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Decision-making between biases and strategies: The contribution of cognitive neuroscience

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Abstract

Decision-making is a fundamental cognitive function that extends beyond controlled laboratory paradigms into complex real-world contexts shaped by uncertainty, social influences, and emotional factors. Traditional models emphasize rational deliberation but often overlook the implicit physiological and neural mechanisms underlying choices. Neuroscientific research shows that decision-making arises from the interplay between executive control, reward sensitivity, affective regulation, and social cognition, supported by distributed neural networks including the prefrontal cortex, limbic system, and social brain regions. This paper highlights the limitations of conventional assessments, which rely mainly on explicit behavioral measures while neglecting physiological effort, autonomic activation, and neurocognitive correlates. Finally, we introduce the Digitalized Assessment Tool for Decision-Making (DAsDec), as example of an integrative approach combining behavioral, psychophysiological, and neurocognitive metrics. By leveraging wearable technologies and realistic tasks, the tool represents a step toward a more comprehensive understanding of decision-making, with implications for applied domains such as healthcare, management, law and policy-making.

Key words

Decision-making; cognitive neuroscience; cognitive biases; cognitive strategies neuroassessment

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Resumen

La toma de decisiones es una función cognitiva fundamental que va más allá de los paradigmas controlados de laboratorio y se extiende a contextos complejos del mundo real, moldeados por la incertidumbre, las influencias sociales y los factores emocionales. Los modelos tradicionales hacen hincapié en la deliberación racional, pero a menudo pasan por alto los mecanismos fisiológicos y neuronales implícitos que subyacen a las elecciones. Las investigaciones neurocientíficas muestran que la toma de decisiones surge de la interacción entre el control ejecutivo, la sensibilidad a las recompensas, la regulación afectiva y la cognición social, con el apoyo de redes neuronales distribuidas que incluyen la corteza prefrontal, el sistema límbico y las regiones sociales del cerebro. Este artículo destaca las limitaciones de las evaluaciones convencionales, que se basan principalmente en medidas conductuales explícitas y descuidan el esfuerzo fisiológico, la activación autonómica y los correlatos neurocognitivos. Por último, presentamos la Herramienta de Evaluación Digitalizada para la Toma de Decisiones (DAsDec), como ejemplo de un enfoque integrador que combina métricas conductuales, psicofisiológicas y neurocognitivas. Al aprovechar las tecnologías *wearable* y las tareas realistas, la herramienta representa un paso hacia una comprensión más completa de la toma de decisiones, con implicaciones para ámbitos aplicados como la sanidad, la gestión, el derecho y la elaboración de políticas.

Palabras clave

Toma de decisiones; neurociencia cognitiva; sesgos cognitivos; estrategias cognitivas; neuroevaluación

Table of contents

1. Setting the stage: neuroscience for decision-making

The relationship between humans and their choices has been a focal point of research for decades, with groundbreaking contributions from Kahneman and Tversky in the 1970s sparking a new understanding of how cognition and rationality influence decision-making processes. Their work highlighted the limitations of human information processing and introduced concepts such as cognitive biases, which profoundly impact how decisions are made (Kahneman and Tversky 1973). This challenged traditional models of normative rationality, such as the Expected Utility Theory (von Neumann and Morgenstern 1947), which portrayed decision-makers as entirely logical and well-informed.

In the ensuing decades, research has increasingly focused on the boundaries of human decision-making, examining how heuristics and biases shape behaviour. These insights have guided the development of experimental paradigms designed to measure the influence of decisional shortcuts, such as the framing effect or anchoring bias. While such studies have been instrumental in quantifying biases, they often neglect the broader perspective that decision-making is a pervasive and instrumental life skill, critical for navigating complex, real-world challenges (Ceschi *et al.* 2019). Decision-making, from both psychological and neuroscientific perspectives, can be viewed as a higher-order cognitive function encompassing dynamic information-processing, reasoning, and action-implementation processes (Balconi 2023). Maier (1970) seminally proposed that decisions and problem-solving are inevitable aspects of life, and the ability to make sound decisions is essential for achieving and maintaining a high quality of life. Thus, decision-making extends beyond merely overcoming cognitive limitations to being a fundamental skill for addressing the demands of everyday life. Also, while traditional approaches have largely focused on observable behaviours and explicit choices, they often fail to capture the implicit and covert aspects of the decision-making process. This gap limits our ability to investigate the physiological effort, cognitive workload, and emotional arousal that influence decision strategies, as well as the neurobiological underpinnings of uncertainty, reward evaluation, and adaptive control. A neuroscientific approach offers an innovative perspective by integrating both explicit behavioural markers and implicit physiological correlates, such as autonomic activation and neural activity, thereby helping to approach an overarching understanding of decision-making dynamics.

This paper adopts a theoretical framework that views decision-making as an intrinsically complex and situated process. It is shaped by many critical factors, including subjective experiences, task-specific demands, and situational and contextual influences. Expanding further, decision-making research has provided evidence on how individual differences, such as personality traits and genetic predispositions, influence decision patterns. For example, dopamine signalling pathways have been associated with risk preferences and reward sensitivity, while serotonin modulation impacts impulsivity and patience (Doya 2008). Additionally, the integration of social and cultural factors has enriched our understanding of collective decision-making processes, highlighting the relevance of shared norms and values in shaping decisions. By looking at decision-making through a neuroscientific looking glass, we aim to introduce the cognitive and neural mechanisms underpinning this multifaceted process and highlight its significance as a critical life competency.

This introduction lays the groundwork for examining the interplay of cognitive biases, the complexity of decision-making, and innovative tools designed to enhance our understanding and assessment of this crucial ability. Specifically, an innovative tool designed to assess decision-making assess decision-making in a realistic and context-sensitive manner – i.e., the Digitalized Assessment Tool for Decision-Making (DAsDec; Balconi 2023, Balconi and Angioletti 2024) – is here used to exemplify such neuroscientific, multicomponential approach to decisional processes. Indeed, by incorporating behavioural, psychophysiological, and neurocognitive metrics, DAsDec provides an ecologically valid method for investigating the interplay of individual differences in decisional styles (Balconi, Angioletti *et al.* 2023, Crivelli, Allegretta *et al.* 2024, Rovelli *et al.* 2024), decisional strategies (Balconi, Acconito, Rovelli *et al.* 2023, Crivelli *et al.* 2023, Angioletti *et al.* 2024, Crivelli, Acconito *et al*. 2024b), executive control and metacognitive abilities (Balconi, Acconito, Allegretta *et al.* 2023, 2024, Crivelli, Acconito *et al.* 2024a, Balconi, Allegretta *et al.* 2025), emotion regulation and stress management skills (Balconi, Acconito, and Angioletti 2024, Balconi, Angioletti *et al.* 2025), and social-relational factors (Balconi, Allegretta *et al.* 2024, Rovelli and Balconi 2025) in complex and dynamic decision-making scenarios. This tool mirrors a potential paradigm shift in how we measure and understand decision-making processes, offering a replicable model for both research and applied contexts.

2. Everyday decisions: naturalistic situations, heuristics, and biases

Cognitive biases are systematic deviations from rational decision-making, rooted in heuristics and emotional influences. These biases serve as mental shortcuts that can simplify complex decisions in everyday life and in our (overly) complex naturalistic settings, yet at some risk.

Understanding why cognitive distortions occur in decision-making is critical, particularly in high-stakes environments such as professional ones. Cognitive biases often arise from the inherent limitations of human information-processing capacities. Simon's (1955) concept of bounded rationality highlights three main constraints: individuals cannot access complete information, their ability to predict the future consequences of decisions is limited, and they lack full knowledge of all possible alternatives. These constraints, coupled with the physiological limitations of our cognitive systems, make biases inevitable in many decision-making scenarios.

Heuristics, commonly defined as cognitive shortcuts used to simplify problem-solving under conditions of uncertainty, play a dual role in decision-making. While they are adaptive in reducing cognitive load and speeding up decisions, heuristics often lead to systematic errors. For instance, the availability heuristic relies on the ease with which examples come to mind, potentially causing overestimation of recent or vivid events. Similarly, the representativeness heuristic involves making judgments based on perceived similarities to prototypes, which can reinforce stereotypes and overlook critical nuances (Tversky and Kahneman 1974).

The interplay between heuristics and biases manifests in predictable ways across different domains of decision-making and has been highlighted even by neuroscientific research. As an example, it has been proposed that the expression of loss aversion – i.e., the tendency to weigh potential losses more heavily than equivalent gains – could be mediated by heightened amygdala activation, signalling emotional distress linked to loss, and insular activation (Canessa *et al.* 2013). And again, a recent investigation on belief formation and, specifically, on the confirmation bias – i.e., the tendency to favour information that supports pre-existing beliefs contrasting with aversion to use the strength of others' disconfirming opinions to alter own confidence in judgments – highlighted the role of the medial prefrontal cortex (mPFC), linked to self-referential thinking and monitoring of post-decision information (Kappes *et al.* 2020).

The dual-process theory proposed by Kahneman (2011) provides a framework for understanding these biases. System 1, characterized by fast, intuitive, and emotionally driven processing, is more prone to biases, while System 2, which involves deliberate and analytical thinking, can counteract them. However, the operations of System 1 are not always monitored effectively by System 2, making external interventions, such as structured de-biasing techniques, essential.

More recently, a novel twist in such tale was provided by Korteling *et al.* (2018), who tried to define a neural network perspective on cognitive heuristics and biases, emphasizing that heuristic decision-making is fundamentally tied to the brain's design as a biological neural network. Unlike the popular computer metaphor for cognition, this framework asserts that the brain's information processing is shaped by principles evolved for basic survival functions like motor skills, pattern recognition, and associative learning, building on classical theoretical remarks by Churchland (1987) and Damasio (1994). These "Type 1" processes, which underpin fast, intuitive decision-making, are distinct from the more recently developed "Type 2" processes, such as analytic reasoning, calculation, and logic.

The mismatch between the brain's original evolutionary design and the demands of modern cognitive challenges explains the systematic biases observed in decision-making. For example, humans often give disproportionate weight to relative differences over absolute values, a tendency linked to perceptual principles like the Weber-Fechner law. This explains why people expend more effort for small relative gains (e.g., saving € 2 on a € 10 item) than for larger absolute savings with smaller relative impact (e.g., saving € 10 on € 2,000). Such biases arise because the brain's neural "wetware," optimized for perceptual-motor tasks, struggles with abstract logical or statistical reasoning (Kosslyn and Koenig 1992, Korteling *et al.* 2018).

The neural network framework specifically identifies four principles central to the brain's information processing: association, compatibility, retainment, and focus. These principles collectively shape how biases emerge. For instance:

- Association: Neural networks process information by forming correlations, which can lead to cognitive illusions such as overestimating patterns or relationships in data (as examples, think about superstition or false correlations).
- Compatibility: The brain prioritizes information that aligns with existing knowledge and expectations, contributing to biases like confirmation bias and the status-quo bias (see, as an example, Crivelli *et al.* 2023).

- Retainment: Irrelevant or outdated information is often retained and influences decision-making, even when it should be ignored.
- Focus: The brain disproportionately emphasizes certain pieces of information while neglecting others, leading to selective attention and availability biases.

These principles not only explain individual biases but also provide a unifying framework for understanding why heuristics are pervasive. For example, biases such as conservatism, the illusion of truth, and system justification all share a reliance on compatibility, reflecting the brain's preference for coherence and consistency.

While heuristic thinking often produces satisfactory results with minimal effort, it can also lead to suboptimal decisions, especially in contexts requiring Type 2 reasoning. Training and experience can help mitigate these biases by creating neural associations that align with more accurate judgments, allowing experts to make complex decisions intuitively without deliberate analysis (Gigerenzer 2007, Klein 2008). By focusing on the brain's associative, compatibility-driven, and retention-based mechanisms, this perspective may help bridging cognitive and neuroscientific theories. Understanding these principles can guide strategies to predict, counteract, or leverage biases in practical domains like public policy, business, and daily life. It also underscores the need for further research to integrate neural network insights into the study of heuristics and decision-making especially in real-life situations and in naturalistic contexts, which are still often considered an obstacle for formal investigation of the human decisional process.

3. Neuroscience of real-life decision-making: social domain and metacognitive skills

Real-life decision-making is, indeed, a highly dynamic and multifaceted process influenced by a combination of cognitive, emotional, and social factors, as well as contextual constraints that are often unpredictable and complex. Unlike the controlled conditions of laboratory experiments, where decision-making is typically studied in isolated and well-defined tasks, real-world decisions unfold in environments characterized by uncertainty, competing goals, social interactions, and the need for continuous adaptation. Neuroscience has made significant contributions to understanding these complexities, offering insights into how the brain integrates past experiences, affective states, and social influences to guide behaviour.

A central feature of real-life decision-making is its reliance on executive functions (EFs), which govern an individual's ability to evaluate options, plan actions, regulate emotions, and adapt to changing circumstances (Funahashi 2017, Balconi 2023). Neuroimaging and neuropsychological studies have shown that the prefrontal cortex (PFC) plays a key role in orchestrating these high-level cognitive processes, with lateral regions supporting rational analysis and cognitive control, and ventromedial and orbitofrontal regions integrating affective and reward-related information (Zelazo *et al.* 2003, Friedman and Robbins 2022). However, decision-making in naturalistic contexts goes beyond rational evaluations, requiring the individual to balance immediate rewards with long-term consequences, navigate social expectations, and manage stress and uncertainty.

Despite the emphasis in traditional models on logical reasoning and rational calculation, human decision-making is often guided by heuristics—mental shortcuts that, while useful in streamlining cognitive effort, can also lead to systematic biases. These heuristics, deeply rooted in neural mechanisms originally evolved for rapid perceptual and motor processing, explain why decision-making often diverges from normative rationality. As noted above, neuroscientific evidence suggests that biases are not simply errors in reasoning but rather byproducts of the way the brain processes information through associative neural networks, which prioritize coherence, pattern recognition, and familiarity (Korteling *et al.* 2018). The brain tends to weigh discrete changes more than gradual ones, focus on relative rather than absolute values, and favour information that aligns with existing beliefs or expectations – mechanisms that, while advantageous in evolutionary contexts, can sometimes lead to suboptimal decisions in modern, complex environments.

Further key aspects differentiating real-life decision-making from laboratory-based decision models are the role of reinforcement learning and the way such basic function shapes information gathering and decisional processes. Recent research suggests that real-world decision processes involve flexible reinforcement learning mechanisms, where individuals continuously update their choices based on past outcomes and changing environments (Dolan and Dayan 2013, O'Doherty *et al.* 2021). Unlike simplistic economic models that assume decision-makers maximize expected utility based on predefined probabilities, neuroscience reveals that the brain operates through approximate value-based learning, integrating emotional signals, attentional biases, and uncertainty estimations in ways that often diverge from normative rationality (Wise *et al.* 2024).

Furthermore, affective states and reward sensitivity also play a crucial role in shaping decision strategies. The dopaminergic system, particularly pathways involving the ventral tegmental area (VTA), the nucleus accumbens (NAc), and the orbitofrontal cortex (OFC), modulates motivation and reinforcement learning by encoding prediction errors – namely, signals that help individuals adjust expectations and behaviours in response to unexpected outcomes (Holroyd and Coles 2002, Berridge and Kringelbach 2011). However, emotional and motivational biases can distort decision-making under conditions of uncertainty, leading to over-reliance on habitual responses, impulsivity, or avoidance of risky but potentially beneficial choices (Starcke and Brand 2012, Crivelli, Allegretta *et al.* 2024). As an example, individual differences in reward processing – as described by reinforcement sensitivity theory (RST) – shape tendencies toward either risk-seeking or risk-avoidant decision-making (Hall *et al.* 2011, Pessiglione and Delgado 2015). While some individuals are more inclined to seek out novelty and rewards, others are more cautious and averse to potential losses, leading to distinct decision styles that vary across contexts and situations. This interplay between cognitive control and motivational drives is, then, further modulated by emotional regulation, which can either enhance rational deliberation or, in high-stress conditions, lead to impulsive or defensive choices. Stress, in particular, is a significant modulator of decision-making in real-world contexts, particularly under conditions of high uncertainty, social pressure, or time constraints. Research indicates that stress alters neural activity in the PFC and limbic system, often shifting decision-making strategies from reflective and goal-oriented to heuristic and reactive (Starcke and Brand 2012, Phillips-Wren and Adya

2020). Under acute stress, individuals tend to rely more on habitual responses and immediate rewards while neglecting long-term consequences. Chronic stress can exacerbate this effect, impairing cognitive flexibility and reinforcing maladaptive decision patterns. Furthermore, individual differences in stress resilience and executive control influence how people cope with uncertainty and regulate emotional responses in decision-making scenarios (e.g., Tyrka *et al.* 2007).

Another defining feature of real-world decision-making is its inherently social nature. Unlike traditional models that view decision-making as an isolated cognitive process, real-life choices are often made collaboratively, shaped by peer influence, group dynamics, and social norms (Crivelli and Balconi 2023). Recent neuroscientific research points out the potential of novel approaches to the investigation of the social brain and neural underpinnings of social interactions – in primis, the approach named hyperscanning (Balconi and Vanutelli 2017, Crivelli and Balconi 2017, Czeszumski *et al.* 2020) – in exploring and understanding the interaction between social attunement, interpersonal neural synchronization (i.e., the alignment of brain activity across individuals involved in a shared task and/or social exchange), and shared decision-making, particularly in cooperative or emotionally charged contexts. Social understanding, supported by a broad network including the medial prefrontal cortex (mPFC) and the temporoparietal junction (TPJ), suggests that group-based decision-making involves mutual prediction mechanisms, where individuals anticipate and align with the choices of others (Frith and Singer 2008, Hou *et al.* 2022, Zhao *et al.* 2023). Social factors can also introduce confirmation biases, as individuals may selectively seek information that reinforces preexisting beliefs, especially when decisions are embedded in cultural or ideological frameworks.

Finally, metacognitive processes – i.e., the ability to become aware of, reflect on, and regulate one's own mental objects and processes – also play a fundamental role in real-life decision-making. Unlike controlled tasks where individuals are explicitly instructed to weigh options, everyday decisions often involve introspective uncertainty, requiring individuals to assess their own confidence levels and adjust behaviour accordingly. Research has shown that the anterior prefrontal cortex supports metacognitive evaluations, allowing individuals to monitor decision quality, detect errors, and refine strategies over time (Fleming and Dolan 2012, Fleming and Daw 2017). However, distortions linked to such metacognitive processes – such as overconfidence biases or self-doubt – can significantly impact the quality of real-world decisions, particularly in high-stakes domains such as finance, healthcare, or leadership (e.g., Sharot 2011).

Taken together, neuroscientific research has profoundly reshaped – and still is reshaping – our understanding of decision-making by highlighting the nonlinear, context-sensitive, and multi-layered nature of human choices. Rather than adhering to strict rational principles, real-life decision-making is best understood as an adaptive, dynamic process, where cognitive control, emotional regulation, social influences, and uncertainty management interact in complex ways. Understanding these components not only enhances theoretical models but also informs practical applications aimed at properly assessing or improving naturalistic decision-making in diverse settings, from healthcare to business, law, and public policy.

4. Multimodal assessment of a multifaceted process: the Digitalized Assessment Tool for Decision-Making (DAsDec)

Building on the premises outlined above, we would now like to introduce – as an exemplifying case study – the development and testing of a novel digitalized assessment tool designed to evaluate decision-making skills in a realistic, comprehensive, and structured way. The Digitalized Assessment Tool for Decision-Making (DAsDec; Balconi 2023, Balconi and Angioletti 2024) was developed to address a critical methodological and practical gap: the need for an integrative, user-friendly tool capable of capturing the multifaceted nature of decision-making while respecting the complexity of its expression in real-life situations. Traditional assessments, indeed, often focus on isolated or over-simplified aspects of decision-making, failing to provide a holistic profile of how individuals approach, process, and execute decisions across different contexts. DAsDec aims to bridge this gap by offering a multidimensional framework that reflects both dispositional traits and situational adaptability in decision-making.

To achieve this, DAsDec is structured around a modular interface that aligns with a multi-componential model of decision-making. The tool is composed of five independent yet interconnected domains, each assessing a fundamental pillar of real-life decision-making: Decisional Styles, Decisional Strategies, Decisional Efficacy, Decisional Awareness, and Decisional Metacognition.

I. *Decisional Styles* – This domain focuses on stable dispositional traits that shape an individual's general approach to decision-making. These styles represent personal tendencies that persist across different contexts, providing insights into an individual's habitual patterns of thinking, evaluating, and acting when faced with decisions. Since these traits are relatively consistent over time, this dimension can be viewed as a reflection of an individual's cognitive and personality-based predispositions toward decision-making.

II. *Decisional Strategies* – This domain assesses adaptive decision-making processes, emphasizing an individual's ability to analyse contextual factors, devise action plans, and implement decisions effectively. A key feature of successful decision-making is the ability to integrate internal and external information and flexibly adjust strategies based on situational constraints and opportunities. This domain thus highlights the capacity to navigate uncertainty and optimize outcomes through context-sensitive decision strategies.

III. *Decisional Efficacy* – This domain evaluates the efficiency and effectiveness of an individual's decision-making process. It examines how well a person utilizes available information, time, and resources – both personal and external (such as collaboration with others) – to maximize decision quality while minimizing errors and inefficiencies. This component is particularly relevant in high-stakes or time-sensitive scenarios, where resource optimization is crucial.

IV. *Decisional Awareness* – This dimension explores an individual's conscious engagement with decision-making, including self-awareness, situational awareness, and behavioural regulation. Effective decision-making is not only about selecting the best course of action but also about understanding one's cognitive and emotional processes, anticipating potential biases, and responding proactively rather than reactively. A strong sense of decisional awareness enhances self-efficacy, autonomy, and the ability to make informed choices under complex conditions.

V. *Decisional Metacognition* – This domain assesses high-level cognitive and metacognitive skills that are essential for complex decision-making. It includes tasks designed to evaluate logical reasoning, strategic planning, cognitive control, problem-solving, and self-monitoring in real-world scenarios. Metacognitive abilities enable individuals to reflect on, regulate, and refine their decision-making strategies, ensuring that choices align with both immediate goals and long-term objectives.

Each of these domains is supported by a carefully curated set of tests and tasks. The components of the DAsDec tool were selected based on their conceptual relevance and empirical validation in decision-making literature. Where existing assessments were insufficient to capture critical aspects of decision-making, new tasks were developed ad hoc to explore previously unexamined facets of the decision-making process.

In keeping with the above introduced methodological remarks, we deem relevant to note that, before its full implementation, the DAsDec tool has undergone empirical testing to evaluate its feasibility, applicability, and informativeness (Balconi 2023, Balconi and Angioletti 2024). This validation phase has helped ensuring that the tool will not only provide theoretical insights into decision-making but also serve as a practical instrument for assessing and enhancing decisional competencies in various real-life contexts, including professional, educational, and clinical settings. The validation and refinement steps have, now, come to completion with the definition of the first finalized version of the tool, which is currently undergoing its transcription into a complete product that will soon be available to the research and professional communities.

Finally, at the light of the exploratory and explanatory potential of the neuroscience perspective, the tool has been designed so to allow the integration with wearable sensing devices. This gives the opportunity of a unified collection of behavioural, psychophysiological, and neurocognitive measurements, providing a comprehensive and multidimensional assessment of decision-making processes. Namely, by combining non-invasive techniques to capture autonomic activation and electroencephalography (EEG) via wearable systems, DAsDec is enabled for the detection of physiological markers mirroring implicit emotional and cognitive responses associated to the explicit ones. This synergistic approach allows for the simultaneous evaluation of explicit decision-making strategies, related neural effort, and affective influences, ensuring a holistic understanding of how individuals process and respond to complex choices, particularly under pressure and uncertainty.

5. Conclusions

Decision-making is a fundamental aspect of human cognition that extends far beyond the simplified paradigms of laboratory experiments. Real-life decision-making is shaped by a complex interplay of cognitive, emotional, social, and contextual factors making it a dynamic and adaptive process rather than a purely rational or static one. Neuroscientific research has profoundly reshaped our understanding of decision-making by highlighting the distributed mechanisms through which biases, heuristics, reward sensitivity, social influences, and metacognition interact in situation-dependent ways.

Traditional models of decision-making often assume a logical, structured approach in which individuals assess available alternatives and choose the most optimal outcome based on rational evaluation. However, real-world decisions are rarely made in isolation; they unfold in environments characterized by uncertainty, competing priorities, emotional pressures, and social dynamics. Neuroimaging and psychophysiological studies have revealed that decision-making is governed by a distributed neural network, with the prefrontal cortex supporting cognitive control and deliberation, the limbic system processing emotional and reward-related cues, and social brain networks processing and regulating interpersonal influences. The neural network framework of decision-making suggests that heuristics and biases, rather than being mere cognitive errors, are deeply embedded features of the brain's architecture, evolved for efficiency in processing information and adapting to a changing environment. Recognizing these complexities underscores the effort required in conceiving and developing assessment and empowerment tools that move beyond traditional measures of decision-making and capture implicit cognitive, physiological, and neural processes alongside explicit behaviour. In this sense, the framework articulated in this manuscript – and exemplified by the integrative logic of the Digitalized Assessment Tool for Decision-Making – aims at a comprehensive, ecologically valid, and multidimensional evaluation of decisional processes.

Beyond theoretical advances, practical implications of a neuroscientific approach to decision-making assessment are vast and span healthcare, education, organizations, and – crucially for the present discussion – law and policy-making. In legal and forensic settings, an integrated and interdisciplinary assessment strategy can enhance ecological validity by connecting overt choices with implicit indices of arousal, cognitive workload, and regulatory control as decisions unfold under pressure, uncertainty, and social influence. When anchored to well-specified tasks and clear analytic steps, such multimodal evidence can contextualize decisional capacity, parse out how situational constraints and biases shaped the route to a choice, and inform tailored interventions (e.g., decision hygiene, metacognitive training) without reducing complex judgments to single metrics. The possibility to interface standardized tasks with wearable body-sensing devices to collect psychophysiological and neurocognitive measures further supports this ecological turn, enabling convergent lines of evidence while maintaining a unitary focus on the decisional process as it is actually enacted.

At the same time, translating this approach into legal contexts presents nontrivial difficulties. Physiological and neural indices are not-deterministic, context-sensitive, and vulnerable to misinterpretation; they must be triangulated with behavioural performance and case materials rather than treated as direct readouts of intention, truthfulness, or responsibility. Standardization of protocols, stimuli, preprocessing, and reporting is essential to ensure reproducibility and comparability across cases and venues. Attention to generalizability and fairness is likewise required, because individual differences (e.g., subjective stress reactivity, personal educational history) and situational factors may modulate signals in ways that may confound naïve interpretations. Finally, admissibility standards caution against overclaiming: multimodal findings should be framed as complementary, explanatory evidence that informs expert opinion and supports legal reasoning, not as dispositive proof. Implementing such assessments responsibly calls for genuinely interdisciplinary competencies. Legal expertise is necessary to formulate answerable questions, define scope, and anticipate constraints of admissibility; clinical and forensic psychology ensure construct validity and defensible case formulation; cognitive neuroscience and psychophysiology provide methodological rigor in task design, sensor choice, artifact control, and signal interpretation; and human-factors know-how supports delivery in applied settings, including operator training and stress-testing of procedures. Governance competencies, then, may tie these elements together in a framework that could be both scientifically robust and practically accountable. Again, given the sensitivity of decisional data, ethical safeguards are not ancillary but constitutive of good practice. Within such guardrails, the interdisciplinary model advocated here can enrich – not replace – traditional approaches to investigation and improvement of decisional processes, by clarifying how cognitive control, affect, social attunement, and metacognition jointly shape the trajectory of real-life choices.

As research continues to uncover the neural and psychological underpinnings of real-world decision-making, future studies should strive to refine investigation methodologies, integrate neuroadaptive technologies, and explore how individual differences shape decision patterns across various domains. By embracing an interdisciplinary perspective that unites neuroscience, psychology, legal studies, behavioural economics, and cognitive sciences, we can develop more effective, personalized approaches to understanding and improving decision-making in the complex and ever-evolving real world.

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