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Neuroscience for a new concept of decision-making style

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ABSTRACT

Decision-making styles refer to the style through which individuals identify and evaluate the information needed to make a decision and how they usually consider the various possible alternatives. While decision-making styles have been explored from several research perspectives, no neuroscientific studies addressed this topic before. Considering the neuroscientific findings on the study of the decision-making process, the purpose of this article is to go beyond the traditional models conceptualizing the styles of decision-making and to provide a novel insight and definition of this concept, through the identification of some of the prerogatives most closely associated with the notion of style: these include self-representation, adaptability, and risk-taking. Within this conceptual framework, it is proposed that the style of a decision-maker is strictly linked to the physiological tendency to tolerate and regulate stress, to the ability to self-represent one's goals and be able to prioritize them, to the adaptability level, and to risk-taking and management traits. To fully understand the construct of decision-making styles, this theoretical contribution also underlines the importance of adopting a conceptual perspective that takes into account behavioural, self-report and neuroscientific measures to profile decision-makers.

Keywords: decision-making style; self-representation; adaptability; risk-taking; stress management

1. Decision-making styles: where to now?

Psychologists, economists, mathematicians, and researchers interested in understanding the human decision-making tendency of individuals have historically studied decision-making from different perspectives.

The traditional models that investigated decision-making are based on the normative theory that defines the decision-maker as rational, knowledgeable, and able to calculate accurately each possible option involved in a decision. According to this perspective, each choice is strictly linked to the utility function and to the chance to maximize the results of the choice (Uzonwanne, 2016). On the contrary, recent evidence demonstrated that people make irrational decisions (Kerjan & Slovic, 2010). This is because several other emotional and motivational processes, beyond the cognitive, rational, and explicit ones, play a role in decision-making dynamics (Balconi & Terenzi, 2013; Lerner et al., 2015; Naqvi et al., 2006). Starting from this evidence, more recent conceptual models underlined how the study of decision-making involves the consideration and analysis of variables including the ontology of the situation and the structure of the decision environment, important sets of information, trends and patterns of behaviour, the characteristics of people involved in the decision and their relationships, and the decision-makers style (Bennet & Bennet, 2008).

Considering such a manifold view of the decision-making construct, it seems relevant to start the analysis of this process from the basics. The style of decision-making refers to the individual habitual and learned response pattern exploited to make a decision, as well as to solve a problem or situation (Scott & Bruce, 1995) and to identify multiple alternatives (Driver et al., 1998). This concept was also previously used to refer to the cognitive style of gathering and evaluating possible alternative information (Behling et al., 1980; Zhang & Sternberg, 2006). Indeed, it is remarkable to go on studying the different individual approaches by which people identify and evaluate the information needed to decide (Albert & Steinberg, 2011), but also how they consider possible alternatives (Rahaman, 2014). These different tendencies to decide could be defined as decision-making styles (Janis & Mann, 1977; Scott & Bruce, 1995).

Previously, decision-making styles have been investigated from several research viewpoints; hence, there is no comprehensive and unified consensus about the study of this complex concept. In fact, distinct research groups have proposed different types of decision-making styles (and also a different number of them).

For example, Simon (1956) identified a satisfying style, in which the alternative that is useful for solving the situation is chosen, and a maximizing style, in which the selected alternative not only solves the situation but brings

about a greater result. From this classification, Schartz and colleagues have developed the Maximization Scale, to differentiate between those who tend to base their decisions on comparison with others by seeking the best option and those who are content with a sufficiently good alternative (Schwartz et al., 2002).

On the other hand, according to Janis and Mann (1977), there are three different decision-making styles (i.e., *vigilance*: painstakingly searching for relevant information and evaluation of alternatives; *hypervigilance*: frantically searching for a way out, impulsiveness; *procrastination*: procrastinating on difficult decisions and *buck-passing*: offloading responsibility to someone else), which differ according to whether there is enough time to make a decision and, consequently, conduct a detailed search for alternatives or to procrastinate and/or defer decision-making responsibility to others.

Also, Scott and Bruce (1995) identified five decision-making styles (i.e., *rational*: comprehensive search for information, inventory, and logical evaluation of alternatives; *intuitive*: attention to details, processing of information, and reliance on premonitions and feelings; *dependent*: seeking advice and guidance from others; *spontaneous*: immediacy and decision as quickly as possible; *avoidant*: avoid decision-making whenever possible), which differ in the level of analysis of alternatives, moving from intuition-based to analytic decision-making (Scott & Bruce, 1995). The same authors, in addition to identifying these five decision-makers, have also devised the General Decision-Making Style (GDMS), aimed at defining the individual decision-making profile (Scott & Bruce, 1995).

A recent effort to unify the different perspectives previously described is that of Leykin and DeRubeis (2010), who identified nine decision-making styles (respected, confident, spontaneous, dependent, vigilant, avoidant, brooding, intuitive and anxious), that differ for the likelihood of behaviour, environmental load, pressure, time available and familiarity with the context (Leykin & Derubeis, 2010).

2. Why a reconceptualization of decision-making style is needed through a neuroscientific approach

Since the conceptual framework of decision-making styles is not yet well defined, the self-report measures used to investigate this construct vary from each other (see the scales and questionnaires mentioned above). The limit of these self-report scales on decision styles is that they create a cluster that does not consider the neurophysiological aspects that characterize each person. In

addition, using these scales, it is possible to investigate only the explicit and conscious aspects of the decision-making styles, that is what individuals believe and refer about themselves, a knowledge that could be biased by several factors, including social desirability. To fully understand a decision-making style in its full complexity, a recent contribution is provided by the neuroscientific perspective, which enables researchers to focus not only on the explicit but also on the implicit components of a decision style (Shiv et al., 2005; Yoon et al., 2012).

Specifically, different studies have been conducted to try to map the temporal dynamics of decision-making in computational approaches (Harris & Hutcherson, 2022) or the visual-saccadic response to investigate the relationship between sensory and motor processes of the decision (Glimcher, 2001), but still no research has been conducted to investigate the neurophysiological correlates that distinguish the different decision styles.

In the following sections, some constructs that play a key role in the concept of decision-making style will be discussed according to a neuroscientific perspective. Indeed, it is proposed that the style of a decision-maker is strictly linked to i) the ability to self-represent one's goals and be able to prioritize them, ii) the adaptability level, iii) the risk-taking and management trait, and iv) the physiological tendency to tolerate and regulate the stress response when facing a decision.

In this regard, specific attention must be paid to the measurement of neurophysiological components and, in parallel to the tools used to measure these constructs. Among the neuro-technologies used to detect implicit measurements of decision-making, there are the electroencephalogram (EEG) (Golnar-Nik et al., 2019), functional Near Infrared Spectroscopy (fNIRS) (Zhang et al., 2021) and autonomic measures recording (Forte et al., 2021). They also allow measuring the typical neuro- and psycho-physiological response of a person while he or she is taking a decision. EEG was also extensively utilized in neuroscientific research to investigate decision-making in a variety of applied ecological contexts, including the luxury fashion industry business (Balconi et al., 2019), the professional domain (Balconi & Fronda, 2019) and shoe items (Baldo et al., 2015). fNIRS, in the same way, was adopted in different settings, including engineering (Hu & Shealy, 2019), economics contexts (Vanutelli et al., 2020), and moral management (Balconi & Fronda, 2020), but also to investigate decision-making processes in group cooperation situations (Zhang et al., 2021). Finally, also autonomic measures were collected to assess psychophysiological parameters linked to the individual's affective and emotional responses involved in decision-making in a variety of applied contexts (Fronda et al., 2021).

3. Self-representation of the decision-making goals

Beyond the different definitions of decision-making styles, any decision between multiple alternative foreseen having a clear goal of what the person wants to achieve with his or her choice. The self-representation of one's goals, together with the capacity to predict the possible obstacles in achieving them, drives the decision-maker in his/her decisions (Kreibich et al., 2020). And the ability to represent one's own goals more or less effectively can affect the decision-making style.

Self-representation of the decision-making goals, however, must also consider the target environment, which is often characterized by stressful and unforeseen events, unexpected changes, and limited time. In this perspective, therefore, it is necessary for the individual not only to have good ability in goal listing, but also to be able to assign them different levels of importance and priority (Gagné, 2018), a timeline for carrying out the objectives and the ability to know how to reorder them on the basis of the degree of effectiveness with which one has been able to reach them.

Given the importance of this capability, various research has been conducted in different fields, such as in the organizational psychology discipline (Vancouver et al., 2010). For example, in the organizational context managers should not only have the ability to contextualize their daily goals, but they should also be able to differentiate them by priority, assigning them a specific time order. The ability to prioritize according to the time variable one goal over another is related to the phenomenon of goal shielding, which according to the theory of Orehek and Vazeou-Nieuwenhuis is a self-regulation strategy that facilitates the management of multiple goals (Orehek & Vazeou-Nieuwenhuis, 2013).

Another possible perspective to study the construct of the self-representation of the decision-making goals could be to assess the ability to reorder one's goals based on their outcome. This skill, in particular, includes the ability to develop a clear awareness of goals achieved and those yet to be achieved.

Despite the relevance of the construct of goals self-representation, neuroscientific literature is still poor. Previous research focused on studying cognitive and emotional responses at the moment of the decision between different alternatives and not yet at the moment of goal self-representation and identification. However, based on studies showing how the Heart Rate (HR) can be considered an index of stress and emotional activation (Balconi & Fronda, 2019; Ditzen et al., 2007), it might be interesting to use autonomic measures to assess the emotional impact and the impact of having to represent one's goals, listing them for priority, time, or efficacy in achieving them.

To the best of our knowledge, no previous neuroscientific studies focused on the neurophysiological correlates of the tendency to represent one's goals, listing them for priority, time, or efficacy in achieving them.

However, the study by Liegel and colleagues, in which participants were induced to make a priority choice between two different tasks, showed how this process is responsible for modulations in low-frequency bands activity (theta, alpha and beta) and an index of proactive cognitive control (Liegel et al., 2022). Starting from this finding, therefore, it might be interesting to deepen with a neuroscientific approach, how cognitive and emotional responses associated with the representation of one's decision-making goals characterize different decision makers profiles. It would also be interesting to evaluate whether there are neurophysiological differences in decision makers who tend to order their decision goals by priority, temporal sequence and outcomes.

4. Adaptability and tendency to change

A second main feature intrinsically related to decision-making style is the concept of adaptability. The scientific literature has examined the construct of adaptability in relation to several aspects, focusing mainly on career adaptability (Johnston, 2018) and personal adaptability at work (Johnstone & Wilson-Prangley, 2021). However, there is no unanimous or commonly accepted definition of adaptability. According to some authors, adaptability to change can be defined as the ability of the individual to modify psycho-behavioural processes in response to changing circumstances, settings and uncertain situations (Martin et al., 2012). Other authors have, instead, investigated the construct from the relationship between the latter and other conceptually similar constructs, which explore the ability of the person to manifest a flexible or inflexible behaviour or attitude in a given situation, such as the cognitive flexibility (Hamtiaux & Houssemand, 2012).

Specifically, cognitive flexibility presents itself throughout a wide range of behaviours (Ionescu, 2012) that enable individuals to adjust their cognitive processing to different sorts of challenges rapidly and efficiently. The literature has highlighted how individuals with high cognitive flexibility are better able to modify mental scripts and behavioural routines in response to changing tasks and contextual conditions than simply reproduce them in the way they were originally learned (Ritter et al., 2012).

This turns out to be a determining factor for high-level roles (e.g., entrepreneurship), as it is directly linked to a greater propensity on the part of the individual to assume and manage risks (Dheer & Lenartowicz, 2019), as

well as better management of decision-making under stress (Kruczek et al., 2020). It is feasible to highlight how the capability of strategic decision-makers to adjust and rearrange their mental representations in response to changes in the external environment may be seen as a crucial competency (Hodgkinson et al., 2011). This concept appears to be connected to the notion that cognitive flexibility might assist in overcoming cognitive inertia, as it enables decision-makers to change their thinking mode to diverse conditions (Laureiro-Martínez & Brusoni, 2018).

In this regard, it is conceivable to suggest an integrated definition of adaptability, including not only the ability to react correctly to external factors influencing change but also the ability to deliberately provoke change and include new components in choices.

In addition to the role of flexibility, the latter proposal also emphasises the presence of two other central components in the adaptability construct, namely proactivity and innovation. In this context, it is possible to conceptualize how proactivity refers to the person's ability to introduce a change - self-induced and strongly linked to his authorship - to improve or to create challenging goals. This concept has been linked to the concept of leadership, and in particular to transformational leadership, democratic and participatory styles of leadership, which are the most predisposed styles to co-participation in decision-making (Balconi & Venturella, 2017; Balconi et al., 2019; Balconi, 2020; Yannuzzi et al., 2020). However, there are currently no neuroscientific studies that specifically investigated the relationship between proactivity and decision-making styles.

Innovativeness, on the other hand, can be conceived as individuals' ability to think creatively about something that others do not think about and introduce new elements into decisions. Literature defines innovativeness as the degree to which an individual makes decisions about innovation regardless of the experience communicated to others. This definition conceives innovativeness as a general trait possessed by individuals, closely related to parallel constructs such as self-confidence, social characteristics (Riesman et al., 1950) and self-control (Snyder, 1974). Regrettably, these studies are over fifty years old and do not investigate parallelism with decision-making approaches or decision-making styles.

Recently, two studies have been conducted to explore the self-report, behavioral and neuro- and psycho-physiological responses of a group of managers compared to a group of non-managers performing a realistic problem-solving task under two distinct conditions: an individual and a group condition. The different sets of results suggested that managers could be able to "feel", even at a deeper and psycho-physiological level, which social condition (in this case, the group one) is more suitable for solving a complex problem in a creative way. These works were aimed at disentangling how distinct

components of the creative decision-making process interoperates within complex natural environments (Balconi et al., *unpublished*). In this context, also psychometric measures could be used to assess the innovativeness style, such as the Mode Shifting Index (MSI; Pringle & Sowden, 2017), which allows to assess the ability to shift between associative and analytical thinking within a creative context, or the Types of Intuition Scale (TINTS; Pretz et al., 2014), measuring the holistic, inferential, and affective intuition types, or the innovation subscale of the Motivational Orientation Test (Alessandri & Russo, 2011).

To sum up, within the construct of the adaptability, except the concept of flexibility for which there are already neuroscientific studies, future studies should focus more on the concepts of proactivity and innovation and their significance for decision-making and for the definition of decision-making styles.

5. The relation between risk-taking, risk management and decision-making style

The decision-making process requires an individual to choose between a riskier action - with a higher reward and gratification – or an action perceived as more secure, involving a lower potential reward (Mather et al., 2009). In this framework, several studies have shown that one of the peculiarities and central axioms of decision-making research is the principle that people make decisions about how to act based on their desire to receive a reward and avoid punishment (Pessiglione & Delgado, 2015). In this context, the literature refers to the term risk-taking to identify that component of decision-making that is activated when the individual is faced with situations that involve uncertainty (Bechara et al., 2005; Krain et al., 2006). Particularly, it has been emphasized that risk takers prefer to make judgments with high potential advantages and high possible negative outcomes, as opposed to opting for more prudent alternatives (Mellers et al., 1997; Slovic, 1987).

From the perspective of the decision-making style, risk-taking and risk management are strongly influenced by certain prerogatives, such as (i) uncertainty, which is related to the predictability of the outcome; (ii) the clear identification of the outcome resulting from the decision-making, in terms of gains and losses; and (iii) the valuation of the value underlying the decision itself, influenced by the expected utility judgment (Ellsberg, 1961; Sanfey et al., 2006).

On the functional level, the probability that an individual chooses to make judgments by taking risks changes significantly based on three particular conditions: situational factors, individual differences, and decision styles, which

are themselves controlled by the decision's features (De-Juan-Ripoll et al., 2021).

Specifically, *situational factors* refer to all decision-related contextual factors, such as time constraints (Olschewski & Rieskamp, 2021).

Individual differences, on the other hand, refer to the set of subject-specific emotional and cognitive processes that regulate decision-making in risk conditions (Mishra & Lalumière, 2011). In particular, a bridge role between these two aspects is covered by executive control, which refers to the subject's ability to control thoughts to inhibit or adapt behaviours according to the situation (Diamond, 2013).

Ultimately, it turns out that decision-making styles are mediated and modulated by many intrinsic qualities of the decision, but they are also impacted by distinct cognitive processes - such as perceptual biases - and emotional processes, such as risk tolerance (Schiebener & Brand, 2015). Various authors have proposed that the foundation of all these processes is the *evaluation* of the appetitive/adverse nature of the outcomes of early decisions, which is also an important factor in modulating stress (Osman, 2012).

Indeed, the decision-making process, from a neuroanatomical standpoint, is often related to the same areas involved in the evaluation, namely the medial prefrontal cortex (mPFC), the ventral striatum (VS), the posterior cingulate cortex (PCC), the amygdala, the insula, and the posterior parietal cortex (PPC) (Grabenhorst & Rolls, 2011; Kable & Glimcher, 2009). Yet, the state of the art in neuroscience indicates that the regions of the brain engaged in risk-taking have characteristics. Specifically, both qualitative and quantitative studies (Bartra et al., 2013; Yarkoni et al., 2011) using functional Magnetic Resonance Imaging (fMRI) demonstrated that, in addition to the various brain regions of interest mentioned previously, the anterior nucleus accumbens (NAcc) and anterior cingulate cortex (ACC) are particularly active. As for the underlying mechanisms, it has been proposed that these regions are the core aspects of a neural risk matrix (Knutson & Huettel, 2015), whose differential activation is thought to facilitate the promotion, inhibition, and control of risky choice (Tisdall et al., 2020).

6. Physiological tendency to tolerate and regulate the stress response during decision-making situations

As beforehand anticipated, modern society increasingly requires individuals to make a variety of decisions under stressful circumstances (Lighthall et al., 2009; Preston et al., 2007). The response to stressful situations is a complex response, whose nature varies depending on the person's specific characteristics and the

circumstances to which the individual is exposed (Koolhaas et al., 2011). Similarly, it is challenging for a decision-maker to critically delineate and identify the set of cognitive processes that underlie the decision-making process, which is frequently highly modulated by stressful conditions (Prezenski et al., 2017). Notably, repeated stressful events influence habit decisions, regulate our willingness to engage in risk-taking, and have a significant impact on our decision-making style (Porcelli & Delgado, 2017).

This consideration is also reflected at the neurophysiological level, as it has been shown that the brain regions associated with the decision-making process are sensitive to stress-induced changes.

Indeed, according to Starcke and Brand (2012), decisions made under risky conditions are influenced by the effects of stress on the dorsolateral prefrontal cortex (DLPFC) that alter the use of functional strategy. Similarly, decisions made under conditions of moderate uncertainty should also be influenced by the effects of stress on the prefrontal cortex (PFC) and limbic system, which interfere with the balance between instinctive and calculated reactions. Stress can also cause better or worse judgment, depending on the scenario. For example, lower sensitivity to the penalty under stressful conditions can increase the search for risk, although this should be investigated more in the literature.

Also, temperament and personality traits can be related to the physiological capacity to tolerate and regulate the stress response involved in decision-making. In a previous study on healthy adults, low levels of novelty seeking were associated with increased cortisol concentrations to a standardized psychosocial stress test (Tyrka et al., 2007), namely the "Trier Social Stress Test" (TSST; Kirschbaum et al., 1993) that mainly consists of an anticipation period (10 min) and a test period (10 min) in which the subjects have to deliver a free speech and perform mental arithmetic in front of an audience. These results suggested that temperament may have links to neuroendocrine stress reactivity that go beyond simple changes in affect state and that could be related to the traits of the individual. Such relation becomes even more interesting to investigate when dealing with decision making.

Also, it is possible to highlight that the capacity to adapt or become accustomed to recurrent stress is also dependent on how a situation is perceived (McEwen, 1998). Indeed, the perception of a situation can be influenced by "decision stressors" such as information overload, time pressure, and, as discussed previously, complexity, uncertainty and risk (Phillips-Wren & Adya, 2020). It is possible to highlight how situations that overwhelm the subject of information can also induce stress and be negative for the accuracy of decisions (Marsden et al., 2006). Nonetheless, the literature does not adequately define the relationship between the previously mentioned conditions and decision

styles. Future research should therefore concentrate more on how the subject's decision-making style influences behavioural performance and psychophysiological response to situations involving stressful conditions.

7. Conclusions

To conclude, this theoretical contribution defines decision-making styles, highlights how they influence the decision and focuses on describing some of the constructs linked to decision-making styles: the goals self-representation, adaptability, risk-taking and risk management, and stress tolerance and regulation.

Based on the different methodologies that have been developed to study decision-making styles and given the interest in understand the decision-making style of a decision-maker in a comprehensive way, from a psychological, neuro- and psycho-physiological perspective, it is here proposed to exploit a multilevel and integrated approach encompassing self-report measures (e.g., using the different scales previously mentioned), behavioural data (e.g., accuracy or reaction times for specific tasks), and neuroscientific tools, such as EEG, fNIRS and autonomic measures recording. Through these last measures, in fact, it is possible to collect the emotional, attentional, and cognitive markers of a specific decision-making style, exploring the neuro- and psycho-physiological profile of the decision-maker.

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