In *'Criminal Investigative Failures'*,
Edited by Kim Rossmo, 2008, Taylor & Francis.

5 Cognitive Biases in Human Perception, Judgment, and Decision Making: Bridging Theory and the Real World

ITIEL E. DROR AND
PETER A. F. FRASER-MACKENZIE

Scientific research into human cognition is well established by decades of rigorous behavioral experimentation, studies of the human brain, and computer simulations. All of these converge to provide scientific insights into perception, judgment, and decision making (Dror & Thomas, 2005; Kosslyn & Koenig, 1995). Many of these theoretical insights play an important role in our understanding of how humans behave in the real world. The scientific research has important bearings on how human perception, judgment, and decision making can be enhanced, as well as how both lay people and experts can (and do) make mistakes. Bridging scientific theory to the real world can assist our understanding of human performance and error and help us evaluate the reliability of humans. Furthermore, it has implications on how to minimize such error through proper selection and training, best practices, and utilizing technology (Dror, 2007, in press). In this chapter, scientific findings about human cognition are discussed and linked to practical issues in the real world of investigations.

We first must understand the theoretical and conceptual framework of perception, judgment, and decision making (Lindsay & Norman, 1977; Marr, 1982; Rumelhart & McClelland, 1986). Information comes to us from the outside world via sensory input (vision, hearing, touch, etc.). As information is received, it is processed; for example, we try to identify and make sense of it, interpret and assign it meaning, compare it to information already stored in memory, and so on. One of the fundamental and established cornerstones of human cognition is that people do not passively receive and encode information. *The mind is not a camera*. We actively interact with the incoming information in a variety of ways. What we see not only reflects the pure and raw data from the input provided by the external world, but it is, to a

large degree, a product of how we interpret interact and with the incoming data. *Perception is far from perfection* (Dror, 2005) because our perception and judgment are influenced by a variety of cognitive processes that are not dominated by the actual data.

In this regard, it is important to distinguish between bottom-up data-driven processes versus top-down processes that are guided and driven by factors distinct from the actual data provided by the external world. The existence and power of such top-down processes in shaping the identification of visual and other patterns has been demonstrated time and again in a number of different studies using a variety of different scientific methodologies, all confirming subjective effects on perception and judgment (e.g., Balcetis & Dunning, 2006; Humphreys, Riddoch, & Price, 1997; McClelland & Rumelhart, 1981; Zhaoping & Guyader, 2007). Top-down influences include, among other things, contextual information, expectation, what we already know (or think we know), hope, motivation, and state of mind. Although top-down processing is essential for human cognition and is a sign of expertise, it can also interfere and contaminate our perception, judgment, and decision-making processes. These biases and distortions arise from a long and well-studied list of cognitive and psychological phenomena (e.g., Evans, 1989; Gilovich, Griffin, & Kahneman, 2002; Hogarth, 1980; Kahneman, Slovic, & Tversky, 1982; Nickerson, 1998; Nisbett & Ross, 1980). These well-established cognitive and psychological phenomena (e.g., confirmation bias, cognitive dissonance, self-fulfilling prophecies, motivated reasoning, hindsight bias, escalation of commitment, etc.) cause people to lose objectivity.

Subjectivity arises when we no longer examine data purely by itself, evaluating it on its own merit without cognitive influences. When we examine information in light of such influences, we unavoidably and unconsciously perceive and judge it differently. When cognitive biases exist, we interact differently and subjectively with the information. This is manifested in a variety of ways. For example, during our examination of the data we are more likely to notice and focus on characteristics that validate and conform to extraneous information or context, a belief or a hope. Thus, the way we search and allocate attention to the data is selective and biased. Confirming data are emphasized and weighted highly, and when data quality is low (and therefore ambiguous and open to different interpretation), the existence of an extraneous influence will make people interpret the data in ways that are consistent with them. We tend to avoid and ignore data that conflict and contradict such biases and disconfirm data that we notice are ignored. Finally, data that do not fit the bias or context and cannot easily be ignored are dismissed and explained away, and weighting of disconfirming data is low.

These and other manifestations of bias and cognitive influences can make perception, judgment, and decision making unreliable. They are

well researched and documented by many scientific studies (e.g., Balcetis & Dunning, 2006; Cordelia, 2006; Ditto & Lopez, 1992; Edwards & Smith, 1996; Evans, 1989; Gilovich et al., 2002; Haselton, Nettle, & Andrews, 2005; Hogarth, 1980; Kahneman et al., 1982; Koriat, Lichtenstein, & Fischhoff, 1980; Kunda, 1990; Nickerson, 1998; Nisbett & Ross, 1980; Tversky & Kahneman, 1974; Zhaoping & Guyader, 2007). The criminal justice system, for example, has in many ways adopted and taken on board these and other cognitive and psychological findings to improve investigations (e.g., Ask & Granhag, 2005; Risinger & Loop, 2002; Stelfox & Pease, 2005). A clear case is the way in which line-ups are conducted. Rather than biasing eyewitnesses by presenting them with the suspect (the target), eyewitnesses are presented with a range of targets that include the suspect as well as numerous decoys. The line-up procedures have been drastically improved by taking into account issues of bias and other cognitive and psychological influences (e.g., Charman & Wells, 2006; Turtle, Lindsay, & Wells, 2003; Wells & Olson, 2003). In this chapter we present cognitive theory and bridge it to practical situations in the real world of investigations. Of course, within the scope of this chapter we can only bring examples, as illustrations, to convey the complex issues at hand.

Initial Impressions and Accountability

Research indicates that early impressions have considerable influence on our final evaluations. Indeed, it is common for people to maintain preexisting beliefs despite dissonant or even contradictory evidence. Nisbett and Ross (1980) describe the phenomenon as *belief perseverance*. It has been demonstrated in many areas, including problem solving (Luchins, 1942), and attitudes to change, as well as stereotype perseverance (Allport, 1954; Hamilton, 1979). Tetlock (1983) provides an example of one such study. In his experiment, participants viewed evidence from a criminal case and then assessed the guilt of a defendant. The information provided was identical in content; however, the order of the presented information was manipulated between participants. The results showed that the participants who were given the prosecution evidence first were more likely to find the defendant guilty than the participants who were given the evidence for defense first. Interestingly, this effect disappeared when participants were initially told that they were expected to justify their decision or that they would be held accountable for their decision. However, if the participants were shown the information and were only told afterward that they would have to justify their decision, then the order effect persisted. This suggests that our judgments are strongly influenced by initial information. Furthermore, influences and effects prior to information collection appear to strongly affect the way the information is perceived and interpreted, and hence how it

is remembered and judged. All of this is further influenced by issues of accountability.

During the early 1990s, it was generally considered that the police were immune from their actions when they were engaged in the detection and suppression of crime. Indeed, in the case of *Hill v. Chief Constable of West Yorkshire* (1989), the mother of one of the victims of the Yorkshire Ripper sought damages in response to the police's failure to apprehend Peter Sutcliffe prior to the murder of her daughter. The House of Lords found that no duty of care arose where there is no special relationship between the victim of crime and the police, and as a result there is no liability in negligence. Moreover, it was considered dangerous as it diverted police resources from fighting crime. However, the cost of error has been shown to increase accuracy in judgment and reduce the effect of biasing factors such as order effects, ethnic stereotyping, and anchoring (Freund, Kruglanski, & Shpitzajzen, 1985; Kruglanski & Freund, 1983). However, it also increases deliberation time (McAllister, Mitchell, & Beach, 1979). Indeed, Kunda (1990) argues that accuracy is a product of deeper processing, resulting from accuracy motives that affect the initial encoding and processing of information. Tetlock (1983, 1985) showed that accuracy-promoting manipulations reduce bias when they are delivered before information presentation, but not after.

Time pressures can increase biasing effects (Freund et al., 1985; Kruglanski & Freund, 1983), perhaps because information selectivity is higher and decision criteria thresholds are lower (Dror, Busemeyer, & Basola, 1999). Although accuracy motivation through accountability appears to increase the quality of decision making, in several studies the biases are not entirely eliminated (Fischhoff, 1977; Kahneman & Tversky 1972; Lord, Lepper, & Preston, 1984; Tversky & Kahneman, 1973). These, as well as other biasing countermeasures, most often reduce and minimize bias but do not eliminate it altogether. Accountability plays a major role in a variety of domains that rely on perception, judgment, and decision making, for example, in the perception of risk and the decision to use force by police (Dror, 2008). In sum, it appears that initial impressions and preconceptions can bias our perception and judgment, which can be detrimental to achieving high-quality, evidence-based decisions. This problem can be reduced by accountability and the cost of error; however, it is never entirely eliminated, and time pressure in particular has a detrimental effect on the ability to ignore biasing factors. It is important to note that these biasing effects are examples of honest mistakes brought about by our cognitive build, which affect us all and are not representative of a conscious, malicious desire to draw one conclusion over another. On the contrary, many times the motivation to "help" and solve a case, to "do justice," clouds our judgments and our ability to reach objective conclusions.

Confirmation Bias

The tendency to confirm an initial theory or preconception and avoid disconfirming information is known as confirmation bias. An example of this is demonstrated by Wason's (1960) selection task. Participants were given a three-number sequence that followed a certain rule. They were required to deduce this rule by proposing potential sequences. They were then given feedback as to whether their proposed sequences followed the rule. The rule was simply "any ascending sequence," yet the rules suggested by participants were generally far more complex. Participants appeared to formulate a potential rule and then only generate sequences that conformed to their rule. If enough sequences were accepted, then the theory would be accepted. Surprisingly, participants tended not to try to falsify their theories.

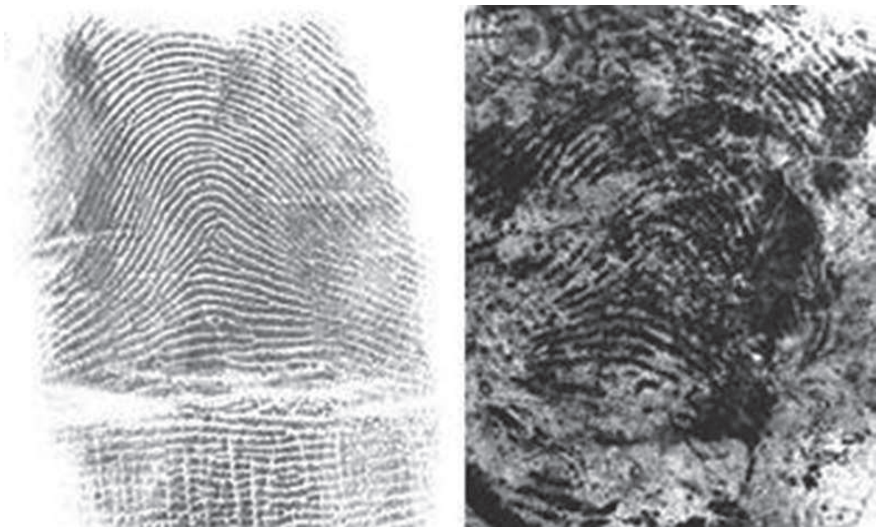
This phenomenon has also been observed in other areas. We often appear to prefer information that is biased toward previously held beliefs, desired outcomes, or expectations (Jonas, Schulz-Hardt, Frey, & Thelen, 2001) or appear to support our expectations in negotiations (Pinkley, Griffith, & Northcraft, 1995), our outlooks and attitudes (Lundgren & Prislin, 1998), our self-serving conclusions (Frey, 1981), or our social stereotypes (Johnston, 1996). Our mind does not seem to be designed to optimize and find the perfect solution to any given problem. Instead, it merely aims to feel sufficiently satisfied with a solution (Simon, 1956, 1982). Therefore, decision makers have a criterion level, a threshold that must be met before a conclusion can be reached. Once this threshold has been reached, it is a *winner takes all* process in which a final and decisive decision is reached (Dror et al., 1999). Investigators will search for and process information until this threshold is reached (Busemeyer & Townsend, 1993; Nosofsky & Palmeri, 1997; Ratcliff & Smith, 2004). Moreover, decision factors such as time pressure can influence this threshold level (Dror et al., 1999).

In the investigative process this means that once a conclusion is reached—for example, who committed the crime—it is cognitively adopted. Additional information is then gathered to confirm the decision (for example, build the best case possible against the person believed to have perpetrated the crime). At this stage, all information is weighted in a biasing context, which means, for example, that information proving the innocence of the person may be ignored or explained away. This is in addition to the problem that the initial determination can be biased because of preconceptions, initial theory, contextual evidence, or even just a hunch. It is quite possible for the initial theory to only be corroborated by confirmatory investigative search patterns and never be truly challenged. This chain of cognitive influences may render the investigative conclusions questionable, if not altogether unreliable.

Forensic Examination: We See What We Expect to See

Interestingly, initial information affects how we perceive visual information as well as facts and figures. Bruner and Potter (1964) provided participants with blurred images that were gradually brought into focus. If the image was initially extremely blurry, it was harder for participants to finally identify the image, even when it was fully brought into focus, than if it began less blurry. People who use weak evidence to form initial hypotheses have difficulty correctly interpreting subsequent, more detailed, information. This has implications for a wide range of forensic evidence, such as fingerprints and closed-circuit television images, where initial information can be of low quality. Top-down processing uses past knowledge, current emotional state, and/or expectations to facilitate perception and judgment, resulting in faster but more subjective impressions. An example of this is waiting for a friend in a crowd and mistaking a stranger for the friend. In this case, our expectations cause us to interpret visual information in a certain way, and what we see conforms to our expectations. Dror and Rosenthal (2008) established that expert forensic examiners can have their judgments biased by extraneous contextual information (see also Dror & Charlton, 2006; Dror, Charlton, & Peron, 2006; Dror, Peron, Hind, & Charlton, 2005). In a number of studies, fingerprint experts were asked to compare prints that had been presented in a biased context. The circumstance affected their judgments, resulting in most of the examiners reaching differing conclusions on identical prints that had been presented within differing contexts. The visual information was processed in a way that conformed to their expectations.

These effects were not due to the experts having varying philosophies, training, or procedures because the conflicting conclusions were reached by the same experts on the same prints; the only difference was the context in which the prints were presented. Indeed, such biases occurred in the investigation of the 2004 Madrid train bombings. Brandon Mayfield's fingerprints were alleged to have been identified against those found on a bag of detonators found in Spain. A senior fingerprint expert from the FBI matched the latent print from the crime scene to Mayfield, who was a Muslim convert and had a military background (see Figure 5.1). The identification was further verified by two additional senior FBI fingerprint experts. Even an independent expert appointed by the court on behalf of the defense matched the print to Mayfield. All experts concluded with 100% certainty that the latent print was Mayfield's (see Stacey, 2004). After the incorrect identification was exposed by coincidence, the FBI's report on this error, as well as a report by the U.S. Department of Justice's Office of the Inspector General, concluded that circular reasoning and confirmation bias played a role in the erroneous identification.



(A) (B)

Figure 5.1 Print A on the left belongs to Brandon Mayfield. Print B on the right was found at the crime scene.

Motivation is another element that can introduce bias. Charlton, Dror, and Fraser-Mackenzie (2008) highlighted the potential of motivational bias in a study in which they interviewed forensic examiners to explore motivational and emotional experiences in routine and high-profile cases. Examiners reported a heightened emotional state both during the search for and on the finding of a match, especially during serious and high-profile cases. For example: "that [the feeling] was, that was great, I mean, to be involved in such a high profile case and finally get a match" and "oh it's a buzz. It's a definite buzz. … When you get one, especially from the search, the buzz is there" (Charlton et al., 2008).

The research suggests that this could quite possibly have contributed to the erroneous matching of Brandon Mayfield's prints. Such failures may be more likely in serious, high-profile cases than in high-volume, day-to-day crimes. Moreover, such crimes carry the heaviest penalties and thus the greatest cost of making an error. Indeed, the Menezes Case highlights this precise point.

The Menezes Case: Context Can Kill

On July 22, 2005, Jean Charles de Menezes, an innocent man, was shot dead at Stockwell Station on the London Underground because he was incorrectly

(A) (B)

Figure 5.2 Photograph A on the left is of Jean Charles de Menezes. Photograph B on the right is of Hussain Osman.

identified as a suicide bomber (see Figure 5.2). His housing complex was under police surveillance because Hussain Osman, suspected of being a potential suicide bomber, lived there. As Menezes left his home, he was followed by police officers who thought he may be their suspect, Osman. Menezes took a bus to a tube station, where he was observed getting off the bus and then getting on another bus. The surveillance team interpreted his actions as an attempt to lose them, when in fact he was going to another tube station only because this one was closed. At Stockwell Station, he boarded a train that had pulled up to the platform. Officers were convinced that he was a suicide bomber and shot him numerous times.

Initial contextual information suggested that Menezes could be the terror suspect. Subsequent neutral information and even disconfirming information was present but appears to have been processed incorrectly. Furthermore, the potential threat of a suicide bombing on a crowded Underground would have induced stress and time pressure. Stressors such as time pressure can affect our decision-making threshold (Dror et al., 1999) as well as increase the biasing effect of erroneous initial information (Freund et al., 1985; Kruglanski & Freund, 1983). Many people will be surprised to learn such mistakes can happen; however, for cognitive experts, it is clear why such errors are made, especially when police officers do not receive proper training on cognitive issues.

The Presentation of Evidence and Emotional Effects

Due to the importance of information context and framing, it follows that the presentation of evidence is vital. The impression of forensic evidence is that it is infallible, scientifically proven, undeniable truth. It therefore has considerable impact on judges and juries. For instance, Sir Roy Meadow's evidence in the Sally Clark sudden infant death case suggested that the chance of Sally Clark having two sudden infant deaths in the family was one in 73 million (see Chapter 4). The probability of a sudden infant death is 1 in 8,543, and Meadows simply squared this value to calculate the probability of two sudden infant deaths in the same household. Statistically, however, this would only be valid if both cases were independent of each other. The findings of a sudden infant death gene rendered the evidence invalid. Nevertheless, the expert evidence had great impact on the case. Forensic evidence in particular is seen under this golden halo effect when in reality "there can be genuine disagreement between forensic scientists just as there can be disagreement between nuclear physicists or art historians" (Roberts & Willmore, 1993).

The presentation of erroneous information not only biases judgments, but seemingly innocuous changes in the way evidence is presented during a trial can have dramatic outcomes on the verdict. For example, descriptions of a psychiatric patient might affect expert forensic psychologist's and psychiatrist's evaluations of whether the patient should be released from a hospital. These descriptions can either be given in frequency terms (e.g., "of every 100 patients similar to Mr. Jones, ten are estimated to commit an act of violence to others") or in statistical terms (e.g., "patients similar to Mr. Jones are estimated to have a 10% chance of committing an act of violence to others"). Research revealed that clinicians who were given such information in frequency terms labeled the patient as being more dangerous than when the same information was presented in statistical terms (Slovic, Monahan, & MacGregor, 2000). Thus, it appears as though alternative ways in which information can be represented, which have no logical or numerical difference, can result in different judgments. This suggests that in some cases, and perhaps more than we are aware, it is not the information itself that is important as much as how it is packaged and processed by the human cognitive system.

An important determinant of how we package information is our emotional state. Research has suggested that the interpretation and selection of information can be greatly influenced by affect. For example, the processing of facial expressions corresponds to the emotional state of the perceiver (Niedenthal, Halberstandt, Margolin, & Innes-ker, 2000; Shiffenbauer, 1974). Even lexically ambiguous sounds are interpreted in a way that conforms to the person's own emotional state (Pincus, Pearce, & Perrott, 1996). This

demonstrates that a person's internal context affects how information is perceived and judged, as well as the decision making that follows.

Research by Zajonc (1980, 1984a, 1984b), Bargh (1984), and LeDoux (1996) shows that affective reactions to stimuli are often more basic than cognitive evaluations (Loewenstein, Weber, Hsee, & Welch, 2001). However, these very processes can be responsible for the erroneous processing of information. Therefore, the emotional context of an investigation could potentially influence the processing of evidence and investigative decision making.

Logic versus Believability

Despite all the research described above, it might still be argued that we can use logical reasoning to override such cognitive and psychological biases. For example, investigators could be made aware of these issues and be asked to keep an open mind, listen only to the facts, free themselves from bias, prejudice, and sympathy, and remain uninfluenced by preconceived ideas and extraneous information. Unfortunately, even logical reasoning is not immune to psychological effects. Evans, Barston, and Pollard (1983) attempted to compare directly the extent to which context and past knowledge interfere with logical thought in simple reasoning tasks. In their experiment, they gave participants statements and conclusions that were either believable or unbelievable and either valid or invalid by logic and reasoning. Participants were asked to decide whether they agreed with the conclusions, using only strict logic and reasoning. Table 5.1 shows how participants were more inclined to support believable conclusions and ignore logic and reasoning.

Table 5.1 Evidence of Belief Bias in Syllogisms with Percentage of Acceptance of Conclusions as Valid

Conclusion	Acceptance
Logically Valid and Believable	89%
Logically Valid but Unbelievable	56%
Logically Invalid but Believable	71%
Logically Invalid and Unbelievable	10%

Source: Evans, Barston, & Pollard, 1983.

It appears that people use past experience more so than logic and rationality to guide their decision making. These systematic deviations from logic are unavoidable cognitive performance restrictions and errors (Johnson-Laird & Byrne, 1991; Kahneman et al., 1982; Oaksford, & Chater, 2001; Rips, 1994). People avoid cognitively taxing processes, preferring the faster and less cognitively involved process of relying on what is believable. Police often

encounter inaccurate information presented as fact, for example, conscious misdirection by a guilty party or erroneous evidence from a witness. Accordingly, to the investigator or examiner, the believability heuristic is forefront in their cognitive processing.

Concluding Thoughts

In this chapter, we discussed the influence of extraneous contextual information on data. Scientific research as well as actual cases (such as the Brandon Mayfield and Menezes incidents) have demonstrated time and again how cognitive bias can cause errors in real world situations. Our minds are not designed to optimize, and it is important to ensure that we have reached a correct conclusion instead of just adopting a "satisfactory" solution. Changes have already occurred in the investigative profession. Dixon (1999) found that detectives who arrest on a hunch or give weak cases "a run" have less status than those who collect conclusive evidence prior to making an arrest. However, many forensic examiners and police officers have not received proper training in cognitive biases, and appropriate procedures and best practices to deal with these issues are needed. Although it is impossible to avoid the influence of extraneous factors on our perception, judgment, and decision making, there is plenty of room to drastically reduce such biases (Dror, in press).

References

Allport, G. W. (1954). *The nature of prejudice*. Reading MA: Addison Wesley.

Ask, K., & Granhag, P. A. (2005). Motivational sources of confirmation bias in criminal investigations: The need for cognitive closure. *Journal of Investigative Psychology and Offender Profiling*, *2*, 43–63.

Balcetis, E., & Dunning, D. (2006). See what you want to see: Motivational influences on visual perception. *Journal of Personality and Social Psychology*, *91*, 612–625.

Bargh, J. A. (1984). Automatic and conscious processing of social information. In R. S. Wyer & T. K. Srull (Eds.), *Handbook of social cognition* (Vol. 3, pp. 1–43). Hillsdale, NJ: Erlbaum.

Bruner, J., & Potter, M. (1964). Inference in visual recognition, *Science*, *44*, 424–425.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: A dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review*, *100*, 432–459.

Charlton, D., Dror, I. E., & Fraser-Mackenzie, P. A. F. (2008). *A qualitative study investigating the emotional rewards and motivating factors associated with forensic fingerprint analysis*. Technical report, University of Southampton, School of Psychology, Southampton, UK.

Charman, S. D., & Wells, G. L. (2006). Applied lineup theory. In R. C. L. Lindsay, D. F. Ross, J. D. Read, & M. P. Toglia (Eds.), *Handbook of eyewitness psychology: Memory for people* (pp. 219–254). Mahwah, NJ: Lawrence Erlbaum.

Cordelia, F. (2006). *A mind of its own: How your brain distorts and deceives*. Cambridge, UK: Icon Books.

Ditto, P. H., & Lopez, D. F. (1992). Motivated skepticism: Use of differential decision criteria for preferred and nonpreferred conclusions. *Journal of Personality and Social Psychology*, *63*, 568–584.

Dixon, D. (1999). Police investigative procedures: Changing legal and political contexts of policing practices. In C. Walker & K. Starmer (Eds.), *Miscarriages of justice: A review of justice in error* (pp. 65–82). Oxford: Oxford University Press.

Dror, I. E. (2005). *Perception* is far from *perfection*: The role of the brain and mind in constructing realities. *Brain and Behavioural Sciences*, *28*, 763.

Dror, I. E. (2007). Land mines and gold mines in cognitive technologies. In I. E. Dror (Ed.), *Cognitive technologies and the pragmatics of cognition* (pp. 1–7). Amsterdam: John Benjamin Press.

Dror, I. E. (2008). Perception of risk and decision to use force. *Policing*, *1*, 256–272.

Dror, I. E. (in press). How to manage cognitive biases. *Forensic sciences policy and management*.

Dror, I. E., Busemeyer, J. R., & Basola, B. (1999). Decision making under time pressure: An independent test of sequential sampling models. *Memory and Cognition*, *27*, 713–725.

Dror, I. E., & Charlton, D. (2006). Why experts make errors. *Journal of Forensic Identification*, *56*, 600–616.

Dror, I. E., Charlton, D., & Peron, A. (2006). Contextual information renders experts vulnerable to making erroneous identifications. *Forensic Science International*, *156*, 74–78.

Dror, I. E., Peron, A., Hind, S., & Charlton, D. (2005). When emotions get the better of us: The effect of contextual top-down processing on matching fingerprints. *Applied Cognitive Psychology*, *19*, 799–809.

Dror, I. E., & Rosenthal, R. (2008). Meta-analytically quantifying the reliability and biasability of forensic experts. *Journal of Forensic Sciences*, *53*, 900–903.

Dror, I. E., & Thomas, R. D. (2005). The cognitive neuroscience laboratory: A framework for the science of the mind. In C. Erneling & D. Johnson (Eds.), *The mind as a scientific object: Between brain and culture* (pp. 283–292). Oxford: Oxford University Press.

Edwards, K., & Smith, E. E. (1996). A disconfirmation bias in the evaluation of arguments. *Journal of Personality and Social Psychology*, *71*, 5–24.

Evans, J. St. B. T. (1989). *Bias in human reasoning: Causes and consequences*. Hillsdale, NJ: Erlbaum.

Evans, J. St. B. T., Barston, J. L., & Pollard, P. (1983). On the conflict between logic and belief in syllogistic reasoning. *Memory and Cognition*, *11*, 295–306.

Fischhoff, B. (1977). Perceived informativeness of facts. *Journal of Experimental Psychology: Human Perception and Performance*, *3*, 349–358.

Freund, T., Kruglanski, A. W., & Shpitzajzen, A. (1985). The freezing and unfreezing of impressional primacy: Effects of the need for structure and the fear of invalidity. *Personality and Social Psychology Bulletin*, *11*, 479–487.

Frey, D. (1981). The effect of negative feedback about oneself and the cost of information on preferences for information about the source of this feedback. *Journal of Experimental Social Psychology*, *17*, 42–50.

Gilovich, T., Griffin, D., & Kahneman, D. (2002). *Heuristics and biases: The psychology of intuitive judgment*. New York: Cambridge University Press.

Hamilton, D. L. (1979). A cognitive attributional analysis of stereotyping. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 12, pp. 53–84). New York: Academic Press.

Haselton, M. G., Nettle, D., & Andrews, P. W. (2005). The evolution of cognitive bias. In D. M. Buss (Ed.), *Handbook of evolutionary psychology* (pp. 724–746). Hoboken, NJ: Wiley.

Hill v. Chief Constable of West Yorkshire (1989) 1 AC 53.

Hogarth, R. (1980). *Judgement and choice*. New York: John Wiley.

Humphreys, G. W., Riddoch, M. J., & Price, C. J. (1997). Top-down processes in object identification: Evidence from experimental psychology, neuropsychology, and functional anatomy. *Philosophical Transactions of the Royal Society, London*, *352*, 1275–1282.

Johnson-Laird, P. N., & Byrne, R. M. J. (1991). *Deduction*. Hillsdale, NJ: Erlbaum.

Johnston, L. (1996). Resisting change: Information-seeking and stereotype change. *European Journal of Social Psychology*, *26*, 799–825.

Jonas, E., Schulz-Hardt, S., Frey, D., & Thelen, N. (2001). Confirmation bias in sequential information search after preliminary decisions: An expansion of dissonance theoretical research on "selective exposure to information." *Journal of Personality and Social Psychology*, *80*, 557–571.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge: Cambridge University Press.

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. *Cognitive Psychology*, *3*, 430–454.

Koriat, A., Lichtenstein, S., & Fischhoff, B. (1980). Reasons for confidence. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 107–118.

Kosslyn, S. M., & Koenig, O. (1995). *Wet mind: The new cognitive neuroscience*. New York: Free Press.

Kruglanski, A. W., & Freund, T. (1983). The freezing and unfreezing of lay-inferences: Effects on impressional primacy, ethnic stereotyping, and numerical anchoring. *Journal of Experimental Social Psychology*, *19*, 448–468.

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, *108*, 480–498.

LeDoux, J. (1996). *The emotional brain*. New York: Simon and Schuster.

Lindsay, P. H., & Norman, D. A. (1977). *Human information processing*. New York: Academic Press.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, E. S. (2001). Risk as feelings. *Psychological Bulletin*, *127*, 267–286.

Lord, C. G., Lepper, M. R., & Preston, E. (1984). Considering the opposite: A corrective strategy for social judgment. *Journal of Personality and Social Psychology*, *47*, 1231–1243.

Luchins, A. S. (1942). Mechanisation in problem solving: The effect of Einstellung. *Psychological Monographs*, *54*, 1–95.

Lundgren, S. R., & Prislin, R. (1998). Motivated cognitive processing and attitude change. *Personality and Social Psychology Bulletin*, *24*, 715–726.
Marr, D. (1982). *Vision*. New York: W. H. Freeman.
McAllister, D. W., Mitchell, T. R., & Beach, L. R. (1979). The contingency model for the selection of decision strategies: An empirical test of the effects of significance, accountability, and reversibility. *Organizational Behavior and Human Performance*, *24*, 228–244.
McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review, 88,* 375–407.
Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology*, *2*, 175–220.
Niedenthal, P. M., Halberstandt, J. B., Margolin, J., & Innes-ker, A. H. (2000). Emotional state and the detection of change in facial expressions of emotion. *European Journal of Social Psychology*, *30*, 211–222.
Nisbett, R. E., & Ross, L. D. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.
Nosofsky, R. M., & Palmeri, T. J. (1997). An exemplar based random walk model of speeded classification. *Psychological Review*, *104*, 266–300.
Oaksford, M., & Chater, N. (2001). The probabilistic approach to human reasoning. *Trends in Cognitive Sciences*, *5*, 349–357.
Pincus, T., Pearce, S., & Perrott, A. (1996). Pain patients' bias in the interpretation of ambiguous homophones. *British Journal of Medical Psychology*, *69*, 259–266.
Pinkley, R. L., Griffith, T. L., & Northcraft, G. B. (1995). "Fixed pie" a la mode: Information availability, information processing, and the negotiation of suboptimal agreements. *Organizational Behavior and Human Decision Processes*, *62*, 101–112.
Ratcliff, R., & Smith, P. L. (2004). A comparison of sequential sampling models for two-choice reaction time. *Psychological Review*, *111*, 333–367.
Rips, L. (1994). *The psychology of proof*. Cambridge, MA: MIT Press.
Risinger, D. M., & Loop, J. L. (2002). Three card monte, Monty Hall, *modus operandi* and "offender profiling": Some lessons of modern cognitive science for the law of evidence. *Cardozo Law Review*, *24*, 193–285.
Roberts, P., & Willmore, C. (1993). The role of forensic science evidence in criminal proceedings. *Royal Commission on Criminal Justice Research, Study No 11*. London: HMSO.
Rumelhart, D. E., & McClelland, J. L. (1986). *Parallel distributed processing: Explorations in the microstructure of cognition*. Cambridge, MA: MIT Press.
Shiffenbauer, A. (1974). Effect of observer's emotional state on judgments of the emotional state of others. *Journal of Personality and Social Psychology*, *30*, 31–35.
Simon, H. A. (1956). Rational choice and the structure of the environment. *Psychological Review*, *63*, 129–138.
Simon, H. A. (1982). *Models of bounded rationality*. Cambridge, MA: MIT Press.
Slovic, P., Monahan, J., & MacGregor, D. G. (2000). Violence risk assessment and risk communication: The effects of using actual cases, providing instruction, and employing probability versus frequency formats. *Law and Human Behavior*, *24*, 271–296.

Stacey R. B. (2004). Report on the erroneous fingerprint individualization in the Madrid train bombing case. *Journal of Forensic Identification*, *54*, 706–718.
Stelfox, P., & Pease, K. (2005). Cognition and detection: Reluctant bedfellows? In M. J. Smith & N. Tilley (Eds.), *Crime science: New approaches to preventing and detecting crime* (pp. 191–207). Cullompton, Devon: Willan.
Tetlock, P. E. (1983). Accountability and the perseverance of first impressions. *Social Psychology Quarterly*, *46*, 285–292.
Tetlock, P. E. (1985). Accountability: A social check on the fundamental attribution error. *Social Psychology Quarterly*, *48*, 227–236.
Turtle, J. W., Lindsay, R. C. L., & Wells, G. L. (2003). Best practice recommendations for eyewitness evidence procedures: New ideas for the oldest way to solve a case. *Canadian Journal of Police and Security Services*, *1*, 5–18.
Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, *5*, 207–232.
Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*, 1124–1131.
Wason, P. C. (1960). On the failure to eliminate hypotheses in a conceptual task. *Quarterly Journal of Experimental Psychology*, *12*, 129–140.
Wells, G. L., & Olson, E. (2003). Eyewitness identification. *Annual Review of Psychology*, *54*, 277–295.
Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inference. *American Psychologist*, *35*, 151–175.
Zajonc, R. B. (1984a). The interaction of affect and cognition. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 239–246). Hillsdale, NJ: Erlbaum.
Zajonc, R. B. (1984b). On primacy of affect. In K. R. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 259–270). Hillsdale, NJ: Erlbaum.
Zhaoping, L., & Guyader, N. (2007). Interference with bottom-up feature detection by higher-level object recognition. *Current Biology*, *17*, 26–31.