The Science of Decision Making – Improving Decision Quality

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The science of decision-making spans a range of disciplines including neurophysiology, neuroimaging, computational modelling, psychiatry, psychology, neuropsychology, economics and more recently neuroeconomics. Each discipline, which draws on distinct approaches and methods, seeks to understand the underlying processes that are required for effective decision making and identify the factors that influence these processes. Whilst the majority of the early neurophysiological and neuroimaging experimental studies were carried out on the animal brain, recent advances in functional magnetic resonance (fMRI) has provided the mechanism to trace the dynamics of unfolding decision-making processes. Advances in electronencephalography and magnetoencephalography also allow researchers to map the neural time course of decision making with millisecond precision.[1] These experiments are necessarily reductive, exploring the influence of a small number of simplified parameters. The data are extended with mathematical models of decision making which start to link the functional areas of the brain with choice behaviour.[2] The addition of computational modelling and psychological studies provide a deeper understanding of the complexity of the psychological processes that underpin simple decision making. It is important to recognise, from the outset, that arbitrators are not making binary decisions with simple parameters.

When we consider arbitration decisions, the process is typically viewed through the outcome and characterised as a choice between outcomes. But arbitration decision making is not a single decision, it is a systematic (and sometimes less systematic) complex process of a series of choices.[3] Each

[1] Harris, A., & Hutcheson, C.A. (2022). Temporal dynamics of decision making: A synthesis of computations and neurophysiological approaches. Wil*ey Interdisciplinary Review of Cognitive Science* 13 (3) 1586.

[2] For example, Farrar, D. C., Mian, A. Z., Budson, A. E., Moss, M. B., & Killiany, R. J. (2018). Functional brain networks involved in decision-making under certain and uncertain conditions. *Neuroradiology*, *60*, 61-69; Forstmann, B.U., Ratcliff, R., Wagenmakers, E.J. (2016). Sequential sampling models in cognitive neuroscience: Advantages, applications, and extensions. *Annual review of psychology*, *67*, 641-666; Turner, B. M., Van Maanen, L., & Forstmann, B. U. (2015). Informing cognitive abstractions through neuroimaging: the neural drift diffusion model. *Psychological review*, *122*(2), 312; Basten, U., Biele, G., Heekeren, H. R., & Fiebach, C. J. (2010). How the brain integrates costs and benefits during decision making. *Proceedings of the National Academy of Sciences*, *107*(50), 21767-21772.

[3] Howard and Seth demonstrate the even the simplest decisions 'buying a car' is a process and a systematic series of choices. Howard, J. A., & Sheth, J. N. (1969). The theory of buyer behaviour. *New York*, *63*, 145.

determination shapes the choice architecture for the decisions that follow. Some of these decisions are quick, simple, and routine. Others have an element of uncertainty. Both have the potential to mediate bias. Bias in a legal context is typically conceptualised as negative bias, bias directed against those who are marginalised in society or traditionally disadvantaged. In the context of arbitration, academic debates of bias are concerned with bias towards parties or positions.[4] These are important and worthy of discussion and debate, but this paper is concerned with bias in a psychological context. In this context, bias is a predisposition to a particular choice. It is not unacceptable; it is a normal and inevitable aspect of decision making. In effective decision making, bias is moderated and modified by reasoning. However, if acceptable bias is resistant to or not exposed to moderation, it could potentially predetermine the decision and thus become unacceptable. As such, if we understand the processes and factors that influence decision making, we can use that knowledge to create structures to improve decision quality and limit the influences that could potentially predetermine our decisions.

1. Brain physiology and decision making

Early studies of brain function identified a relationship between the prefrontal cortex and executive decision making, with human patients who had damage to the prefrontal cortex exhibiting poor judgment, planning and decision making.[5] This association with reasoning and the pre-frontal cortex was confirmed by fMRI studies which map the brain's decision-making circuitry. Using simple choices, the studies extended the location of decision making to several different areas of the brain including the dorsolateral prefrontal cortex (memory and cognitive control), the right insula (associated with risk reward behaviour), and the anterior cingulate cortex (error processing).[6] Decision making is not limited to the reasoning and executive decision-making areas of the brain. The limbic system (including the amygdala, basal ganglia, and cerebellum) is also involved. Even in the simplest of decisions the

[4] See for example, Donaubauer, J., Neumayer, E., & Nunnenkamp, P. (2018). Winning or losing in investor-to-state dispute resolution: the role of arbitrator bias and experience. *Review of international economics*, *26*(4), 892-916; Puig, S., & Strezhnev, A. (2017). Affiliation bias in arbitration: an experimental approach. *The Journal of Legal Studies*, *46*(2), 371-398; Brekoulakis, S. (2013). Systemic bias and the institution of international arbitration: a new approach to arbitral decision-making. *Journal of international dispute settlement*, *4*(3), 553-583; Luttrell, S. (2009). *Bias Challenges in International Commercial Arbitration: The Need for a 'real Danger' Test* (Vol. 20). Kluwer Law International BV.

[5] See for example, Mesulam, M-Marsel. "The human frontal lobes: Transcending the default mode through contingent encoding." *Principles of frontal lobe function* 54 (2002): 8-30. Stuss, Fuster, J. (2015). *The prefrontal cortex*. Academic press; Goldman-Rakic, Patricia S. "Development of cortical circuitry and cognitive function." Child development (1987): 601-62; D. T, and Benson, D. F. (1986). The Frontal Lobes. Raven Press, New York.

[6] For example, Liu, T., & Pleskac, T. J. (2011). Neural correlates of evidence accumulation in a perceptual decision task. *Journal of neurophysiology*, *106*(5), 2383-2398; Ho, S. S., Gonzalez, R. D., Abelson, J. L., & Liberzon, I. (2012). Neurocircuits underlying cognition–emotion interaction in a social decision-making context. *NeuroImage*, *63*(2), 843-857.

limbic system - the system associated with motivation, emotion, and memory - is activated.[7] Whilst distinct areas of the brain, these do not operate independently, and the complex system of networking transmits signals rapidly from one area of the brain to another in less than 300ms. It takes one fifth of a second for a signal from the right side of the brain to move to the left side, and a simple decision can be made in less than a second.[8] When the decision-making moves from a simple decision with a clear and certain outcome, to a decision with a level of uncertainty, the level of activation of all systems increases.[9] The activation process is even more complex when we move from individual to group decision making and where negotiation and trade interactions are uncertain.[10]

2. Decision making and cognitive psychology.

Cognitive psychology moves from the physiology of the brain, to the processes from activation and action in decision making. The two systems model (system 1 and system 2) of judgement and decision making was brought to popular attention by Daniel Kahneman and Amos Tversky.[11] Both systems are a collection of processes which are distinguished by their speed and controllability. System 1 is intuitive, occurs spontaneously and does not require a high level of cognition. It is in this stage of the process that prior beliefs and heuristics (mental short cuts) are generally thought to have the most influence. System 2 is slow, data rich, deliberative high-level reasoning which requires effort, concentration, and the execution of rules. This is the form of reasoning often described as 'logic', traditionally associated with legal decision making. Whilst some suggest that there are distinct areas of brain stimulation associated with each system, it is generally agreed that the processes do not work

[7] Please note the limbic system singular is used here for simplicity. There is an argument that the limbic system consists of several distinct systems see Rolls, E. T. (2015). Limbic systems for emotion and for memory, but no single limbic system. *cortex*, *62*, 119-157.

[8] This speed is related to the drift diffusion model (DDM) which only applies to simply binary decisions and not the complex reasoning associated with judgment. For a review of the DDM see Myers C, Iterian A, Moustafa AA (2022) A practical introduction to using the drift diffusion model of decision-making in cognitive psychology, neurosciences and health sciences. Frontiers of Psychology 13, 1039172.

[9] Gloy, K., Herrmann, M., & Fehr, T. (2020). Decision making under uncertainty in a quasi-realistic binary decision task–An fMRI study. *Brain and Cognition*, *140*, 105549.

[10] The studies demonstrate the complex cognitive and emotional processes which interact, activating areas of the brain including the anterior insula, ventral striatum and lateral orbitofrontal cortex – parts of the brain which are known to act in emotional self-regulation and reward processing related to subjective emotion and motivation and brain processes related to evaluation of incentives. Hollmann, M., Rieger, J. W., Baecke, S., Lützkendorf, R., Müller, C., Adolf, D., & Bernarding, J. (2011). Predicting decisions in human social interactions using real-time fMRI and pattern classification. *PLoS One*, *6*(10), e25304.

[11] Tversky, A., & Kahneman D."Rational choice and the framing of decisions." *Decision making: Descriptive, normative, and prescriptive interactions* (1988): 167-192; Kahneman, D., & Tversky, A. Choices, values, and frames. *American psychologist* 39.4 (1984): 341; Kahneman, D., & Tversky A. The psychology of preferences. *Scientific American* 246.1 (1982): 160-173.

in isolation.[12] System 1 provides the instinctive initial response to the choice context and this response is moderated by the system 2 deliberative reasoning. The systems are integrated and mutually supportive and continuously interact throughout the decision-making process. Whilst little is known about the processes of arbitration decision making, modern theories of judicial decision making suggest that judges rely on both intuition and reasoning to reach a decision. Judges initially have a gut reaction, a system 1 response, as to what is 'right' or 'fair' in reaction to the stimulus of the case and legal arguments. The instinct can be affirmed, over-ruled, or adjusted by 'logic', system 2 reasoning. This theory is supported by the work of several authors who posit that even expert decision makers initially make intuitive judgements (system 1) which they might or might not over-ride with deliberation (system 2).[13] Indeed, Kahneman and Frederick suggest that the intuitive judgement is expressed overtly only if it is endorsed by system 2 as 'system 1 quickly proposes intuitive answers to judgement problems as they arise, and system 2 monitors the quality of these proposals which it may endorse, correct or override.' [14]

There are several aspects of the system 1 response which act as initial biases in the decision-making processes, many are mediated through heuristics. Parsimony, minimising energy expenditure, is a guiding principle of the physiology the brain. As such, the brain uses mental shortcuts as tools to reach decisions. These mental shortcuts are detailed elsewhere, but for completeness it is important to highlight some of those heuristics that have been identified as a facet of experimental judicial decision making.[15] In 2001, Guthrie, Rachlinski and Wistrich identified that judges were as susceptible to certain heuristics as lay decision makers. [16]

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[12] See for example De Neys, W., & Goel, V. (2011). Heuristics and biases in the brain: Dual neural pathways for decision making. In *Neuroscience of decision making* (pp. 125-141). Psychology Press; Sanfey, A. G., & Chang, L. J. (2008). Multiple systems in decision making. *Annals of the new York Academy of Sciences*, *1128*(1), 53-62.

[13] Frederick, P. D., Nelson, H. D., Carney, P. A., Brunye, T. T., Allison, K. H., Weaver, D. L., & Elmore, J. G. (2017). The influence of disease severity of preceding clinical cases on pathologists' medical decision making. *Medical Decision Making*, *37*(1), 91-100; Nakhaeizadeh, S., Dror, I. E., & Morgan, R. M. (2015). The emergence of cognitive bias in forensic science and criminal investigations. *Brit. J. Am. Legal Stud.*, *4*, 527; Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise: a failure to disagree. *American psychologist*, *64*(6), 515.

[14] Kahneman, D. & Frederick S. (2002) "Representativeness revisited: Attribute substitution in intuitive judgement" in T. Gilovich, D. Griffin and D. Kahneman (Eds) *Heuristics of Intuitive Judgment: Extensions and Applications*, New York: Cambridge University Press, page 51.

[15] For a review of heuristics see Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual review of psychology*, *62*, 451-482.

[16] See Guthrie, C., Rachlinski, J.J., & Wistrich A.J. (2001). Inside the Judicial Mind. *Cornell Law Review,* 86(4) 777. It is important to note that this study took place on judicial training day. Whilst a very different context to the courtroom, the authors argue that even in the highly constrained context of judicial decision-making heuristics will play a role. Arbitration decisions are not reached under the time constraints of many judicial decisions, but several studies demonstrate that in complex decisions with a level of uncertainty heuristics play a role.

Although, better than lay decision makers at limiting the effect of the anchoring heuristic, and framing heuristic, judges are equally susceptible to representative, hindsight, and egocentric heuristics. Both the representative and hindsight heuristic are engaged in a decision on probability or likelihood of an event. The representative heuristic bases the judgment on the extent to which the evidence is representative of the category. This subjective heuristic is based on the decision maker's prior knowledge and the conception of chance. The hindsight heuristic is the subjective shortcut which often leads to an overestimation of prediction of the past, and an overestimation of another's ability to predict an outcome of an action or decision. This is a result of the decision makers reflections on a known outcome. The final heuristic is that of egocentric bias. Like the other tools of decision-making, this heuristic is an estimate of probability, but rather than the probability of an event occurring, this centres on the probability of decision maker error. As with lay decision makers, judges are as susceptible to overestimate their own ability. In part, this is because of a lack of accurate comparator.

Although subjective, heuristics are sensible estimation procedures, they are not irrational and engage highly sophisticated mental processes including feature matching and memory retrieval. Heuristics offer an effective starting point in the decision-making process which can be moderated by system 2 reasoning facilitated by information, time, openness, and an opportunity to challenge the instinctive response. These studies do not suggest poor judicial decision making, rather they highlight the subjective nature of decision making and the humanity of the expert decision maker.

Influence of Values on Decision Making

Many of the heuristics are mental shortcuts, quick estimates, mediated by system 1 processes. Values are also mediated by heuristics but do not serve as a mental shortcut. In contrast, values serve as a filter through which a decision maker evaluates the choice. Values are a central facet of individual identity.[17] Over the last three decades, there has been an increasing body of psychological research that investigates the content and structure of values and how an individual's personal value priorities shape decision making.[18] Values in this context are defined as;

[17] Values underpin our personality, ideology, moral positioning see for example Anglim J., Knowles, E.R.V., Dunlop, P.D., Marty, A. (2017). HEXACO personality and Schwartz's personal values: A facet level of analysis. *Journal of Research in Personality* 23 – 31.

[18] See for example Rokeach, M. (1973). *The Nature of Human Values* (Free Press); Feather, N.T. (1995) . Values, Valences and Choice: The Influence of Values on the Perceived Attractiveness and Choice Alternatives. *Journal of Personality and Social Psychology,* 68, 1135; Maio, G.R., & Olson, J.M. (1998) Values as Truisms: Evidence and Implications. *Journal of Personality and Social Psychology*, 74, 294; Sagiv, L., & Schwartz, S.H., (2000). Value Priorities and Subjective Well-Being: Direct Relations and Congruity Effects. *European Journal of Social*

> [E]nduring beliefs that a specific mode of conduct is personally or socially preferable to an opposite or converse mode of conduct or end state of existence.[19]

This definition highlights one of the key characteristics of personal values, which is that values are tools of evaluation. They serve as the lens through which we view the world and the foundation for the evaluative decision of what is positive or desirable. The work of Schwartz suggests whilst value terms are numerous and granular, all conserved trans-situational abstract values can be encompassed into overarching motivations which are driven by three requirements; firstly the needs of individuals as biological organisms, secondly the requirements of coordinated social interaction and finally the requirements for the smooth functioning and survival of stable groups.[20] These motivations can be further divided into those that have an internal (impact on the individual) or external (impact on wider society) focus. Schwartz has provided a model of the overarching motivations which organises the values based on the motivational goal (Table 1). Individual decision makers may affirm all values, but in reaching a decision between one or more values a value or values will be prioritised, and it is this value hierarchy which is central to decision making. In an unconstrained choice, the decision maker will make a decision that aligns with the values that are situated higher up their personal value hierarchy.[21] This unique feature distinguishes values from other constructs of self (such as attitudes and traits).

Psychology 30, 177; Bardi, A., & Schwartz, S.H. (2003). Values and Behaviour: Strength and Structure of Relations. *Personality and Social Psychology Bulletin,* 29, 1207; Bernard, M.M., Maio , G.R., & Olson,J.M. (2003). The Vulnerability of Values to Attack: Inoculation of Values and Value-Relevant Attitudes. *Personality and Social Psychology Bulletin,* 29, 63; Maio, G. R., Pakizeh, A., Cheung, W. Y., & Rees, K. J. (2009). Changing, priming, and acting on values: effects via motivational relations in a circular model. *Journal of personality and social psychology*, *97*(4), 699.

[19] Rokeach, M. (1973). *The nature of human values*. New York, NY: Free Press.

[20] Schwartz, S.H. (1994). Are There Universal Aspects in the Structure and Content of Human Values? *Journal of Social Issues,* 50, 19, page 21

[21] Feather, N.T. (1995). Values, Valences and Choice: The Influence of Values on the Perceived Attractiveness and Choice Alternatives. *Journal of Personality and Social Psychology*, 68, 1135; Bardi, A., & Schwartz, S.H. (2003). Values and Behaviour: Strength and Structure of Relations. *Personality and Social Psychology Bulletin*, 29, 1207.

Table 1: Replicated and adapted table of 19 values defined by motivation from Schwartz *et al (*2012)[22]

Value	**Conceptual definitions in terms of motivational goals**
Focus on self	
Self-Direction • Thought • Action Stimulation Hedonism	Autonomy Freedom to develop one's own ideas and abilities. Freedom to determine one's own actions. Individual excitement, change, novelty. Pleasure, gratification.
Focus on self in society (close relationships (social, work, professional)	
Benevolence • Dependability • Caring Face Achievement Humility Security • Personal Conformity • Rules • Interpersonal	 Being a reliable and trustworthy member of the 'ingroup' Devotion to welfare of the 'ingroup' Maintaining public image, and associated power and security. Success based on social standards. Recognising one's insignificance in the wider world. Safety of one's environment, family, close community. Compliance with rules, law and formal obligations. Avoiding disrupting relationships.
Focus on wider society	
Security • Societal Tradition Universalism • Concern • Nature • Tolerance Power • Dominance • Resources	 Safety and stability of wider society. Maintaining and preserving traditions Commitment to equality, justice and protection of all people Preservation of the natural environment Acceptance of those who are different Power through control over others Power through control of material and resources.

This value prioritisation is observed in the judgments of cases which divided the UK Supreme Court. In these most difficult cases the decisions remain anchored in individual value priorities.[23] Indeed,

[22] Schwartz, S.H., Cieciuch, J., Vecchione, M., Davidov, E., Fischer, R., Beierlein, C., Ramos, A., Verkasalo, M., Lönnqvist, J.E., Demirutku, K. and Dirilen-Gumus, O. (2012). Refining the theory of basic individual values. *Journal of personality and social psychology*, *103*(4), p.663.

[23] Cahill-O'Callaghan, R. (2020) *Values in the Supreme Court: Decisions, Division and Diversity*. (Hart Publishing, UK)

Justices will reach decisions which align with a consistent set of values across a series of cases which divide judicial opinion.[24] This is not unexpected, or incorrect, again it is an inevitable facet of decision making when the evidence is complex and the outcome uncertain (two legally valid outcomes). Values are activated through the amygdala, [25] which is activated in the system 1 response, as such values are activated immediately and provide an anchor and a filter for system 2 reasoning. Values thus orientate mechanisms of decision making towards value priorities and subsequently guide information processing and judgment in system 2 processes. Once engaged, values are infused with positive or negative feeling.[26] The intensity of feeling is related to the importance of the value to the individual, with increased emotional intensity associated with a violation of an important value. Values are mediated through the affect response.

The affect response operates when you have an immediate positive or negative reaction to some idea, proposal, person, or argument. In social cognition theory, this is commonly known as the 'gut reaction' and sets up an initial orientation, positive or negative, in the decision maker toward the object.[27] The response occurs rapidly and automatically, typically without conscious thought. Whilst some decisions elicit strong emotions, the affect response in decision making is a constant 'faint whisper of emotion' but it is perhaps the animation of the activated value (s) with emotion which makes decisions which do not align with an individual's values most difficult.[28]

System 1 instinctive responses - a filter for system 2 reasoning

System 1 and system 2 processes are active concurrently. The automatic and controlled cognitive operations compete for the control of the explicit or overt response. This process between reasoning and the affect heuristic was aptly characterised by Finucane and others as 'the dance between affect

[24] Cahill-O'Callaghan, R., (2015). Winner of the SLS Annual Conference Best Paper Prize 2014: Reframing the judicial diversity debate: Personal values and tacit diversity. *Legal Studies,* 35(1), pp. 1-29.
[25] Chuang, Y. S., Su, Y. S., & Goh, J. O. S. (2020). Neural responses reveal associations between personal values and value-based decisions. *Social cognitive and affective neuroscience*, *15*(12), 1299–1309.
[26] Maio, G. R. (2010). "Mental representations of social values." In *Advances in experimental social psychology* (Vol. 42, pp. 1-43). Academic Press. Tamir, M., Schwartz, S. H., Cieciuch, J., Riediger, M., Torres, C., Scollon, C. & Vishkin, A. (2016). Desired emotions across cultures: A value-based account. *Journal of personality and social psychology*, *111*(1), 67.
[27] Grabenhorst, F., Rolls, E. T., & Parris, B. A. (2008). From affective value to decision-making in the prefrontal cortex. *European Journal of Neuroscience*, *28*(9), 1930-1939; Persson, E., Asutay, E., Hagman, W., Västfjäll, D., & Tinghög, G. (2018). Affective response predicts risky choice for fast, but not slow, decisions. *Journal of Neuroscience, Psychology, and Economics*, *11*(4), 213.
[28] Baron, J., & Spranca, M. (1997). Protected values. *Organizational behavior and human decision processes*, *70*(1), 1-16.

and reason'.[29] Both are involved when the stakes are high and the issue uncertain. Indeed, several studies of the processes of system 2 reasoning suggest that the priorities identified in the instinctive response shape the slow deliberative processes of system 2 reasoning.[30]

The starting point of decision making is evidence accumulation.[31] Even at this stage of the process, priority is attributed to the evidence that aligns with the instinctive position, gathering more information that aligns with the initial preference.[32] Recent research also suggests that more attention is paid to the evidence that aligns with initial preferences, which can enhance the weighting of options and attributes in evidence accumulation.[33] Evaluation of the options depends on the accumulation of evidence from multiple sources and the arbitration decision requires the review and evaluation of a significant number of interdependent items of evidence, prior to evaluating the available alternatives.[34] The process of evaluation is also anchored in the instinctive response, where the confirmation bias may result in selective overweighting of choice-consistent evidence.[35]

Whilst there is little consensus on the processes of evaluation of evidence in complex uncertain decision, all models highlight the centrality of the subjective initial responses of the decision maker. [36]

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[29] Finucane, M. L., Peters, E., & Slovic, P. (2003). "Judgment and decision making: The dance of affect and reason" in eds Schneider, S.L. & Shanteau J. *Emerging Perspectives on Judgment and Decision Research* pp. 327 - 364

[30] For a review see Hallsson, B., Siebner, H., Hume R. (2018). Fairness, fast and slow: A review of the dual process of fairness. *Neuroscience and Biobehavioural Reviews* (89) 49 – 60.

[31] Studies suggest that evidence accumulation (gradual build up) in the brain actually occurs within the lateral intraparietal (LIP) and motor cortices. See for example Wong, K. F., Huk, A. C., Shadlen, M. N., & Wang, X. J. (2007). Neural circuit dynamics underlying accumulation of time-varying evidence during perceptual decision making. *Frontiers in computational neuroscience*, *1*, 115; Ploran, E. J., Nelson, S. M., Velanova, K., Donaldson, D. I., Petersen, S. E., & Wheeler, M. E. (2007). Evidence accumulation and the moment of recognition: dissociating perceptual recognition processes using fMRI. *Journal of Neuroscience*, *27*(44), 11912-11924.

[32] Krajbich, I., Lu, D., Camerer, C., & Rangel, A. (2012). The attentional drift-diffusion model extends to simple purchasing decisions. *Frontiers in psychology*, *3*, 23998; Wang, S., Krajbich, I., Adolphs, R., & Tsuchiya, N. (2012). The role of risk aversion in non-conscious decision making. *Frontiers in psychology*, *3*, 14557.

[33] Teoh, Y. Y., Yao, Z., Cunningham, W. A., & Hutcherson, C. A. (2020). Attentional priorities drive effects of time pressure on altruistic choice. *Nature communications*, *11*(1), 3534.

[34] Parés-Pujolràs, E., Travers, E., Ahmetoglu, Y., & Haggard, P. (2021). Evidence accumulation under uncertainty-a neural marker of emerging choice and urgency. *Neuroimage*, *232*, 117863.; Schustack, M. W., & Sternberg, R. J. (1981). Evaluation of evidence in causal inference. *Journal of Experimental Psychology: General, 110*(1), 101–120.

[35] Cahill, L., & McGaugh, J. L. (1995). A novel demonstration of enhanced memory associated with emotional arousal. *Consciousness and cognition*, *4*(4), 410-421; Talluri BC, Urai AE, Testsos K, Usher M, Donner TH (2018). Confirmation bias through overweighting of choice consistent evidence. Current Biology 28 (19) 3128 - 3135.

[36] The theoretical frameworks include bayesian models (a sequence of multiplicative products of a prior opinion); posssion process stochastic models (an accumulation of evidence until a critical weight is achieved and fixed); sequential weighting models (cumulative) and information integration models (each piece of evidence is weighted separately, and decision is based on the average). Vorms, M, Lagnado, D. (2019. Coherence and credibility in the story-model of jurors' decision-making: Does mental simulation really drive

This initial response - grounded in working memory, experience, expertise, knowledge and values - shapes every stage of the decision-making process.[37]

Arbitrators, albeit expert decision makers, are not immune to these influences and the normal predispositions of a human decision maker. If these influences are not challenged and disrupted, indeed if the decision maker is not open to persuasion, then the initial instinctive influences may serve to predetermine the final decision and thus become unacceptable bias. So, what does the science of decision-making mean for arbitrators?

Science and arbitration

> 'We believe that most judges attempt to 'reach their decisions utilising facts, evidence, and highly constrained legal criteria, while putting aside biases, attitudes, emotions and other individuating factors.'[38]

Guthrie, Rachlinski, Wistrich quoting Nugent, set the context in which judges and arbitrators make decisions and there is no suggestion in this paper that judges or arbitrators are making consciously unacceptably bias decisions. This paper recognises that all human decision makers have limited cognitive capacity and are constrained by contextual factors (including time and resources). As such, decision making must be efficient. Many of the instinctive quick decisions are correct, indeed the ability to make accurate quick judgments is a hallmark of expertise,a but if these instinctive judgments are not moderated by system 2 processes there is a potential that the initial instinctive position may serve to narrow the frame of the decision-making process and thus serve as an unacceptable bias and lead to errors. [39]

Several factors improve decision quality and reasoning including time (system 2 processes require time), information (within the constraints of cognitive overload, additional evidence and data improve reasoning), structured decision making (structured and process driven decision making improves decision quality) and justification of reasoning (the process of writing encourages reflection). But as

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the Evaluation of the Evidence? In *Model-Based Reasoning in Science and Technology, Technology: Inferential Models for Logic, Language, Cognition and Computation* (pp. 103-119). Springer International Publishing
This is increasingly under scrutiny in the context of the digital environment see for example Topcu, Y. I., Özaydın, Ö., Kabak, Ö., & Ekici, Ş. Ö. (Eds.). (2021). *Multiple criteria decision making: beyond the information age*. Springer Nature.

[37] Phelps, E. A., & Sharot, T. (2008). How (and why) emotion enhances the subjective sense of recollection. *Current Directions in Psychological Science* 17 (2), 147.

[38] Guthrie, C., Rachlinski, J.J., Wistrich, A.J. (2007). Blinking on the Bench: How Judges Decide Cases. *Cornell Law Review* (93) 1.

[39] Girgerenzer, G. & Gaissmaier, W. (2011) Heuristic Decision Making. *Annual Review of Psychology* (62) 451

the science suggests in complex decisions with no clear outcome, the instinctive response will anchor the initial decision, how the information is processed and the system 2 deliberation. It is, therefore, essential that the instinctive response is disrupted. For those arbitrators making decisions alone, it is difficult to challenge the instinctive response. Indeed, whilst individuals may recognise biased reasoning in others, there is little evidence that they can identify their own biases, despite education.[40] One disruption approach has had some traction; the 'consider the opposite' strategy requires the decision maker to consider that their instinctive judgments may be wrong and revisit their decision from the opposite position. This strategy has been demonstrated to be effective, albeit time consuming.[41]

Panel decision making, in theory, has an inbuilt mechanism of challenge. Research on panel decision making demonstrates that the expression of disagreement and dissent on panels improves decision quality, increases discussion intensity, creativity, and divergent thought and limits bias.[42] In this context, disagreement challenges existing norms and assumptions and encourages the majority to scrutinise their decision making. It can disrupt, reshape, and reframe the dominant positions. The party appointed system should encourage challenge and divergent thought, if all positions are equally heard and considered. However, despite the many structures to support discussion, even in UK Supreme Court some judges are quieter than others.[43]

There is also a deference to expertise evident in the UK Supreme Court, which encourages consensus around the expert. While, expertise is important as a source of knowledge, the deference to the expert can serve to perpetuate bias rather than challenge it. Indeed, this deference to expertise can underpin a psychological phenomenon known as groupthink and may result in a position or line of

[40] Pronin, E., Lin, D. Y., & Ross, L. (2002). The bias blind spot: Perceptions of bias in self versus others. *Personality and Social Psychology Bulletin*, *28*(3), 369; Risen, J. L. (2016). Believing what we do not believe: Acquiescence to superstitious beliefs and other powerful intuitions. *Psychological review*, *123*(2), 182; Scopelliti, I., Morewedge, C. K., McCormick, E., Min, H. L., Lebrecht, S., & Kassam, K. S. (2015). Bias blind spot: Structure, measurement, and consequences. *Management Science*, *61*(10), 2468.

[41] Arkes, H. R., Faust, D., Guilmette, T. J., & Hart, K. (1988). Eliminating the hindsight bias. *Journal of applied psychology*, *73*(2), 305.; Mussweiler, T., Strack, F., & Pfeiffer, T. (2000). Overcoming the inevitable anchoring effect: Considering the opposite compensates for selective accessibility. *Personality and Social Psychology Bulletin*, *26*(9), 1142.

[42] Schulz-Hardt, S., Brodbeck, F. C. , Mojzisch, A. , Kerschreiter, R. & Frey, D. (2006). Group Decision Making in Hidden Profile Situations. *Journal of Personality and Social Psychology, 91* (6), 1080-1093. De Drue, C., Karsen, K.W., West, M.A. (2001). Minority Dissent and Team Innovation: Importance of Participation in Decision Making. *Journal of Applied Psychology* (86) 1191.

[43] I use quieter here as a reflection of the external voice of the Justice heard through the delivery of judgments. Several studies demonstrate that many new arrivals to the Supreme Court bench are unlikely to deliver judgments in the early months of their arrival. Hagle, T.M. (1993) Freshman Effects' for Supreme Court Justices *American Journal of Political Science* (37) 1142. Cahill-O'Callaghan, R., (2020) Values in the Supreme Court: Decisions, Division and Diversity (Hart Publishing, UK)

reasoning dominating.[34] This form of groupthink is most evident when there is a small group of decision makers, making an important and complex decision and the outcome is undetermined.[35] The type of decisions being made by a panel of arbitrators.

Finally, challenge and different perspectives are only effective, if the position provokes critical engagement.[44] Engagement in this context is not simply acknowledgement of the different view, but discussion of the foundation of the disagreement and those who engage must also be open to persuasion away from their instinctive position.

Conclusion

This paper explores the scientific foundations of decision making and systems of activation, conduction and processing that result in the final outcome. Examination of the complexity and speed of decision making, highlights the many possible factors that predispose human decision making and the very limited control the individual decision maker has on the process. This knowledge allows us to consider the structures and processes that ensure that normal predispositions do not predetermine the outcome and become unacceptable bias.

[44] Dooley, R. S., & Fryxell, G. E. (1999). Attaining decision quality and commitment from dissent: The moderating effects of loyalty and competence in strategic decision-making teams. *Academy of Management Journal*, *42*(4), 389.