

Another technique that appears to effectively reduce several common biases is mindfulness meditation. Mindfulness can be defined as a present-oriented, open, and non-judgmental state of conscious awareness (Brown & Ryan, 2003). It is considered an inherent human capacity that can be enhanced by meditational practices. Advocates of mindfulness argue that it reduces negative affect and increases subjective well-being by focusing attention on the present. Increased mindfulness has been found to reduce negativity bias (Kiken & Shook, 2011), confirmation seeking and over-confidence (Lakey et al., 2007), and also the sunk cost effect (Hafenbrack et al., 2014).

Models and decision support systems that provide tools and explicit rules to guide decisions, may also help to counteract the adverse effects of judgement bias. This can for instance be achieved by allowing the user to employ heuristics while warning for the likely biases, and by anticipating the likely use of heuristics and providing information that offsets the effects of such use (Larrick, 2004).

However, decision aids can also introduce or aggravate biases (Davis et al., 2005), depending on the way they present their outcomes (framing bias, induced when outcomes are represented as either gains or losses) or how they guide the user through the decision process (confirmation bias, induced by framing the options for the user or by presenting checklists).

# 4 General findings, conclusions and discussion

The objective of this literature study was to investigate to what extent individual characteristics, mental states and external factors affect a person's susceptibility to judgment and decision biases. This knowledge can be used to develop strategies to mitigate biased thinking of own forces, and to develop strategies to evoke biased thinking in other actors, in order to influence and change their behaviour.

The results of the literature study indicate that each of the reviewed aspects can affect cognitive biases under certain conditions (though with respect to culture the evidence is scarce) – see text box 'Overview of the summarized findings'. Note that the factors found to reduce cognitive bias may in fact merely mitigate the behavioural effects rather than preventing the bias from occurring at all.

*Text box: Overview of the summarized findings*

**Personal characteristics**
Several types of *cognitive ability*, as well as employing deliberate information processing may mitigate various cognitive biases (in particular: sunk cost, base rate, over confidence, belief, framing). For anchoring and conjunction bias, the evidence is mixed. Emotional intelligence has been found to reduce some biases. In general, cognitive ability does, by itself, not prevent biases from occurring, but it may help to learn how to prevent or reduce its effects on behaviour.

*Expertise* : Experts are less likely to misinterpret the context than novices. They are therefore more likely to select the thinking style appropriate for the context, and are subsequently less prone to bias than non-experts.

*Personality* appears to correlate with certain biases because it determines the way people weigh and processes information.

Few studies have investigated the effects of *culture* on bias. It is however expected that culture may affect sensitivity to bias through cultural differences in preferred thinking styles.

**Mental state**
While it is uncertain whether the effects can actually be attributed to mood and emotions, subliminal presentation of affective stimuli can shift appraisal of subsequent stimuli in the affectively congruent direction (priming). Emotions affect risk taking behaviour and can be used by subjects as a source of information to appraise a situation or a person. A number of studies are consistent with emotions affecting attention and information processing, which in turn affects the likelihood of biased decisions: negative emotions and feelings of uncertainty invoke a deeper level of information processing. Positive emotions and feelings of certainty, in contrast, promote a more superficial and faster level of processing.

**External factors**
External factors can trigger a certain decision mode: either heuristic or deliberate. Heuristics can lead to biases when they are used in an inappropriate context but may be effective when they are used in the context to which they apply.

In this chapter we will discuss the limitations of our study, but also the chances or possible benefits for application of the gained knowledge in the military organisation. As we did not specifically study the implications or use in the military context in this research, the points that we raise in paragraph 4.2 are considered to be ‘food for thought’[6].

## 4.1 Limitations of the present study

The results that were reviewed in this research have mostly been obtained in laboratory conditions involving simplified tests that have specially been designed to induce cognitive biases. It is therefore not clear if, and how these results translate into real-life military practice.

Another limitation that applies to the scientific literature in general is that studies reporting significant effects are (much) more likely to be published than studies that find no effects (publication bias: Fanelli, 2010; Francis, 2012; Franco et al., 2014). This may lead to an overestimation of the effect of the reviewed variables on the occurrence of bias.

We used the dual-process heuristic-deliberate framework to summarize, unify and understand our findings. However, not all reported effects fit into this framework. For instance, effects reported on emotional priming are different from studies that demonstrate effects of emotion, indicating a different underlying mechanism.
Also, some of the effects upon judgment and decision making seem to be working against each other. For example, people who need to perform under pressure and time constraints are expected to apply heuristics which makes them vulnerable for bias. However, at the same time, it is known that pressure induces a negative mood which often elicits deliberate thinking strategies. And although deliberate thinking tends to guard people against the risk of bias, this is not always the case.
Exactly when it does, and when not, is still difficult to quantify. This underlines the need to more fully understand the mechanisms underlying cognitive bias.

## 4.2 Relevance for Defense

The current operational contexts are typically characterized by uncertainty about the intentions, capabilities and strategies of the parties involved. Command and control judgments and decisions made under such circumstances are known to involve heuristics, with the risk of cognitive bias coming into play.

An infamous example of distorted judgement and its consequences is the USS Vincennes shoot-down incident, in which a U.S. Navy Aegis cruiser destroyed an Iranian commercial airliner, mistaking it for a hostile attacker.

This incident has been investigated from multiple perspectives (e.g., Fogarty, 1988; Klein, 1998). One important factor leading to the incident was the fact that neither the team nor the captain challenged the assumption, initially made by the Air Warfare Officer, that the unidentified track was an enemy F14. All incoming information was subsequently fitted into that erroneous assumption.

[6] And are, in some cases, direct input for upcoming research projects under research programmae V1522

Radar operators ‘saw’ the track descending and increasing speed while later analysis showed it was in fact climbing. Similarly, the analysis also showed that the track stayed within its lane margins, although personnel reported it to be outside. In short, there are many indications that confirmation bias affected judgment and decisions. The USS incident was a reason for the US Defence to initiate a large research program, called TADMUS (Tactical Decision Making Under Stress; Cannon-Bowers & Salas, 1998).

Successful preparation, execution and management of military operations in complex and unstable conditions requires competent commanders and staff personnel. A thorough understanding of judgment, decision making and behaviour, as well as the circumstances and mechanisms that jeopardize the quality of these core military abilities, is of eminent importance. Knowledge and insights on the underlying mechanisms of human judgement, decision making and cognitive bias can provide the military with recommendations on several fronts. We will discuss a few of such implications. Our literature study pointed out that the effects of cognitive biases on decision making are not completely fixed within and between individuals. This suggests opportunities to apply this knowledge for selecting and training personnel, application in the military Decision Making Process and influencing target audiences.

### *4.2.1 Implications for the military decision making process*

The military realize that their missions are characterized by uncertainty, variability and inconsistency. With the intention to support commanders in coping with these conditions, the military decision making processes make use of structured, step-by-step topics that need to be addressed (in the Tactical Decision Making Process as used on battalion level and up, or the OATDOEM[7] process as used at company level and below). Although a strict methodology and checklists certainly have their value, it can also be argued that they do not invoke the level of thinking that is needed to examine tactical problems from multiple perspectives. They may even prevent the level of critical thinking that is needed to understand, visualize and truly appreciate the nature of the complex ill-structured problems that officers often face (Williams, 2010).The information and insights presented in this report may stimulate reflection on designing the military decision making process in such a way that it improves the quality of military judgment, and helps commanders to prevent bias in their decision making.

### *4.2.2 Implications for training military decision making*

Experts in military tactical command treat decision making as a problem solving process (Serfaty et al., 1997). They have large collections of schemas, enabling them to recognize a large number of situations as familiar and allowing them to use an efficient (heuristic) decision mode (Klein, 2008). Another capacity of experts are their problem solving skills which they can deploy if an immediate match between the actual problem situation and available mental schemas cannot be established.

---

[7] The Dutch acronym for: orientation on the (problem) situation, analysis of the assignment, terrain & weather, threat & enemy, other actors, and own means

When faced with an unfamiliar tactical problem, experts collect and critically evaluate the available evidence, seek for consistency, and test assumptions underlying an assessment. The nature of this process can be described as experience-based iterative problem solving in which correcting for one problem sometimes leads to identification of another problem (Cohen et al., 1998).
This behaviour does not come naturally. It takes deliberative mental effort to imagine or elaborate a proposition that is contrary to what we generally assume. Such findings about expert behaviour may be used to develop and organize training methods that help novice commanders to acknowledge the danger of bias entering the process, and to support the application of bias-countering strategies (e.g., van den Bosch & de Beer, 2007).This can be done at the level of individuals, but also to organize and to train staff in generating and evaluating assumption-competing hypotheses. 'Red-teaming' is an example of such a training, that may be used to counter the effects of what is called 'group-think' (Janis, 1982): a group's desire for harmony in the group resulting in irrational or dysfunctional decision-making.

#### *4.2.3 Protecting own forces against self-induced bias*

The information and insights resulting from the present study may stimulate the development of new ways to protect the own forces against cognitive bias in concrete situations.

There are many examples how various cognitive biases can effect military practice and decision making (Janser, 2007; Williams, 2010). For example, in counter IED operations the focus is often on routes that have been hit before, or on routes that contain high value targets. It requires reflection to realize that the selection of focus areas may very well be the result of a *search set bias*, caused by the availability heuristics. This realization may stimulate the commander to look for adversaries in areas where there have been no prior cases of IEDs or ambushes, because the enemy may be more likely to place IEDs there.

Another example is how *anchoring bias* may affect political-military decision making. Imagine a situation where a government coalition contemplates on contributing to an international military operation in the Middle-East. They may first discuss this idea with the nation's military and ask them to make an estimation of the personnel and materiel required for this potential mission. The military may then take the conditions, assumptions and targets into account and deliver an estimate to the best of their knowledge. However, during the process of political developments and negotiations among governments, the nature of the desired mission may have changed significantly. The foreseen mission has then become far more dangerous, the rules of engagement have become less clear, and there is far less support from friendly-nations. This may render the initial estimate of required personnel and materiel as severely inadequate. However, the outcome of the subsequent negotiations between government and military regarding the required military means for the mission is likely to be seriously affected by the estimate given in response to the original request (the anchor).

The information and insights presented in this report may help to realize the danger of bias in situations such as these. Furthermore, although the effects of anchoring are very difficult to withstand (Kahneman, 2011), it may help to develop strategies to reduce its effect in situations like the one described above.

### *4.2.4 Influencing enemy behaviour by inducing bias*

Knowledge on the mechanisms affecting judgement and decision making, as reported here, may be used to influence opposing forces. History provides successful examples of this practice (Williams, 2010). In the second world war, the British exploited the anchoring bias to deceive the Germans with the deception scheme called the Cyprus Defence Plan. The British were concerned that their 4,000 troops on Cyprus were insufficient to repel a German attack. Via the creation of a false division headquarters, barracks, and motor pools along with phony radio transmissions and telegrams, the British set out to convince the Germans that 20,000 troops garrisoned the island. A fake defensive plan with maps, graphics, and orders was passed via double agents using a lost briefcase. The Germans fell for the ruse. This deception anchored the Germans on the 20,000 troop number (the anchor) for the remaining three years of the war. In spite of their own analysis that the number might be too high, intelligence intercepts and post-war documents revealed the Germans accepted the number almost without question. This shows that the Germans were more confident in their assessment than justified by the contradictory information they had. In short, the Germans were anchored, made insufficient adjustments and had overly narrow confidence intervals.


### *4.2.5 Protecting own forces against enemy-induced bias*

Mechanisms affecting judgment and decision making may be exploited by the enemy to bias judgment and decisions of our own forces (see Williams, 2010). For example, following the deadly experience of the U.S. Army Rangers in Mogadishu in 1993, force protection issues dominated subsequent military deployments (to Haiti and Bosnia) to such an extent that they actually hampered the execution of the overall strategic mission. Due to the imaginability bias (Tversky & Kahneman, 1974) force protection issues were suddenly assumed equally important to mission success, because people could easily imagine dead soldiers being dragged through the streets of foreign cities. More recently, IS killed several of their prisoners of war in the most repulsive ways and posted video recordings of these executions on social media. By doing so, IS used (perhaps unintentionally) the imaginability bias to affect their enemies' decisions. Since people can easily imagine the course of these horrifying events they tend to overestimate their likelihood (and not their *actual* frequency of occurring: Tversky & Kahneman, 1974). By creating vivid and emotional experiences, IS also makes sure that the event is stored prominently in their enemies' memory, thus exploiting the availability bias. Because these horrible events are easily remembered people tend to overestimate their likelihood or frequency of occurring even more. It must be noted that this biased perception does not automatically predict the kind of response that follows. It is conceivable that the bias induces and amplifies anger, possibly leading to a desire for revenge. However, it is also conceivable that the bias induces fear, possibly causing reticence to take action. A possible outcome may also be that 'the home front' demands such stringent force protection measures that the mission's actual objectives become more difficult to attain. This report may help to realize that an enemy may effectively deploy mechanisms to induce all forms of cognitive and social bias, and may clarify the need to develop strategies to guard against this practice.

# 5 Food for thought

This section lists some ideas and loose ends that may come to mind when reading this report. Some of these may warrant further investigations or will be part of future studies.

Table 1. Some ideas and loose ends. The numbers refer to icons next to related sections of this report .

| | |
|---|---|
| 1 | The fact that people tend to use heuristics in complex and uncertain situations may effectively be used to influence the behaviour of other parties: one may force an opponent to fall back on heuristics (predicable behaviour) by creating confusion. |
| 2 | To what extent can analytical thinking be trained? |
| 3 | Can people switch between analytical and intuitive thinking styles? And if so, can that be trained? |
| 4 | People with higher numeracy have better analytical skills and are less prone to several biases. Does training numeracy also reduce bias susceptibility? |
| 5 | Biases that enhance resilience (such as optimism bias or over-confidence bias) may also hamper social interaction. |
| 6 | Characteristics that are typically considered positive in a military context (e.g., optimism or a high level of self-confidence, that both contribute to high resiliency) may also induce negative behaviour like over-confidence and risk-seeking. |
| 7 | Cultural differences in bias have practical consequences for the development and deployment of misleading and biasing strategies: influencing strategies have to be specifically designed for the culture of the target population. |
| 8 | Awareness of one's own state of mind (e.g., mindfulness) is relevant for decision making: one should realise that being happy reduces vigilance and induces superficial judgements, whereas being sad or uncertain stimulates more thorough information processing. |
| 9 | Have military learned to ignore fear and stress, but not other emotions when making decisions? This could have important consequences for military operations and influencing tactics. |
| 10 | The finding that affect influences decision making biases may be used to influence target populations more effectively: for instance, sadness and anger enhance risk taking, while stress enhances the framing effect. |
| 11 | It is unknown whether the Less-is-More Effect also applies in a military context: the current practice is to seek more and additional information in complex and uncertain situations. |
| 12 | The finding that speaking in a foreign language reduces the framing effect suggests that this may be a positive side effect of working in an international coalition. |

| | |
|---|---|
| 13 | Anchoring bias may be relevant in strategic communication: even irrelevant passing remarks may bias important decisions. This places serious restrictions on one's own choice of words, but offers opportunities for influencing opponents. |
| 14 | The ability to exclude emotions from the decision making process is not only relevant on the battlefield but also during planning. |
| 15 | Military analysts should not be susceptible to the emotional aspects of information and behaviour. |

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# A Terminology

**Anchoring bias**: a tendency to make decisions biased toward previously presented information (the "anchor").

**Attribution error**: the tendency to see behaviour as a product of the actor's dispositions and to ignore important situational determinants of the behaviour.

**Availability heuristic**: the tendency to judge the frequency or likelihood of an event by the ease with which relevant instances come to mind.

**Base rate neglect**: a tendency to ignore statistical information (prior probabilities) and focus on information only pertaining to a certain case.

**Belief bias**: a tendency to draw conclusions that agree with one's own beliefs - i.e., to evaluate the logical strength of an argument on the basis of the believability of the conclusion.

**Bias**: errors in decisions that arise due to limitations of cognitive processing. Biases are often explained using dual-process theory, which states that we have two cognitive systems, one that is fast and intuitive, and another that is slow and deliberate. Biases occur when our fast system operates without the oversight of the slow system.

**Bias blind spot**: the tendency to recognize bias in others but not in oneself.

**Cognitive bias**: a consistent deviation from an accurate perception or judgment of the world. Inferences about other people and situations may be drawn in an illogical fashion. Individuals create their own "subjective social reality" from their perception of the input.

**Cognitive reflection test**: test to assess the ability or disposition to resist reporting the response that first comes to mind.

**Confirmation bias**: a tendency to search for, interpret, focus on and remember information in a way that confirms one's preconceptions.

**Conjunction fallacy**: a combination of conditions is considered more likely than a general condition.

**Crystallized intelligence**: the ability to use skills, knowledge, and experience.

**Emotional intelligence**: the ability to recognise one's own and other people's emotions, to discriminate between different feelings and to identify their causes.

**Fluid intelligence**: the capacity to think logically and solve problems in novel situations, independent of acquired knowledge. It is the ability to analyse novel problems, identify patterns and relationships that underpin these problems and the extrapolation of these using logic.

**Framing bias**: a bias in decision making depending on the way in the information is presented (e.g., whether options are presented in terms of gains or loss).

**Halo effect**: a tendency to let the perceived valence of a single aspect dominate the overall judgment of a person or situation.

**Heuristics**: simple decision rules (rules of thumb) that ignore part of the available information but work well in a given environment.

**Hindsight bias**: the tendency to erroneously perceive events as inevitable or more likely once they have occurred.

**Imaginability bias**: the tendency to use our imagination to make a subjective premonition of a future event for which no memories of actual instances come to mind.

**Incidental emotions or affect**: emotions or a baseline affective state that is unrelated to the decision itself.

**Less-is-more effect**: In uncertain and ambiguous conditions heuristics (ignoring part of the information) can lead to more accurate judgments than weighting an adding all available information.

**Loss aversion**: the tendency to overweigh losses relative to gains.

**Need for cognition**: an individual's propensity to enjoy and engage in thought.

**Negativity bias**: a tendency to weigh negative information more heavily than positive information.

**Numeracy**: the ability to process basic probability and numerical concepts.

**Omission bias**: the tendency to prefer harm caused by omissions over equal or lesser harm caused by acts.

**Optimism bias**: the tendency to overestimate the likelihood of positive events (and to underestimate the likelihood of negative events) happening to oneself, compared to others.

**Outcome bias**: a tendency to evaluate the quality of a decision based on its outcome rather than on what factors led to the decision.

**Over-confidence bias**: an inclination of individuals to overestimate their own abilities to successfully perform a particular task.

**Sunk cost effect**: a tendency to persist in an endeavour once an investment of money, effort, or time has already been made.

# B Literature search methodology

Literature searches were performed with Google Scholar. As search terms we used the names of several well-known biases (Anchoring, Anchoring bias, Attribution error, Base rate neglect, Belief bias, Confirmation bias, Conjunction fallacy, Framing, Halo effect, Hindsight bias, Omission bias, Negativity bias, Outcome bias, Over-confidence bias, Sunk cost effect) as well as some general terms (Bias, Cognitive bias, Decision bias, Decision making, Heuristic bias, Heuristics; for a definition of these biases see Appendix A) and combined them with (conjunction: AND) terms related to human (emotion OR experiential OR individual differences OR intuitive OR intuition OR mental state OR mood OR personality OR reasoning OR thinking OR trait) or environmental (context OR environment OR priming) factors. The searches were initially restricted to articles reporting empirical studies in peer reviewed journals. The relevant papers that were found in this initial search served as a starting point for subsequent searches, that included all later papers and reports referring to papers from the initial set (found by using the ‘Cited by’ function in Google Scholar). We included studies found using this method in the review only (1) if they involved influences of personal or environmental factors on human decision making and (2) if they present a cross-sectional view of the current state of this field of research.

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Effects of personal characteristics, mental state and external factors on susceptibility to bias: a literature study

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15. ABSTRACT (MAXIMUM 200 WORDS (1044 BYTE))

Cognitive biases and heuristics are pervasive simplifications and distortions in judgement and reasoning that systematically affect human decision making. Knowledge in this area may enable Defense to foresee and reduce detrimental effects of biases and to influence others more effectively. In a literature study we assessed the influence of personal characteristics (cognitive abilities, expertise, personality, cultural background), mental states (mood, emotions, stress, attention, expectations) and external factors (e.g., information availability, time constraints, physical discomfort) on the occurrence of cognitive biases. We found that each of the aforementioned factors can affect cognitive biases, though little is known about the effects of culture. Factors that appear to reduce a cognitive bias may in fact suppress or override its behavioral effect rather than preventing the bias from occurring at all. Bias susceptibility and the occurrence of biases depend on thinking style (heuristic versus analytical), where thinking style is associated with an individual’s personal characteristics, mental state and external factors. In general, biases are reduced when an analytical thinking style is applied. However, whether a specific thinking style reduces or enhances a given bias also depends on the context. Finally, we provide some results on debiasing techniques and link our findings to military practice.

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