La collana della Scuola di Alta Formazione Dottorale accoglie le migliori tesi di dottorato dell'Università degli Studi di Bergamo, insignite della dignità di stampa e sottoposte a procedura di *blind peer review*.

This work examines the relationships between decision-making (DM), risk-taking (RT) and creativity (divergent thinking, DT). Investigating the relationship between how people make decisions and the role of creative thinking (particularly divergent thinking) in this process could open the possibility of designing interventions to help people maintain autonomy and independence in their daily DM and risk management behaviours.
From the studies conducted, it can be concluded that there is a relationship between creativity (DT) and decision-making. Furthermore, DT is related to functional DM strategies and risk-taking profiles defined in the literature as more functional. This may suggest that strengthening divergent thinking may improve risk management and decision-making skills.

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47

Collana della Scuola di Alta Formazione Dottorale
- 47 -

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The Role of Creativity and Divergent Thinking

UNIVERSITÀ DEGLI STUDI DI BERGAMO

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Table of contents

Introduction

In this dissertation, an investigation about the relationship between the decision making (DM) process in lifespan, risk taking (RT), and creativity has been conducted.

Society is nowadays characterized by greater uncertainty and complexity than in the past. As a result, risk dominates individual and social consciousness in the twentieth century, and this increases the challenge of providing answers to the question, "How do people make decisions?" (Nyhlen and Liden, 2014). Furthermore, this society emphasizes independence and autonomy across the lifespan (Mather, 2006); making decisions is an essential skill at any age. However, some studies show an age-related decline that could compromise the ability and efficiency to take decisions in the financial domain and various aspects of daily life (Gamble et al., 2015). Despite this, good knowledge based on experience can be a protective factor in the DM process (Li et al., 2013). Cognitive, emotional, and motivational factors are crucial in the choice's process (Strough et al., 2015) and the relationship between emotions, cognition, bio-regulatory processes, and DM is well established during lifespan (Ramchandran et al., 2020). Besides, creativity, significantly divergent thinking (DT) (flexible thinking, fluidity of thought and originality) are also hallmarks of human intelligence involved in DM under uncertain or open situations (Collins and Koeklin, 2012). Even if DT is often confused with general "creativity", it has been better defined as an open-ended mental process that favours the generation of more answers to a given open problem, also considering unusual alternatives (the most striking example of DT is found alternative uses for a common object) (Palmiero et al., 2020).

DM includes finding concrete solutions to a problem by adapting them to the situation, identifying and selecting possible solutions, both formally and informally. Creativity plays a fundamental role in this process, especially in the case of formal DM, which is non-routine, relatively complex and non-repetitive. In this case, procedures, schemes, and methods in this type of decision-making may not exist and may not always be readily available as the problem and situation may lack precedents (Singh and Tyagi, 2020).

The firsts two chapters of this dissertation describe the different theories concerning the DM process, risk perception and DT. Chapter 1 concerns the evolution of the concept of DM from the first studies conducted in the 1950s to the contemporary ones; the description of the neuroanatomic correlates of the DM process and the differences in lifespan. The second chapter refers to creativity and divergent thinking (DT). Specifically, the evolution of the construct of DT and creativity is described,

presenting the main theories in this field; the chapter also considers the neuroanatomical correlates related to the constructs and changes in lifespan.

The main goal of the third chapter is to bring together knowledge from studies of how people make decisions, creativity, and DT. It is clear from the first two chapters that it is crucial to investigate the relationship between these constructs. However, because findings on DM, RT, and DT in the literature have often been inconsistent, we conducted a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This review allowed us to highlight how the study of this relationship, especially between RT and DT, has historically suffered from some theoretical and methodological problems.

Chapter 4 describes three empirical studies conducted by the University of Bergamo with Champlain College (Vermont, U.S.A.) and the Catholic University of the Sacred Heart (Milan, Italy). The first study investigates the three constructs using self-report questionnaires: General Decision-Making Styles, GDMS, Domain-Specific Risk-Taking Scale, DOSPERT, and Alternative Uses task, AUT among two samples of healthy young Italians and Americans (18-30 years). The second study investigates the relationship between DT, DM and RT in the lifespan in a sample of healthy Italians (18-75 years). The GDMS, DOSPERT, AUT and a DT task were also used in this study. Finally, the third study investigates this relationship in a sample of healthy Italians (18- 75 years) through the Melbourne Decision-Making Questionnaire, MDMQ; the Ultimatum Game; the Iowa Gambling Task and a DT task, Figure Task.

In Chapter 5, the general conclusion reports discussion and future direction/practical implications. From the organizational and operational point of view, the research was conducted online due to the health emergency caused by SARS-CoV-2 (Coronavirus Disease 2019). However, thanks to the help of colleagues from the three universities involved, starting from the end of February 2020 (when we saw the closure of the universities), we administered experiments and questionnaires remotely online. In particular, the Qualtrics platform was used for the self-report questionnaires, the DT and the Ultimatum Game, while for the other performance task, the Iowa Gambling Task, we proceeded with the implementation and programming on Pavlovia.

Chapter 1 Decision Making and Risk Taking

1.1 What is a decision?

Redish (2013) defines decision making (DM) as the process of selecting an action, meaning anything that physically affects the world (Grillner, 2003; Searle, 1965). Based on these premises, a decision is defined as any process that man puts into action, resulting in selecting an action from several possible alternatives (Redish and Mizumori, 2015).
DM is the result of cognitive and emotional processes, which determine the selection of the most adaptive behaviour among different alternatives involving the assessment of benefits (rewards and gains) and costs (punishments and losses) that could arise from choices (Bechara et al., 2000; Verdejo-Garcia et al., 2007). DM is a fundamental skill in everyone's life and is related to how decisions are made and not just with the subsequent outcome that follows them because this is sometimes out of our control (Antonietti and Valenti, 2017). It is a complex concept that does not simply imply "choice" but includes several processes. Therefore, we refer to the DM process and not simply the decision (Geisler and Alwood, 2018).

In cognitive psychology, Simon (1956) has theorized that people's decisions, and the procedures involved in this process, are determined by two main factors: the conditions under which the decision is made and the cognitive limits proper to men decisions. The limits of the cognitive system of the DM are related to environmental uncertainty due to incomplete information that people could consider. Simon (1995) pointed out that humans would use different procedures to make a choice depending on the arising conditions; the individual finds a sense of the situation, and it depends on several factors, such as the number of available alternatives, information about the results/consequences of each alternative, and various environmental factors (such as the presence of others) (Simon 1995).

According to Tversky and Kahneman (1992), theories of choice under uncertainty always consider three fundamental aspects: the objects of choice (gains and losses), the evaluation of alternatives, the proper characteristics of uncertain events, and possible outcomes. Furthermore, according to Hastie and Dawes (2009), a decision is a response to a situation characterized by three components: the decision-maker could explore multiple alternatives; the decision-maker has expectations about the

possibility that events have effects; the results are evaluated in terms of personal values (rewards and / or punishments) and purpose. From these premises, it can be deduced that decision-making is a complex process.

The beginning of DM research was characterized by dualism, the opposition between rational choice and passionate choice. On the one hand, there was the perfect choice based on profit maximization in these theories, while on the other hand, the choice is conditioned by emotional and social factors (Bellelli and Di Schiena, 2012, p. 85-92). Besides, it is known that decisions are driven by external (stimuli) and internal (affective aspects) factors and by the time it takes to achieve the reward (Leon et al., 2020).

1.2 Theories of decision making

In a review published in 2020, Strough and Bruine de Bruine described the different theories that have tried to explain this construct over the years. DM theories can be divided into three groups: normative, descriptive, and prescriptive theories. The former refers to the economic theories of rational choice (Edwarsd, 1954; Yates, 1990), according to which humans are led to choose what maximizes gain and thus obtain the desired outcome.

While at first what guided the study of human choice behaviour, was the notion of rationality and *perfect rationality* (Edwards, 1954; Newell et al., 1958), it was soon realized that people constantly violate rational predictions and the laws of logic (Wason, 1968; Koechlin, 2020).

These premises gave rise to the study of descriptive theories that refer to man's limited rationality (Simon, 1956). A milestone in this field is the work *The Administrative Behavior*, in which Simon (1947) introduced bounded rationality. Since the late 1940s, with the introduction of the concept of bounded rationality, various studies have recalibrated the theories underlying their actions in all areas of DM, including management theory (Simon, 1956; Kalantari, 2010; Kerr et al., 2007). Finally, prescriptive theories are the theories that propose interventions that fall back on the DM process (Bruine de Bruine and Bostrom, 2013).

A series of human cognitive boundaries play a decisive role in DM perspectives, which emerges through uncertainties and ambiguities (Simon 1955, 1990). Likewise, Simon (1955,1957) pointed out some characteristics present at the basis of human behaviour caused mainly by the limits of human cognition and some innate physical constraints.

During the DM process, humans' rational behaviour can be compared to a pair of scissors whose blades represent the problem's circumstantial elements and the subject's computational capabilities, respectively (Simon, 1956).

Cognitive, ethical, cultural, emotional, and social limitations, ambiguities, and incompleteness of information about alternatives, environmental constraints, the difficulty of anticipating consequences, the complexity of the problems, the limited DM time available, are the elements that- by pressing on the blades of the scissors- modify and influence the subject's field of actions (Turpin and Marais, 2004; Cristofaro, 2017).

In everyday choices, these errors have proven to be useful and seem to play an important role concerning the limits of human cognition, which rationally fails to consider all the information that would be needed to make decisions in a perfectly rational way (Dawes and Mulford, 1996; Hertwig, et al., 2005; Hahn and Warren, 2009; Gigerenzer, et al., 2012; Gigerenzer, 2015). From 2000 onwards, the mind-brain revolution has also helped researchers understand this concept (Cristofaro, 2017).

1.2.1 Normative and descriptive theories: from perfect to bounded rationality

Early DM theories were based on normative principles, considering the "*homo oeconomicus*" as the subject of choice, and the basic philosophy guiding these theories was absolute rationality; for this reason, they have been called Normative Decision Theory (Fishburn, 1988) and Rational Choice Theory (Blume and Easley, 2008). This body of theories was a guideline until the 1970s and involved formulating principles and normative rules of comparative evaluation and choice between alternatives (Rumiati and Bonini, 2001).

Normative theories are based on four rational choice processes (Edwards, 1954; Parker and Fishoff, 2005; Krstić, 2020): belief assessment; value assessment; integration combining belief and values; metacognition (awareness of weaknesses and strengths of one's decision process).

The normative model has its basis in the notion of *Expected Value*, which describes man's tendency to make decisions based on a logical-mathematical and statistical analysis of the probability of an event occurring. Expected utility theory includes a family of related theories that fall into two groups: "decision making under conditions of risk" and "decision making under conditions of uncertainty" (Luce and Raitfa, 1957). The former explains decisions that produce consequences and results with known probability; the latter concerns decisions whose results are uncertain due to events and circumstances whose probability is unknown. According to these theories, the decision-maker should compare these rules and adapt behaviours to obtain an optimal relationship between costs and benefits.

Among these, the most important is the theory of *Expected Utility* (EU) (von Neumann and Morgenstern, 1944; Morgenstern and von Neumann 1953) developed in mathematics and economics,

which lays down two principles as the basis for human choice: consistency (i.e., preferences are adjusted to standards/rules - axioms) and maximization (strategies for the best result). This theory assumes that future events can be represented by associating each of them with a numerical value. This number, in turn, represents the probability linked to the occurrence of each outcome. Thus, the concept of expected value refers to assessing events' consequences, taking due to this occurring probability (Bellelli and Di Schiena, 2012, p. 20-21).

Standard *Expected Utility Theory* (von Neumann and Morgenstern, 1944) was proposed and formulated in addition to game theory and soon became an essential basis for understanding how people make decisions in uncertain and risk situations. Furthermore, as described below, risk aversion and risk-seeking are determined solely by the utility function in expected utility theory.

In the late 1940s and early 1950s, criticisms of the axioms were spread by some authors (Preston and Baratta, 1948; Mosteller and Nogee, 1951), underlining previous violations of theory distortions regarding probabilities (Edwards, 1954). In this regard, studying the theory of *expected utility* and *rational choice*, Daniel Kahneman and Amos Tversky (1986) proposed a different theory that explains human behaviour when making decisions in risky situations. Many studies have pointed out that people violate their assumptions and predictions in some situations, which form the basis of expected utility theory; people are sensitive to gains and losses in different ways depending on the context and situation (Kahneman and Tversky, 1979).

The authors concluded that people do not choose perfectly rationally based on the probabilities of events. Instead, however, they select information based on individual patterns, which are also dictated by different framings of the options and by different reference points that are considered (Tversky and Kahneman, 1986). Thus, a reference dependence seems to emerge (Tversky and Kahneman, 1991), and this is the central assumption of the theory the authors propose: The *Prospect theory*.

The *Prospect theory* highlights some differences in DM compared to subjective expected utility theory, as shown below. Within this theory, there is ample space for the concept of "frame". The frame is defined as a mental structure that simplifies and guides understanding an otherwise complex reality. It is the frame within which judgement takes shape, and the subject can mentally represent the consequences of events (Antonietti, 2013, p. 76).

One of the differences from previous theories is that individuals do not assess the value of an option as absolute, but rather it is defined in terms of gains or losses relative to a reference point. Thus, potential gains and losses are not objective but are defined concerning subjective reference points that may vary over time and depending on the individual's situation (Antonietti, 2013, p. 76). Individuals also tend to overestimate small probabilities during the DM process but underestimate

large ones. Furthermore, individuals during a decision evaluate losses and gains differently from reference points, creating an asymmetry in the utility function in gains and losses that could explain loss aversion (Shao and Lee, 2014). For example, Tversky and Kahneman (1986) have shown that the intensity of displeasure following a loss is greater than the pleasure produced by winning the same amount of money. Likewise, people treat gains and losses differently, in the direction of loss aversion (in particular, they seem to overestimate losses compared to comparable gains) (Kahneman and Tversky, 1979; Tversky and Kahneman, 1986, 1991; Kahneman, et al., 1991). In line with this consideration, people tend, for example, to place more value on objects they own than on similar things they do not have, and that the disutility of giving up good is greater than the utility of buying it (Levy, 1997). This asymmetry also emerges about risk orientation, in the sense that people tend to be risk-averse concerning gains and risk-accepting to losses (Kahneman and Tversky, 1979). In the *Prospect Theory*, DM processes consist of two phases: framing and evaluation (Kahneman and Tversky, 1979). The subject uses the framing/assembly phase to collect and analyze information; The decision-maker constructs a representation of the acts and results. On the other hand, the second phase implies evaluating each perspective's value and choosing the most valuable alternative accordingly (Levy, 1997).

Proceeding to compare the two theories, while in Expected Utility Theory the crucial notion was that of "utility", in Prospect Theory this is replaced by the notion of "value". Moreover, the decision-maker does not treat the analysis of possible outcomes in terms of actual probability but distorts it, leading to overestimating small probabilities and underestimating medium to large ones (Cherubini, 2012).

The *frame* plays a fundamental role in the problem's representation; it can be considered as the point of view adopted by the decision-maker concerning the problem in front of him. This point of view is determined, in part, by the very formulation of the DM problem, the ethical-cultural-social norms of the subject, his habits and his characteristics (Cherubini, 2012). In addition, the *Prospect Theory* (Kahneman and Tversky, 1979) has placed some psychological aspects of the DM process as a crucial focus, introducing the importance of context and frame and the concept of awareness (Cherubini, 2012).

By proposing a comparison between the theories presented above and prospect theory, it can be inferred that the former, like mathematical theory, present a series of axioms, logical and internally consistent, which guarantee their validity (Favero and Modesti, 2013). Four of these were evaluated as the most relevant by Tversky and Kahneman (1981), who tried to highlight their limitations: the axiom of transitivity; the axiom of dominance; the axiom of invariance and the axiom of

independence (Tversky and Khanemn, 1981; Kahneman and Tversky, 1979). The axiom of transitivity prescribes that if outcome A is preferred to outcome B, B is preferred to outcome C, then outcome A must also be preferred to outcome C. Tversky (1969) has shown a contrary intransitivity of preferences in numerous circumstances. The second axiom of dominance states that the rational decision-maker always chooses the option with the highest expected value. However, Tversky (Kahneman and Tversky, 1979; Tversky and Khanemn, 1981) showed that there is often a violation of this axiom: if the dominant option implies a certain amount of risk, the risk aversion variable comes into play as a top regulating choice. The third axiom, invariance, states that this order cannot be modified if one outcome is preferred due to how the options are presented or compared (Rumiati and Bonini 2001). However, this axiom has also been refuted by numerous experiments that focused on studying the framing effect. The last axiom is independence, which assumes that if a particular outcome is independent of the choice made (A or B), it should be completely independent by the context (Savage, 1954). *"If you are indifferent between A and B, you will still be so if A and B appear inside a lottery"*. Again, Tversky refuted this axiom by demonstrating that it can act quite differently than it was prescribed.

1.2.2 Dualistic model of decision making

Despite the validity of the *Expected Utility Theory*, psychological research soon revealed that man's rationality is limited (Rumiati and Bonini 2001), influenced by judgment, irrationality, emotion.
In addition to the *Prospect Theory* illustrated above, a dualistic model of the DM process is presented in the most recent literature (Evans and Stanovich, 2013; Evans, 2008; Stanovich et al., 2011), which proposes two main components: the intuitive system and the analytical-rational system (referring to "Two model of thinking", Slovic et al., 2004). Furthermore, Kahneman and Tversky's studies from "prospect" theory (Kahneman, 2003; Kahneman and Tversky, 1979; Tversky and Kahneman, 1974) have contributed to the introduction of a dual view of thought processes regarding the distinction between two modes of cognitive and DM functioning, an affective/experiential system, and an analytical/ deliberative system (Evans, 2008; Osman, 2004).
Chester Barnard (1938), in *Executive Function*, stated that it is possible to make certain decisions without a transparent and conscious reasoning process and, when this happens, it is "so inexplicable that we call it intuition" (p. 305). In the following years' many researchers studied the relationship between intuition and decisions taken within dynamic environments where incomplete information could be found (e.g., Harper, 1988; McCarthy et al., 1993), defining intuition to accelerate the DM process (Prietula and Simon, 1989) and to manage the trade-off between speed and accuracy of the

process itself (Orlandi and Pierce, 2020). Evolution has led to the differentiation of two opposing mental systems that can be defined as System 1 and System 2: System 1 (Slovic et al., 2002) is also called the experiential and tacit system (Hogarth, 2001), while System 2 is also called the analytical and rational system (Slovic et al., 2002; Hogarth, 2001). While the activation of the intuitive system leads to choices that are made quickly, based mainly on impressions and without the use of relevant cognitive resources, on the contrary, the activation of the analytical-rational system involves a systematic evaluation of information before choosing which path to take (Slovic et al., 2004).
Metcalfe and Mischel (1999) also proposed a dual model of thought, which involves hot and cold systems. The first allows the subject to respond immediately to stimuli to satisfy needs. Thus, according to their emotional value, a system controls external objects obtained by reacting to stimuli. The second, aimed at controlling behaviour; its purpose is to allow the subject to be aware of his actions and consequences (Antonietti, 2013, p. 11-17).

Considering these perspectives, what emerges in studies tends to attribute successes to System 2 (analytical, rational and cold), while System 1 (emotional and experiential and warm) leads people to failures and flawed thinking (Antonietti, 2013, p. 11-17). A dual neural system also reflects the dual system. Intuitive thinking activated the left lateral temporal lobe (BA 21/22), the analytical reasoning, activated the bilateral superior parietal lobe (BA 7), and the deductive reasoning activated in addition to the parietal and temporal lobe the right lateral prefrontal cortex when people can resist the experiential temptations on the incongruent base-rate problems (Vartanian and Mandel, 2011).

Sanfey and colleagues (2006) associated System 1 with the amygdala, insular cortex, orbitofrontal cortex (OFC), anterior cingulate cortex, nucleus accumbens; and System 2 with the dorsolateral prefrontal cortex (DLPFC), anterior prefrontal cortex, (APFC), and posterior parietal cortex (PPC) [Table 1]. In line with this distinction, even when discussing DM styles, the intuitive and rational styles have almost always been considered two rival theoretical models (Wang et al., 2017).

Neural Correlates	**System 1**	**System 2**
Sanfey, Lowenstein, McClure and Cohen, 2006	Amygdala, insular cortex, orbitofrontal cortex, anterior cingulate cortex, nucleus accumbens	Dorsolateral prefrontal cortex, anterior prefrontal cortex, posterior parietal cortex
Vartanian and Mandel, 2011	Left lateral temporal lobe, BA 21/22	Bilateral superior parietal lobe, BA 7

Table 1 - Neural correlates of System1 and System 2

1.2.3 Heuristics, cognitive biases in decision making and risk taking

The gap between limited rationality and olympic rationality is not only a boundary, but, on the contrary, it can be considered as an adaptation that allows people to face complex situations with the cognitive means and the limited information in their possession, using strategies to cope with the complexity of the task starting from the constraints of the cognitive system (Rumiati and Bonini, 2001). Heuristics intervene in the information processing phase during the DM process (Tversky and Kahneman, 1974). As already mentioned above, the decision-maker is hardly able to analyze all the available information and alternatives. Instead, the decision-maker tends to rely on and adopt strategies called heuristics, which allow him to save resources by relying on the most readily available information (availability heuristics) or on processes that he can easily imagine (representativeness heuristics) (Kahneman et al., 1982).

These strategies require less mental effort and information from the decision-maker than required if one were to proceed according to absolute rationality dictates (Bellelli and Di Schiena, 2012, p.22).

Furthermore, according to the "*Heuristic and Biases Program*" (Tversky and Kahneman 1974), the intuitive system causes people to fall victim to evident biases, while the rational-analytical system critically analyses impressions. System 1 is about judgments and decisions made automatically and quickly, based on impressions characterized by feelings, passions, and emotions (fast-thinking Kahneman, 2011); on the contrary, System 2 has a controlled and slow operation (slow thinking, Kahneman, 2011).

The main goal of the "*Heuristic and Biases Program*" (Tversky and Kahneman, 1974) was "to understand the cognitive processes that produce both valid and invalid judgments" (Kahneman and Tversky, 1996, p. 582). Subsequent studies in the field of DM conducted by Kahneman and Tversky (1982) have defined heuristics as economic and functional strategies as they save cognitive resources when making choices in complex situations, even though they may expose humans to the risk of generating systematic errors (biases) (Kahneman, Slovic and Tversky, 1982).

Heuristics can be defined as simple rules for solving problems and the following logic very differently from sequential ones. For example, Tversky and Kahneman (1974) proposed four main heuristics employed in the judgment under uncertainty linked with the concept of the frame presented in prospect theory (e.g., *Representativeness*, *Availability*, *Adjustment and anchoring*, *Affective heuristics* (Tversky and Kahneman 1974; Slovic et al., 2004)).

The study of heuristics has undoubtedly had a significant impact on DM processes and has represented a turning point in considering even the most impulsive part of the decision. For Kahneman and Tversky (1972), heuristics are systematic tendencies that can sometimes lead to misleading reasoning by violating predictions based on logical normative criteria the fallacy of

conjunction (Tversky and Kahneman, 1983), and it is this rule that has been the basis of the critique of Gigerenzer (1996) and colleagues. In addition, they have highlighted some of the limitations of Tversky and Kahneman's (1996) description of heuristics. Gigerenzer (1996) opened the debate by considering some fundamental points in the description of heuristics: narrow norms, single event probabilities with reference, and content blind norms probably not reducible to conjunction rule.
Despite this, Gigerenzer (1991) sees the study of heuristics as a transition phase and not a point of arrival in research on DM. For the author, a good decision needs the application of procedures, schemes, an analysis of the content, and, in this context, it is also fundamental to consider emotions (Gigerenzer and Todd 1999). The most particular and well-known heuristic considered by Gigerenzer is the Fast and Frugal Heuristic, which allows people to quickly consider the available information (Antonietti, 2013, p.19) and stop searching for alternatives when a solution that might be satisfactory is found. This kind of heuristics, for example, is very useful in the medical field, especially in emergency medicine (Gigerenzer, 2000).
According to Stanovich and West (2000), the alternative explanations provided can be grouped as follows: performance errors; computational limitations; errors in applying regulatory models; a different interpretation of the problem, by the subjects, from that of the experimenter; individual differences. Heuristics, in turn, are associated with cognitive errors called cognitive biases (Gigerenzer and Gaissmaier, 2011): *"Cases in which human cognition reliably produces representations that are systematically distorted compared to some aspect of objective reality"* (Haselton et al., 2015).

People rely on reasons and analytical processes to solve a problem and consider emotions that can guide the choice process or heuristics that can save time and resources (Gigerenzer and Gaissmaier, 2011) - e.g., *Framing* (Gigerenzer and Gaissmaier, 2011); *Anchoring* (Kahneman and Tversky, 1974; Furnham and Boo, 2011); *Attribution errors* (Gigerenzer and Gaissmaier, 2011); *Self-confirmation* (Baldi et al., 2013). Individuals also use heuristics and biases to cope with risky experiences, in particular the illusion of control, the Locus of control (Cohen, et al., 1979), the optimistic bias (Weinstein, 1984), and the affective heuristic (Finucane et al., 2000). Furthermore, risk has both an objective and a subjective component, and its assessment does not refer only to the objectively determined probability of the occurrence of the consequences of an event (Hanna and Chen, 1998).

1.2.4 The influence of emotion in decision making

The circumstances in which human beings are called upon to make decisions are characterized by uncertainty and incompleteness of information, and people often show sudden and sometimes

inconsistent changes in the choices they make and one of the aspects that characterizes this discrepancy is the role that emotions play in this process (Wu et al., 2012).

From the 1970s onwards, several economic theorists became interested in "failures" and irrational choices in the DM process, linked to how people perceived risk and began to study irrational biases related to emotional aspects (e.g., fear, greed, anger) (Samuelson, 1965; Fama, 1970; Loewenstein, 2000). In addition to using heuristics and cognitive biases to resolve them, these irrational biases have been attributed to psychological factors with emotional overtones - including fear, greed and other affective reactions to price fluctuations and wealth shocks. Thus, to explain individual and market anomalies, a growing field of research has begun to examine the links between emotions and irrational DM (Loewenstein, 2000).

Initially, the influence of emotions was studied in terms of "passions", in contrast to rationality (impartial spectator), which are perpetually one opposite to the other (Smith, 1759). One of the most influential authors who studied the role of emotions in the DM process was Damasio (1996), introducing the concept of the somatic marker, which includes the importance of emotional connotation and affect in making decisions and considering the available alternatives. According to the author (Damasio, 1996), the DM process is different from an analytical process that systematically considers each possible alternative's advantages and disadvantages. He proposed the somatic marker hypothesis starting from observations of patients with lesions in the medial ventral prefrontal cortex (VMPFC), who, despite normal cognitive function, had deficits in emotions and feelings together with abnormalities in DM (Damasio, 1994). Damasio (1994) noted that in facing complex choices, individuals activate various strategies that refer to the results of past choices and for which it is possible to recognize a similarity of analogy with the ones they are facing presently. Thus, previous experiences act as memory traces (markers) that are not always conscious and can reactivate emotions and feelings positively and negatively.

These markers have been defined by Damasio (1994) as somatic markers (emotional signals), outcomes of experiences of somatic nature, capable of labelling experiences relevant to future actions according to whether they are perceived positively or negatively. Somatic markers attribute value to specific situations and scenarios (Vartanian and Mandel, 2011) and past choices; therefore, they condition the choice, mainly by previous somatic responses, confirmed by neurological and neuropsychological evidence. Emotions are said to enable humans to optimize actions and choices in the surrounding environment; the systems underlying the DM process play the role of resource optimizers that help the individual to gradually make the most appropriate choice, with the help of body signals activated in response to environmental stimuli (Damasio, 1994; Slovic et al., 2004).

According to Damasio (1994), a lifetime of learning leads to constructing and defining experiences marked by positive and negative feelings directly or indirectly linked to somatic/physical states. Moreover, these negative or positive somatic markers are permanently linked to images: when a marker signals a possible negative outcome, it reacts with an alarm; on the contrary, when a positive marker is associated with the image of positive consequences, the latter becomes an incentive signal for action. In this way, somatic markers increase the accuracy and efficiency of the DM process by helping people to make more functional and adaptive decisions (Damasio, 1994; Slovic et al., 2004). From these observations, Damasio (Bachara and Damasio, 2005) studied the consequences in patients' DM process with damages to the ventromedial prefrontal cortex and the structures involved in representing the body state (amygdala, insula, somatosensory cortex, cingulate and basal ganglia). The author verified that, in this case, the somatic marker is not activated, prompting patients to use a cognitive cost-benefit analysis, which results in a slower analysis of alternatives and can lead to unhealthy, non-functional, perseverative, and non-adaptive choices (Bachara and Damasio, 2005).

Damasio and Bechara (2002; Bechara, 2004) were among the first authors to study the emotional component in the DM process, investigating cortical and subcortical components (Bechara, 2004; Bechara and Damasio, 2003). According to the somatic marker theory, pleasant and unpleasant events are used as markers for future experiences through the activation of subcortical circuits, and the amygdala and the VMPFC are fundamental areas for DM regarding the control of rewards/punishments/emotions (Bechara et al., 1999; Bechara, 2005).

Following the division proposed by Hastie (2001), emotions are differentiated into experienced emotions, anticipated emotions, or decision process emotions and consequence emotions. Loewenstein and colleagues (2001) defined emotion as a visceral reaction linked to the perception of risk, or uncertainty, that accompanies the decision-maker, and Damasio (1994), in his theory of the somatic marker, speaks of these visceral reactions, distinguishing them as positive and negative if they act as an incentive or as a wake-up call. Immediate emotions, aroused by the presence of a specific stimulus, are then divided into two sub-categories: incidental emotions, which are to be attributed to experiences independent of the object being evaluated; and integral (Lerner and Keltner, 2000; Ferrer et al., 2016), representing the affective response directly associated with the object of judgement or decision. It seems that negative/positive moods can influence DM performance differently, especially in risky situations (Suhr and Tsanadis, 2007).

Among the models that aimed to investigate the role of immediate emotions in DM, there is the one proposed by Janis and Mann (1977). The authors, as previous shown, stated that DM performance degrades if strong emotions are not associated with it. Thus, the authors explain choice coping as emotion-focused coping. Depending on how the decision-maker assesses their self-efficacy (high or

low) in dealing with the problem, they will adopt different strategies, respectively, either problem-focused or emotion-focused.

Another model for describing emotional influences in DM is the Risk as Feeling Hypothesis (RAFH), proposed by Loewenstein and colleagues (2001). This model explains that, when faced with a decision in uncertainty and risk, specific reactions can be determined based on possible consequences, which influence the risk assessment (Loewenstein et al., 2001). The critical aspect of this model is that it explains how often a subject's decisions under the pressure of emotions can, in many cases, differ from what he would otherwise adopt based on a simple assessment of what will be (Bellelli and Di Schiena, 2012, p. 85-86).

Studies in neurophysiology and neuropsychology have confirmed the growing evidence of the importance of emotions in the DM process. These studies have also investigated the relationship between the limbic, emotional mechanism and the prefrontal cortex functions. The classical conception, which, as presented, was based only on the rational model, has given way to more complex research in which the emotional aspects have become the focus (Vartanian and Mandel, 2011)

The influence of the subject's emotional and affective state, both positive and negative, plays an essential role in choosing several available alternatives. Zhu and Thagard (2002) underlined how emotions could be significant for actions' origin and execution and control. Emotions have become part of the DM process from a neurological perspective since Damasio's (1994) somatic marker studies. Concerning anticipatory emotions, they result from a prediction made by the person and have a solid adaptive value (Mellers et al., 1999). Therefore, the focus in this area has mainly been to understand whether and how the anticipation of regret influences choices in both workshop and everyday life (Bar-Hillel and Neter, 1996; Ritov and Baron, 1990; Simonson, 1992).

1.3 Decision-making styles and personality

1.3.1 Decision-making styles

The DM process depends on different factors: the context (Payne, et al., 1993), time pressure (Ahituv et al., 1998); and the complexity or difficulty of the task (Brehmer, 1992), but also it refers to individual differences in DM style. Besides them, research has defined the individual thinking styles (Gambetti et al., 2008) as the preferred way of thinking (Sternberg, 1997) about strategies that the subject is used to adopt when he finds himself acting or thinking (Antonietti, 2013). Recently, rather than studying cognitive styles *per se*, the focus has shifted to research to identify and describe styles as predictors of performing tasks and solving problems (Iannello, 2007; Iannello and Antonietti,

2012). Much research has highlighted the importance of studying individual decision styles in the DM process to investigate the propensities to act in certain situations within different contexts when making choices (Stanovich and West, 2000). However, DM styles constitute a narrower construct and are limited to DM situations than thought styles, considered a broader category (Keefe, 1987). Decision styles are not personality traits, rigid and unchangeable but conceived as flexible and modifiable in response to specific decision contexts, situations, and circumstances (Hayes and Allinson, 1998; Gambetti et al., 2008). The main distinction found in literature is two-dimensional and refers to the deliberative-intuitive dimension (Epstein et al., 1996). This definition differentiates individuals between those who make decisions analytically and reflexively and those who, on the contrary, tend to make decisions quickly and intuitively. Although the rational style and the intuitive style have been regarded as rivals and independent, studies have shown that they can be understood as two processes that stand on a continuum and are therefore linked (Allinson and Hayes, 2012; Wang et al., 2017).

The first distinction between DM styles was proposed by Jung (1921), who pointed out some individual characteristics that play a fundamental role in the DM process. Jung (1921) distinguished between individuals whit “thinking” and “feeling”, identifying, with the former, those who rely on analytical, logical and purely rational thoughts and behaviour, while the latter (feeling) refers to those who pay more attention to emotion when making decisions. Based on these distinctions, Keegan (1948) identified eight DM styles, including thinking with intuition, thinking with sensing, feeling with sensing, feeling with intuition.

In the following years, Janis and Mann (1977) developed the Flinders Decision-making Questionnaire (FDMQ), intending to measure three DM patterns: defensive avoidance, hypervigilance and vigilance starting from a theory of DM that considers optimizing and sub-optimizing, satisficing and *quasi-satisficing* strategies. The authors concluded that these behaviour patterns depend on personality traits and contextual situations (Janis and Mann, 1977). Later, Mann and colleagues (1988) presented a revision of FDMQ, the Melbourne Decision making Questionnaire (MDMQ). This second instrument investigates four styles of DM: vigilance, hypervigilance, procrastination and avoidance (Note et al., 2000).

In the same period of Janis and Mann (1977), Arroba (1977) distinguished six DM styles: logical (oriented towards achieving one's objectives and making one's merits count), blind (characterizing a fast and effortless DM process), hesitant (i.e., procrastinating), emotional (based on emotions, feelings and subjective aspects), accommodating (oriented towards satisfying the expectations of

others) and intuitive (in which the decision-maker imposes his own choice without being able to justify it).

Instead, Scott and Bruce (1995) propose identifying multidimensional decision styles by differentiating the rational, intuitive, dependent, avoidant, spontaneous style. These distinctions form the basis of the General Decision-Making Style (GDMS) described below as one of the questionnaires used for the current research (Scott and Bruce, 1995). The *rational style* is characterized by a careful and thorough search for information and a systematic and logical evaluation of alternatives. The *intuitive style* focuses on trusting one's sensations, intuitions and attention to detail. The *dependent style* characterizes those subjects who base much of their behaviour on others' judgment and advice. The *avoidant style* shows a tendency to avoid making decisions and characterizes a procrastinating attitude. Finally, the *spontaneous style* is characterized by immediate intuitions and a desire to decide as quickly as possible. Many authors (i.e Bruine de Bruin et al., 2007) have emphasized the effectiveness of the rational and intuitive styles to guide the decision-maker to an optimal choice, while the dependent, spontaneous and avoidant styles are disadvantageous and labelled as maladaptive.

In contrast to Scott and Bruce (1995), Schwartz and colleagues (2002) identify a pervasive and relatively stable DM process rather than a specific and punctual DM style. Therefore, they define two tendencies: maximizing and satisficing. Maximizers tend to seek the best possible result (Moyano-Díaz and Mendoza-Llanos 2021); satisficers tend to settle for a sufficiently good alternative. Studies by Schwartz and colleagues (2002) showed negative correlations between maximizers and positive characteristics such as happiness, optimism, self-esteem and life satisfaction. Maximizers are less satisfied than satisficers in DM and are more likely to engage in social comparison. In addition, the maximizers were found to be more sensitive to regret. On the other hand, the same authors found positive correlations between maximizers and depression, rigorousness, and regret.

These two categorizations by Scott and Bruce (1995) and Schwartz and colleagues (2002) show areas of overlap and coincidence with the distinction identified by Torrance (Torrance et al., 1977; 1978; Torrance, 1987), distinguishing individuals with a left-handed thinking style and individuals with right-handed thinking style. According to Torrance (1987), the left-handed thinking style was usually linked to logical thinking, verbal code, and analytical procedures, while right-handed thinking was more related to original, unusual, artistic reasoning and visual strategies.

1.3.2 Personality traits

Additional elements that could influence the DM process are personality traits as emerged considering DM styles. Several studies have investigated how DM style can be predictable based on the personality characteristics of the decision-maker (Riaz and Batool, 2012; Rahaman, 2014; Bajwa et al., 2016; Franken and Muris, 2005; Deniz, 2011).
In its five basic dimensions (neuroticism, extroversion, agreeableness, conscientiousness, and openness to experience), personality can influence decision making, especially in situations of uncertainty and ambiguity (Franken and Muris, 2005; Hooper et al., 2004; McCrae and Costa, 2003).

In the literature, several pieces of evidence have been collected over the years using questionnaires to investigate DM styles, such as the Melbourne Decision Making Questionnaire, MDMQ (Scott and Bruce, 1995), and personality tests, such as the Big Five Inventory (BFI, Costa and McCrae, 1990; John and Srivastava, 1999). For example, the BFI is a five-factor model that investigates personality traits identifying five distinct personality factors: extroversion, agreeableness, conscientiousness, neuroticism, openness (Goldberg et al., 1980; Digman, 1990; Costa and McCrae, 1990; John and Srivastava, 1999).
Considering neuroticism, for example, high scores on this dimension are linked to a propensity to worry and affective disorders linked to stress (McCrae and Costa, 2003). On the other hand, conscientiousness is a personality construct, defined as the propensity to follow socially prescribed norms, the “tendency to respond in a certain way under certain circumstances” (McCrae and Costa, 2003). It is a fundamental determinant of health and positive and active ageing; a lack of conscientiousness is linked to behaviours at risk for health (Gullone and Moore, 2000; Terracciano and Costa, 2004; Weller and Tikir, 2011). The construct is related to controlling impulses, performing actions directed towards a goal, thinking/planning/organizing, behaving coherently concerning a circumstance (Roberts and Robins, 2000), and delaying gratification.

Neuroimaging studies show a link between conscientiousness and neural regions associated with attention, goal-oriented planning, and cognitive control (DeYoung, 2010; Adelstein et al., 2011). Openness is one of the Five-Factor Model dimensions (FFM; Digman, 1990) of personality traits linked to exploring information, identifying stimuli directed towards a goal, and helpful strategies to achieve it (DeYoung et al., 2014; DeYoung, 2015). The construct is defined “in both structural and motivational terms. Openness is seen in the breadth, depth, and permeability of consciousness and in the recurrent need to broaden and examine experience” (McCrae and Costa, 1997). This construct

influences perceptions in daily life attitudes and is linked to the possibility of taking into consideration the opinions of others, seeking more alternatives as solutions to a stimulus, referring to openness to experiences that can lead to more intrinsic rewards for engaging in activities cognitive, which can also be a motivational factor for getting involved in the face of complex decisions (Denissen and Penke, 2008). On the other hand, less openness can lead to distorted judgments based on limited information or present and fleeting emotions (Stanovich and West, 2008; Haran et al., 2013). The evidence gathered (Bayram and Aydemir, 2017) underlines that the rational and intuitive DM styles (MDMQ) are positively associated with all four BFI personality traits, except neuroticism. The dependent style (MDMQ) is positively associated with both agreeableness and neuroticism traits (BFI). The spontaneous style shows a negative correlation with agreeableness and conscientiousness traits and a positive correlation with neuroticism. Therefore, the results suggest that an extroverted personality is often accompanied by a spontaneous DM style, a pleasant personality by an intuitive and dependent style, a conscientious personality by a rational and intuitive style, and, at the same time, protects against the avoidant, and maladaptive style. A neurotic personality approaches the intuitive, avoidant and spontaneous DM styles and departs from the rational style. Finally, an open-minded personality often involves a rational DM style. The link between personality traits and DM is still controversial; some significant studies involve mainly adolescents in the literature, but this significance seems to weaken considering the adult sample (Cooper et al., 2008).

1.4 The role of risk

Risk is defined as a measure of uncertainty about an outcome (Kahneman and Tversky, 1984), and it is a fundamental component in the decision-making process. For example, risk taking is defined as "*the propensity to select an option that potentially leads to a relatively large gain or loss instead of an alternative associated with a relatively small gain or loss*" (Slovic et al., 1987). Moreover, when people have to make decisions, they often have to consider a risk component dictated by uncertainty (lack of all necessary information, limited rationality in considering all possible alternatives, difficulty predicting consequences with certainty). Some theories, especially economics, point out that the individual in the decision-making process takes several steps to determine each alternative's expected reward. Thus, the risk associated with it and risk-seeking or risk aversion are not violations of "normative DM theory", but it could be well explained by theories such as subjective expected utility theory and prospect theory (Bell, 1995; Savage, 1954; Kahneman and Tversky, 1979).

1.4.1 Definition of risk

Risk and uncertainty can be introduced and considered at different levels of the decision-making process: in the demand function, the cost function or both (Cristofaro, 2017).

In psychology, the risk is defined as the propensity to adopt behaviours in which the consequences are not entirely predictable, resulting in a loss or gain. In predicting future uncertain events, the risk is the variability compared to what is expected, that is, the possibility that a result other than expected may occur (Lubart et al., 2019).

Over the years, the attitude to risk has been considered a personality trait or a general domain, but several studies have introduced the hypothesis that risk is context-specific and domain-specific (MacCrimmon and Wehrung, 1986; 1990).

Considering risk as a personality trait means considering it a stable characteristic, not determined by situations but linked to biological or early childhood differences (Eysenck et al., 1985; Allport and Allport, 1921). On the other hand, considering risk related to different domains means thinking of it concerning behaviour determined by specific situations and tasks, emphasizing the more complex character of the concept of risk (Mischel and Shoda, 1995). This second definition follows the subjective differences in decision making partly result from differences in risk perception. This causes people to behave differently when faced with ambiguous and uncertain situations by considering the possible alternatives in terms of gains (risk as something desirable) or losses (risk as something to be avoided) (Weber and Weber, 2001; Blais and Weber, 2006).

Among the components of risk, there are three main aspects: intolerance/tolerance of uncertainty and ambiguity (Ladouceur, Talbot and Dugas, 1997), cognitive risk tolerance (Snelbecker, 1967; Charyton, 2005, 2008), and risk propensity (i.e., risk appetite) (Sitkin and Pablo 1992). Intolerance/tolerance of uncertainty and ambiguity is closely related to anxiety (Ladouceur et al., 1997).

Ambiguity is a fundamental and unavoidable component of decision making (Payne et al., 1992), and the ability to tolerate ambiguity avoids premature closure of choice alternatives in context (Stoycheva and Lubart, 2001) and helps a person to cope with the discomfort of conflict-induced by the uncertain decision-making situation (Einhorn and Hogarth, 1981).

Uncertainty can be described as the tendency to consider as intolerable the occurrence of a future adverse event. Individuals who find it difficult to tolerate uncertainty feel threatened by an uncertain future stimulus and focus on anticipating future consequences (Iannello et al., 2017).

Cognitive risk tolerance is a positive psychological construct (Feldman, 2003) that can be considered the subjects' predisposition to formulate and express ideas regardless of the possible opposition from others or the consequences of their choice (Charyton 2013a; Charyton 2013b).
Finally, *risk propensity* is defined as the willingness to take on potential risks to obtain positive results (it is state and context-specific), also allowing the possibility that adverse personal outcomes may occur as a result (Dewett, 2006). These two aspects of risk, ambiguity tolerance and cognitive risk tolerance, are central attributes for creativity and creative thinking, as described in later chapters (Charyton and Snelbecker, 2007; Zenasni et al., 2008; Charyton, 2005; Charyton et al., 2008).

1.4.2 Risk in decision making

Risk perception also influences the prediction of uncertain future events by defining the variability regarding what is predictable in terms of loss or gain (Lubart et al., 2019) and is related to the possibility of making judgments without knowing the actual outcome/consequences actions (Kahneman, 2003).
The most studied decision domains that exhibit varying degrees of risk include gambling, financial investments, business decisions and personal decisions (health, social, ethical) (MacCrimmon and Wehrung, 1986; 1990; Weber et al., 2005; Blais and Weber, 2006).
In society, three categories of risk can be distinguished. First, risk as feelings refers to quick, instinctive, and intuitive responses and reactions in the face of danger. Second, risk analysis involves using logic, reason, and scientific deliberation on the management of hazards. The third category is called “simple” risk (Slovic et al., 2004; Slovic and Peters, 2006). Finally, the ability to recognize certain risks and estimate them is innate and learned (Girotto et al., 2007). However, risk education and learning will never be exhaustive and cover all the stimuli that an individual will face in his/her life (e.g., “new risks” and new situations).
Irrational risk behaviour (biases), in addition to those described above, includes overconfidence (Barber and Odean, 2001; Gervais and Odean, 2001), loss aversion (Kahneman and Tversky, 1979; Shefrin and Statman, 1985; Odean, 1998), herding (Huberman and Regev, 2001), psychological accounting (Tversky and Kahneman, 1981), miscalculation of probabilities (Lichtenstein et al., 1981), and regret (Bell, 1982; Clarke et al., 1994).

1.5 Neuroscience of decision making and risk taking

The DM process involves many brain areas (Schultz and Dickinson, 2000). The prefrontal system plays a fundamental role in successful DM, but in addition to this area, the limbic system and the amygdala are also fundamental to effective DM (Iannello and Antonietti, 2008). To investigate the role of neuroscience in DM, two groups of models are crucial: the reinforcement learning models (RL) (Sutton and Barto, 1998; O'Doherty, 2004) and the uncertainty monitoring models (UM) (Behrens et al., 2007). The former defines the result's value that maximizes the action's usefulness, guiding the set of behavioural activities. The latter emphasizes that the executive functions can influence the decision, that is, the ability to infer the consequences and results of the action, can help the actor to recalibrate the behaviours and make them more efficient in a continuous monitoring activity (Doya 2002; Samejima and Doya, 2007). However, these models do not explain how the frontal executive function can control the behavioural strategies that lead individuals to act in changing environments (Collins and Koechlin, 2012).

What is known about the cognitive neuroscience of DM is most based on the study of patients with frontal lobe damage that showed the differences between normal and pathological DM mechanisms (Fellows, 2016). An example is the study of patient *Phineas Gage.* He was a worker who survived a dynamite explosion. Thanks to modern neuroimaging techniques, Damasio and colleagues (1994) decided to reconstitute the accident by studying the skull of Gage (Vartanian and Mandel, 2011). They found differences from the first studies on the patient as an impairment in personal and social DM, despite preserved intellectual abilities, especially in bilateral damage of Ventro Medial Prefrontal Cortex (VMPFC).

Patients like Phineas Gage carry out the DM process after the injury is no longer functional since it does not consider the consequences of their actions. Furthermore, patients cannot learn from previous mistakes and are led to repeat choices that are not functional, which leads to losses (Vartanian and Mandel, 2011). As Damasio and colleagues (1994) have shown, damage to the VMPFC leads to difficulties in using and activating the somatic (emotional) signals necessary to guide and influence decisions in the good direction (Bechara et al., 1999; Damasio, 1996). The VMPCF acts as a zone of convergence and divergence about past events recorded in memory and emotionally connoted neuroanatomical structures that induce emotional responses (brainstem). The somatosensory and insular cortex contains the conscious or unaware representations of the event itself (Damasio, 1994). Within the VMPFC, the area most involved in the DM processes is the orbitofrontal cortex (OFC) that is activated in specific contexts such as "economic" or "reward" (Roesch and Olson, 2004; Padoa-Schioppa and Assad, 2006). In addition, several studies conducted with Functional Magnetic Resonance Imaging (fMRI) have also shown the activation of these areas during the assignment of

values or preferences to a choice (Volz et al., 2006) and during reinforcement learning (Montague et al., 2006). In addition to these areas, nuclei of the midbrain, striatum, parietal cortex, and dorsolateral prefrontal cortex (DLPFC) are also activated in tasks requiring the management of reward value information (Fellows, 2007; 2016). For example, DLPFC is activated in conditions of risk, where the consequences of choices are uncertain and unknown, and it controls reward behaviour based on information obtained from experience (Wallis and Miller, 2003; Barraclough et al., 2004; Huang, 2017; Luo et al., 2017). It is known that the dorsolateral prefrontal cortex is mainly activated in overcoming inappropriate heuristic perceptions during the choice (Vartanian and Mandel, 2011). The rLPFC (right lateral prefrontal cortex) seems to primarily engage in incongruent problem-solving tasks where it is required inhibitory control and conflict resolution, but also when people feel negative emotions during the process of DM (i.e., in case of risk and uncertainty) (Goel et al., 2000; Aron et al., 2004; Van Veen and Carter, 2006; De Martino et al., 2006; Huettel et al., 2005; Hsu et al., 2005; Sanfey et al., 2003). Moreover, several subcortical structures are implicated in the DM process, i.e., the amygdala, and mesolimbic - mesocortical dopaminergic projections, related to reward and addiction (Schultz, 2002). The amygdala plays an essential role in emotions in the DM process (Bechara et al., 2003). It allows, in the face of a stimulus (primary inducer), to connote it emotionally. Not only this is possible with intrinsically pleasant or unpleasant objects, but also in the case of concepts such as winning or losing money, which elicit a somatic response as the primary inducer, in this case; the function of the amygdala is to couple the characteristics of the object with its emotional attribute (Vartanian et al., 2011). Furthermore, the amygdala is activated when a “fight or flight” behaviour is required, allowing rapid responses deriving from relatively automatic processes (Berkowitz, 1993; LeDoux, 1996). Unlike the VMPFC, which is involved in emotional situations guided by thought, reasoning and more controlled processes (Schneider and Shiffrin, 1977) that could be defined as secondary inductors (i.e., thoughts and reflections). Bechara and colleagues (2003) showed that this highly emotional brain structure could help make more rational decisions, thus having an essential DM role.

The neuroanatomical areas taken into consideration when talking about risk-taking are very similar. They overlap with those described above for the decision process because, as we have seen, the risk is a vital component of choice, especially in uncertain situations. One of the fundamental aspects of the neuroscience of risk perception is the dopaminergic system activity, especially in predicting, signalling, and learning the value of punishments and gains (Mohr et al., 2010). Several studies have revealed the dopaminergic system's direct action during the DM process in risky situations (Shao and Lee, 2014). In addition to dopamine, other neurotransmitters also influence the individual's choice,

such as serotonin that controls processing immediate (low levels) or delayed (high levels) rewards (Tanaka et al., 2007). Dopaminergic neurons are present in the midbrain and project to those important regions for encoding value, probability, rewards (reinforcement, reward and punishment) and signalling of aversive stimuli: the ventral striatum and caudate nucleus (Tobler et al., 2008; Seymour et al., 2004).

In addition to these areas, a fundamental role is played by the ventromedial prefrontal cortex (VMPFC), the ventrolateral prefrontal cortex (VLPFC), the orbitofrontal cortex (OFC), dorsolateral prefrontal cortex (DLPFC) and the insular cortex (Shao and Lee, 2014). For example, the OFC has connections with the insular cortex, the anterior cingulate cortex, and limbic regions. These connections allow information from external/internal stimuli to be linked to body states (Paulus et al., 2007). The insula, in turn, is activated by situations with high physiological and emotional arousal that influence the anticipatory processes of DM (Shao and Lee, 2014).

1.6 Decision making and risk taking in lifespan

Across the life span, DM skills (Resistance to Framing, Recognizing Social Norms, Under/overconfidence, Applying Decision Rules, Consistency in Risk Perception, Path Independence, and Resistance to Sunk Costs; Parker and Fischhoff, 2005) relate to good decision consequences (Bruine de Bruin et al., 2007). Moreover, an efficient DM process is crucial for living an independent and autonomous life (Mather, 2006). Taken together, research on the mechanisms behind age differences in DM shows a complex picture in which changes in cognitive resources interact with affective (emotions) and motivational factors. The older population grows beyond industrialized nations; therefore, a better understanding of age differences in DM is gaining importance, and the challenges of ageing are essential to help older adults remain self-reliant (Löckenhoff, 2018).

Furthermore, in their reviews, Grady (2000) and Bäckman and colleagues (2006) showed that ageing is associated with a neurobiological and cognitive decline, which consequently changes the DM abilities of the elderly.

An inefficient and non-functional DM process could indicate cognitive ageing, linked to a decline in some structures and brain functioning, leading to poor decisions (Tymula et al., 2013; Ramchandran et al., 2011). These difficulties can also make healthy older adults vulnerable and fragile in making economic and financial evaluations (Tymula et al., 2013). Therefore, it is crucial to keep in mind that neurobiological, neurophysiological, and neuro-behavioural changes in the elderly influence these two systems, and, in particular, the analytical component weakens to the advantage of the affective one (De Beni and Borella, 2015).

The emotional impact that investments and choices can affect decisions is crucial in lifespan (Feng and Seasholes, 2005). Furthermore, the elderly tend to be more affected by loss than gains, and this attitude often leads them to remain anchored to losing decisions for longer than the younger, precisely because of the aversion to the risk of taking decisions that would lead to a loss (Kahneman and Tversky, 1979; Odean, 1998).
The famous French cognitive neuroscientist Etienne Koechlin (Collins and Koechlin, 2012) proposed that DM can be considered structured according to different main components: cognition, motivation, emotion, and brain structures. Several studies showed that some DM skills decline, while others remain untouched or improve with age. Ageing is associated with longer deliberation times and reduced risk taking. However, considering impulsivity, that in general, decreases with age, some components remain stable or increase, i.e. risk tolerance (reduced judgments of personal risk); reflection impulsivity (that is, the tendency to make rapid decisions based on limited information) and delay aversion (discounting of delay rewards).

Several studies investigated age effects on DM and risk perception (Best and Charness, 2015). It seems that while the elderly generally avoids physical risks, they face changes in risk-taking in the medical field (Hanoch et al., 2018) or perceive themselves as less risk-inclined in using the Internet as well as for taking financial risks (Samanez-Larkin and Knutson, 2015). Many studies on DM focused on changes in these abilities throughout life (Queen and Hess, 2010; Sproten et al., 2018), whereas other studies have shown that risk preferences do not change (Ashman et al. 2003; Henninger et al., 2010; Zamarian et al., 2008) and have found that older individuals are more risk-averse than younger ones (Deakin et al., 2004; Dohmen et al., 2011; Tymula et al., 2013). Furthermore, there are mixed results, and one recent meta-analysis finds no evidence of a change in risk-taking for lifespan (Mata et al., 2011). It emerged that older adults are less likely than younger people to engage in the DM process in the first place and often circumvent the whole process (Finucane et al., 2002). Instead, they tend to delegate the choice or avoid it, and both laboratory experiments and research confirm this trend into realistic choices (Chen et al., 2011; Löckenhoff et al., 2016).
Adults/seniors tend to look for fewer possible solutions considering a limited number of alternatives (Reed et al., 2013) to involve less information and, therefore, the possibility of making decisions more quickly (Mata and Nunes, 2010). On the one hand, this implies considering general and personal information as more important but reduces the search for more information sources and, therefore, more alternatives (Hess et al., 2013; Cansino et al., 2013). They, therefore, tend to consider less compressed and more systematic decision strategies and alternatives, both in action and in the representation of the various choice options (Mata et al., 2007).

This happens because, in this age group, people are more inclined to use heuristic strategies based on previous experiences and rely on these in proceeding with the choice (Bruine de Bruin et al., 2016). This attitude is also reflected in the difference in risk perception and management of risk between younger and older. The latter seems less willing to take risks than young people, although recent research shows this is not the case for all DM fields. (Mamerow et al., 2016; Mather et al., 2012; Pachur et al., 2017).

Numerous studies highlighted the existence of a neural basis shared between cognitive and emotional intelligence and specifically showed the role them in economic decline in DM in healthy ageing (Barbey et al., 2014; Gläscher et al., 2009; Gläscher et al., 2010; Haier, 2016, Barbey et al., 2014; Operskalski et al., 2015). Starting from these premises, Eberhardt and colleagues (2019) proposed a description of different elements that influence the decision process in ageing. According to this study, individual differences can be divided into the cognitive aspects potentially relevant to financial decisions and the individual non-cognitive differences that characterize potentially relevant decisions, especially in financial DM. The first group of components include mathematics and knowledge based on experience, the second group includes emotions, especially in the negative aspect and motivation (Eberhardt et al., 2019).

Concerning the strategies used in the DM process (heuristics), there is a change in people's life courses, especially about how alternatives and information are presented to older people when deciding. Older adults make fewer optimal and less efficient decisions due to heuristics as they tend to consider more the positive attributes provided by various choice options. This performance in decision tasks seems to decrease significantly in some domains with age, but performance is not related to gender (Besedes et al., 2012).

Changes in the DM with advancing age have been studied also by Rosi and colleagues (2019), reporting that older people are less accurate in applying decision rules. However, this decline is mediated by working memory and verbal fluency (a component of DT as reported on chapter 2).

1.6.1 Cognition

Regarding cognition changes, it is fundamental to consider the speed of process, working memory, inhibition: components that decline with age (Löckenhoff, 2018; Cattell, 1943). In addition to these aspects, special attention should be paid to fluid and crystallized intelligence (Löckenhoff, 2018).

Fluid intelligence refers to online cognitive processing, reasoning, associated with inductive reasoning, novel problem-solving, "manipulation of abstractions, rules, generalizations, and logical relationships" (Carroll, 1993), while crystallized intelligence refers to offline processing, it is

dependent on prior experience and related to learning and acculturation. Since the first (e.g., reasoning, problem-solving) weakens with age, older adults should perform worse DM tasks that tap fluid cognitive ability. They seem to be less adaptive in choosing appropriate strategies (Lemaire et al., 2004), vulnerable to making inconsistent choices (Tymula et al., 2013). Furthermore, older adults often overestimate the ability to recall their previous choices (Groß and Pachur, 2019) due to cognitive neglect of prior losses in the present or future choices. The elderly is also characterized by an aversion to ambiguity (Tymula et al., 2013), leading to heuristic biases, making older, less adaptive decision strategies.

Furthermore, Samanez-Larkin and Brian Knutson (2015) showed that although fluid cognitive ability declines linearly in adulthood, crystallized ability increases non-linearly, and these changes imply context-dependent differences in DM performance [Figure 1]. If the decision requires a higher involvement of fluid and low crystallized intelligence, younger individuals might perform better than older individuals; conversely, when the high crystallized ability is required, older individuals might perform better (Samanez -Larkin and Knutson, 2015)

Working memory plays a fundamental role in the DM process because it allows memory and manipulation of data in the pre-decisional moment (Salthouse, 2010). Consequently, a decline in this ability can lead to limitations in the pre-decisional collection of information and compromise strategies requiring constant comparison between multiple alternatives.

Numerous studies showed that inhibitory control changes dramatically over the life course following an inverted U function (Bedard et al., 2002; Cowan et al., 2006; Dempster, 1992; Durston et al., 2006; Zelazo et al., 2004), and a decline in inhibitory ability (Butler and Zacks, 2006) may increase the intrusion of irrelevant information and guide decision-makers towards ineffective responses.

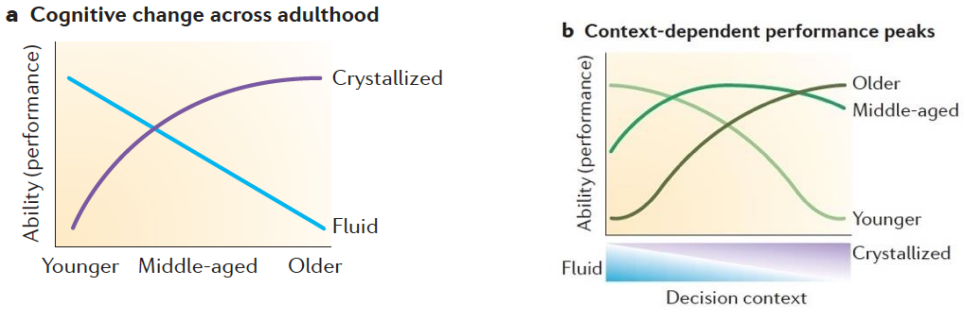


Figure 1 - Age-related differences in decision performance depend on cognitive demands (Samanez - Larkin and Knutson, 2015)

More generally, a physiological decline in executive functioning skills can hinder the strategic allocation of resources in the DM process and implement functional behaviours in the choice

(Salthouse, 2010). These difficulties emerge most strongly when the older person is faced with choices in complex scenarios, when he/ she is required to make decisions in a short time, and when there is no clarity between what is essential to the context and what is irrelevant (Salthouse, 2010).
Nevertheless, performance on some DM tasks may require experience, which increases with age, so older adults should perform at least as younger adults (Bruine de Bruin et al., 2012). Moreover, experience-based knowledge is crucial for acquisitions in different cognitive domains that could positively influence decisions and choices (e.g., Baltes et al., 2006; Salthouse, 2004). An essential aspect in this context is crystallized intelligence, which can relate the experience to personal finances and other domains of life. This can be functional in countering age-related cognitive decline and facilitating better and more functional DM in the financial sphere (Li et al., 2013). This is linked to crystallized intelligence that is domain-specific, pragmatic, and idiosyncratic (vocabulary knowledge, complex job performance, music composition, sports, arts) (Salthouse, 2004; Verhaeghen, 2003; Sturman, 2003; Hayes, 1981; Ericsson et al., 1993).
In addition to executive functions and these aspects of intelligence, one of the cognitive components involved in DM is a mathematical skill, particularly numeracy (the ability to understand and manipulate numerical and probability information) (Schwartz et al., 1997). This skill is crucial for making decisions, especially in the health area (insurance and screening), as well as in economic and financial (inflation, pensions) fields (Peters et al., 2007; Reyna et al., 2009; Lusardi, 2012; Van Rooij et al., 2011). However, when these numeracy math skills are evaluated throughout life, older adults perform worse than younger adults due to cognitive decline in fluid intelligence skills (e.g., Bruine de Bruin et al., 2015; Lusardi, 2012).

Older individuals seem to face more significant difficulties in making decisions (Frank et al., 2007; Hanoch and Rice, 2006; Hibbard et al., 2001) and are more prone to decision errors (Finucane et al., 2002) concerning specific cognitive aspects, especially memory situations. Memory can be defined as any physical change (within the brain and between neurons) that carries information about the historical past (Engert and Bonhoeffer, 1999; Malinow and Malenka, 2002; Silva et al., 1998). Memory is fundamental in the DM tasks as it allows past information to intelligently and functionally guide the process of choosing and considering variables (Dudai and Carruthers, 2005; Schacter et al., 2007). However, the past and the strategies used in previously seen contexts do not always play a role in favour of current choices, especially when subjects are in dynamic environments where it may be essential to discard obsolete information (Kraemer and Golding, 1997). In addition to the permanence part of the memory, its transience capacity plays a key role. When the environment changes, it may also help change the task's strategy and analyze the available options. Otherwise, the risk is to

persevere in not functional choices and sometimes even harmful (Richards and Frankland, 2017). The transience function of memory can then help in eliminating information that is no longer appropriate for the context, in favour of more efficient and valuable information for that particular situation: forgetting is necessary for flexible behaviour in dynamic environments such as those in which humans often (if not always) find themselves moving (Dong and Potenza, 2016; Epp et al., 2016).

Richards and Frankland (2017) highlighted the importance of impermanence as a function for optimizing memory-driven DM in changing environments by allowing individuals to exhibit flexible behaviour and generalize past events to new experiences. A fundamental aspect of memory-related cognitive skills is that the ability to recall information selectively requires attentional control, target retention and inhibition of less relevant information (Balota and Faust, 2001; Waszak et al., 2010; Zelazo et al., 2004).

Linked to the concept of memory capacity, Castel and colleagues (2011) hypothesize the presence of a "motivational" selectivity in the field of DM focusing on essential or high-value information while limiting access to lower-value or more peripheral information. However, this behaviour has not been seen in children and adolescents and the older old, possibly due to incomplete development in the former or declining frontal lobe function in the latter case and insufficient metacognitive monitoring (Castel et al., 2011). Motivation is linked to thinking decisively about a person's complex problems (need for cognition) (Cacioppo et al., 1984). This varies from individual to individual, and in particular, the literature underlines that motivation plays an essential role in decisions and choices in the economic field: those who have a greater interest in financial news seem to have more chances to save (Brounen et al., 2016). It appears that older adults are less motivated to engage in complex tasks than younger adults if they are perceived as potentially irrelevant to achieving their goals (Bruine de Bruin et al., 2015; Hess et al., 2014; Strough et al., 2015).

1.6.2 Emotion and affect

Regarding *emotion and affect*, we have to consider incidental affect, integral affect, the trade-off aversion, and literature shows that older adults often base their decisions on positive affective information because they are less arousing (Charles and Carstensen 2007). Generally, they avoid sunk costs and biases (Bruine de Bruin et al., 2012). Emotional aspects influence DM because emotions provide meaning to various alternatives and information that the decision-maker can consider (e.g., Peters et al., 2000). The emotional responses are defined in a two-dimensional space characterized by emotional value and excitement. There are reduced levels of negative affective experience in adults than in young people, while positive affective experience remains unchanged. This change

related to age can cause less attention and reduced memory for negative material than positive experiences. This implies that older people may assess costs and benefits, losses and gains differently from young people in DM (Samanez-Larkin and Knutson, 2015).
From studies in this field, it appears that older people tend to be more emotionally driven than younger people in making decisions by the motivation to optimize positive emotional experiences (De Beni and Borella, 2015).
This could also be linked to lower availability of attentional resources with advancing age, especially those negatively connoted and a poorer memory for these events than those positively connoted (Samanez-Larkin and Knutson, 2015). In this way, older people tend to adopt simple DM strategies with a low cognitive load (Chen and Sun, 2003). This propensity, dubbed the "positivity effect", is found in various contexts, both in the information processing phase preceding the choice itself and in the act of DM and evaluation of consequences (Peters and Büchel, 2011). As mentioned above, the weakening of analytical processes leads to compensation with the consequent enhancement of affective processes (De Beni and Borella, 2015).

By describing affection/emotion, neural networks play an essential role, especially considering the responses to gains and losses. The affect – integration – motivation framework, taking up some previous models, shows that the neural components anticipate the gains and losses in the DM process, respectively, in the first case with the dopaminergic projections to the *nucleus accumbens* and the second with the noradrenergic and dopaminergic projections to the anterior insula. A fundamental role is then played by integrating with the mPFC and the glutamatergic projections that subsequently promote the motivational component and further evaluate possible alternatives (Samanez-Larkin and Knutson 2015) [Figure 2].

The propensity to the positivity effect and affectivity heuristics (Löckenhoff and Carstensen, 2005) can lead the elderly to some errors and failures in DM, precisely because it causes their decisions to be guided by affective labels that are gradually associated with the stimuli without adequately investigating all the alternatives and information they own (Slovic et al., 2002; Rydzewska et al., 2018). As a result, a sort of bias is created whereby attention is directed purely on positive information (Peteres et al., 2007) and in this way, the experiential component takes over in the research process, conditioning the little evidence collected based on memories, which is strongly connoted by the positivity effect (Rydzewska et al., 2018).

1.6.3 Changes in neural substrates

Physiological changes in the elderly brain are driven by atrophy and loss of neurons due to apoptosis, and this loss of brain tissue tends to be more severe in the frontal lobes, which are crucial in the DM process (Raz et al., 2005).

Considering the *neural substrates*, as regards the differences in the DM process according to the singular ages, we moved from an initial focus on the temporal and lateral medial regions, implicated in cognitive processes such as attention and memory ageing, towards the prefrontal regions associated with executive functioning, the frontostriatal pathways associated with the elaboration of rewards and limbic regions associated with affective elaboration (Hess et al., 2015).

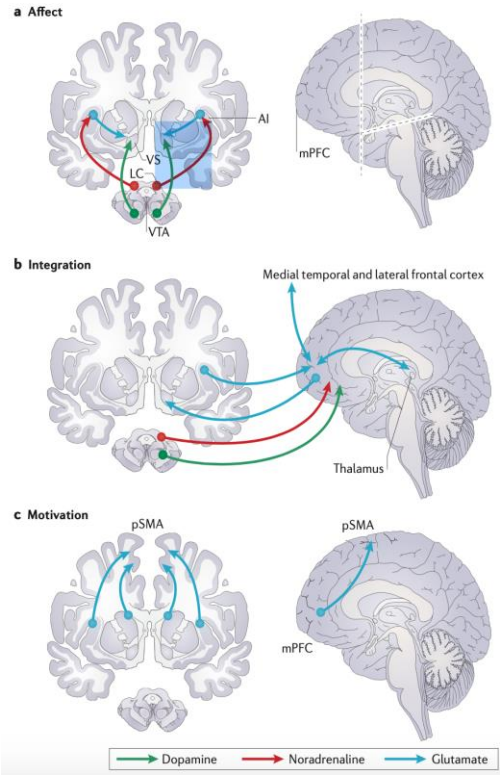


Figure 2 - Important components of the affect–integration–motivation framework (Samanez-Larkin and Knutson, 2015)
[Ventral Tegmental Area=VTA; Ventral Striatum= VS; Anterior Insula=AI; Locus Coeruleus=LC; Media Prefrontal Cortex= mPFC; Pre-Supplementary Motor=pSMA]

Taken together, these studies on the mechanisms behind the DM process and the age differences show an interaction between deliberative and experiential resources with affective and motivational factors. However, in the last two decades, the rapid improvements in imaging techniques have begun to consider the neurobiological bases and the neural substrates of this ability (Löckenhoff, 2018). Among these regions, the dorsolateral prefrontal cortex (DLPFC) plays a significant role in cognitive

control and executive functions (e.g., Barbey et al., 2013; Ballard et al., 2011), and it has a pivotal role in DM as well (Camus et al., 2009). For example, right DLPFC is involved in self-regulation and inhibitory cognitive control on affective impulses, and it could limit the influence of impulses in DM behaviour (Pripfl and Lamm, 2015).

Concerning the cognitive skills listed above, in the transition from childhood, adolescence, and adulthood, the development of the frontal lobes leads to some abilities' changes, including memory capacity (Welsh et al., 1991).

Neuroanatomical differences may lead to good memory capacity, but this is not necessarily associated with good metacognitive skills, which are crucial in managing risk and dealing with uncertain situations (Shin et al., 2007). Increased risk-taking and overconfidence in one's memory capacity are related to changes in the nucleus accumbens relative to frontal development (Galvan et al., 2006; Galvan et al., 2007; Shin et al., 2007).

As previously described, neuroanatomical and neurophysiological changes are accompanied by changes at the level of neural circuits, in particular dopaminergic circuits, characterized by a reduction in dopamine receptors which consequently modifies reward learning and thus affects stimulus-response learning mediated by reward, especially in the case of new associations (Kraytsberg et al., 2006; Inoue et al., 2001).

To summarize, to understand how DM strategies change in ageing, one cannot disregard the study of changes at the neuronal level, both structural and related to dopaminergic systems, as these are generally involved in executive functions, working memory, episodic memory and processing speed, functions that are fundamental for functional DM (Shao and Lee, 2014).

Chapter 2 Creativity and divergent thinking

Unlike other constructs studied in psychology and neuroscience, there is no unambiguous explanation of the creative process in the literature, and there is no single cognitive or neural mechanism uniquely linked to creativity (Dietrich, 2019). To highlight the difficulty of defining this construct, Plucker, Beghetto and Dow (2004) selected 90 articles in different fields (economics, psychology, and education) from scientific journals that had the word "creativity" in the title. The authors point out that only 38% of these tried to define "creativity explicitly".

An essential contribution to the study of creative thinking is provided by factorial psychology, for which thought is made up of units of factors that correspond to cognitive abilities. To better study creativity, it has been broken down into several subtypes, and the most significant was the concept of *divergent thinking* (DT) proposed by Guilford (Guilford, 1967).

This chapter describes the evolution of creativity in its components and the role of divergent thinking in the creative thinking process.

2.1 Creativity

Creativity is defined as the process of creating something new, original, and capable of adapting to the task's restrictions with a value in a context (Sternberg and Lubart 1999; Bourgeois-Bougrine, 2020). Runco and Jaeger published an article on the "Creativity Research Journal" (2012), tracing the history of the definition of the term creativity. The two authors consider the definitions proposed by Barron (1955) and Stein (1953) as standard. Barron (1955) wrote, *"The first criterion of an original response is that it should have a certain stated uncommonness in the particular group being studied (...). A second criterion that must be met if a response is called original must be adaptive to reality. This requirement intends to exclude uncommon responses which are merely random, or which proceed from ignorance or delusion*" (p.478-479).

In line with this definition Stein (1953) defined creativity in these terms: "*The creative work is a novel work that is accepted as tenable or useful or satisfying by a group in some point in time (...) By 'novel' I mean that the creative product did not exist previously in precisely the same form. The extent to which a work is novel depends on how it deviates from the traditional or the status quo*".

In his definition Stein (1953) includes usefulness, novelty and emphasizes the difference between personal and historical creativity (Runco et al., 1996; Runco and Jager, 2012).
We cannot avoid mentioning Bruner (1964, 2005), who studied creativity concerning learning, stressing the pervasive nature of creativity in various human dimensions (cognitive, behavioural, social). According to Bruner (2005), creativity is accompanied by the term *surprise*, of which he defines three types: predictive, metaphorical and formal. The first is the surprise linked to the prediction of the outcome of the action, the second is typical of art, while the third arises because of the combination of elements that usually appear distant from each other (Bruner, 2005).
According to Kaufman and Sternberg (2007), when we talk about creative ideas, we refer to three fundamental components, taking up the proposed definition of creativity. First, creative ideas must represent something new and different from what has already been produced, they must be of high quality and appropriate to the situation/context and the task at hand (Kaufman and Sternberg, 2007). To sum up, also according to these authors, an idea to be creative must be new, good and relevant.

2.1.1 Types of creativity

Types of creativity are described in the Four C model of creativity (Kaufman and Beghetto, 2009). The model includes mini-c (personal creativity), Little-c (everyday creativity), Pro-c (expert creativity), and Big-C (genius creativity). The authors' studies began with Little-c and Big-c; two further specifications were added, the mini-c and Pro-c (Kaufman and Beghetto, 2009).
Several authors investigated Big-C creativity (Simonton, 1994; 2004; Gardner, 1993; Csikszentmihalyi, 1999), referring to evident creative contributions resulting from a creative genius. However, the other predominant approach to creativity focuses on its contribution to everyday activities, the "common man" (Richards et al., 1988). The authors who study this type of creativity refer to the concept of little-c, and their theories aim to show how creative potential is widely distributed and can be an opportunity facing everyday problems (Kaufman and Baer, 2006; Sternberg et al., 2004). Alongside these two dimensions, Beghetto and Kaufman (2009) proposed two new categories, mini-c and Pro-c [Figure 3]. Mini-c is defined as the new and personally meaningful interpretation of experiences, actions and events, and it is in line with what Runco calls "personal creativity" (Runco, 2004). In this category, the dynamic and interpretative processes of comprehension, the construction of reality within the socio-cultural context, predominantly come into play (Beghetto and Plucker, 2006; Vygotsky, 2004). Vygotsky (in Moran and John-Steiner, 2003, p. 63) proposed a definition of creativity in line with this category as "*internalization or appropriation of cultural tools and social interaction…not just copying, but rather a transformation or*

reorganization of incoming information and mental structures based on the individual's characteristics and existing knowledge".

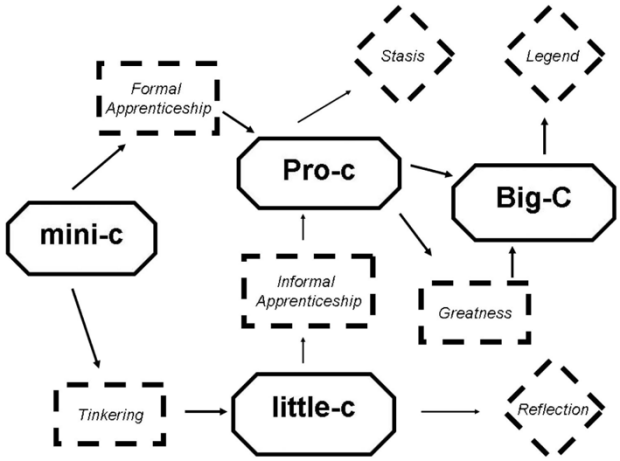


Figure 3 - Four C model of creativity

The Pro-c category represents the evolutionary and effort progression beyond little-c but has not yet reached Big-C's status (Kaufman and Beghetto, 2009). In particular, Pro-c is reached after a specific time engaged in an activity requiring creative skills (Kaufman and Beghetto, 2009). An example of an existing theory that would seem to fall into the Pro-c category is the Theory of Propulsion of Creative Contributions (Sternberg et al., 2002).

2.1.2 Models of the creative process

Models of creativity have been proposed since the 19th century and can be said to stem from the statement of Helmholtz, a physicist and psychologist who wrote about problem-solving*: "happy idea came unexpectedly without effort, like an inspiration"* (Wallas, 1926, p. 80; Sadler-Smith, 2015). The resulting models of creativity have mainly taken into account four phases of the creative process, which can be summarised as preparation, incubation, illumination, and verification, although they have been deepened and partly modified by various researchers (Lubart, 2001).
Guilford (1950), while emphasizing the importance of the four-stage models as will seen below, also identified other skills that are involved in the creative process, such as sensitivity to problems, the ability to produce many ideas from a given situation or problem, the ability to change the point of view and to reorganize the elements involved. Both conscious and unconscious aspects of the human mind always play a crucial role in the proposed models, especially in the phases of preparation and

evaluation/verification of the solution and its consequences; the unconscious aspects are involved mainly in the phases of incubation and illumination (Sadler Smith, 2015).

Wallas' theory (1926) of creativity is a milestone in research to the extent that many researchers on this topic still take it as a foundation (Vartanian et al., 2013). This theory is based on four stages of the creative process: preparation, incubation, illumination, and verification (Wallas, 1926). The model is evocative of theories of associationism; Wallas (1926), in his book The Art of Thought, often uses the terms "associations" to describe the dynamics at work in the conscious and non-conscious processes that explain this four-stage model. Sadler-Smith (2015), starting from this model, added a further step, identified with the term: Intimation [Figure 4]. The intimation is a *"manifestation of a rising train of association that may ascend toward the threshold of consciousness at different rates, and last for varying lengths of time"* (Sadler-Smith, 2015).

The model is thus identified with three levels of consciousness (consciousness, fringe consciousness, non-consciousnesses) and five interlinked steps: preparation, illumination, and verification, which are part of the first level; intimation, which occupies the second level, while incubation, which invokes the non-conscious processes, engages the third one (Wallas, 1926).

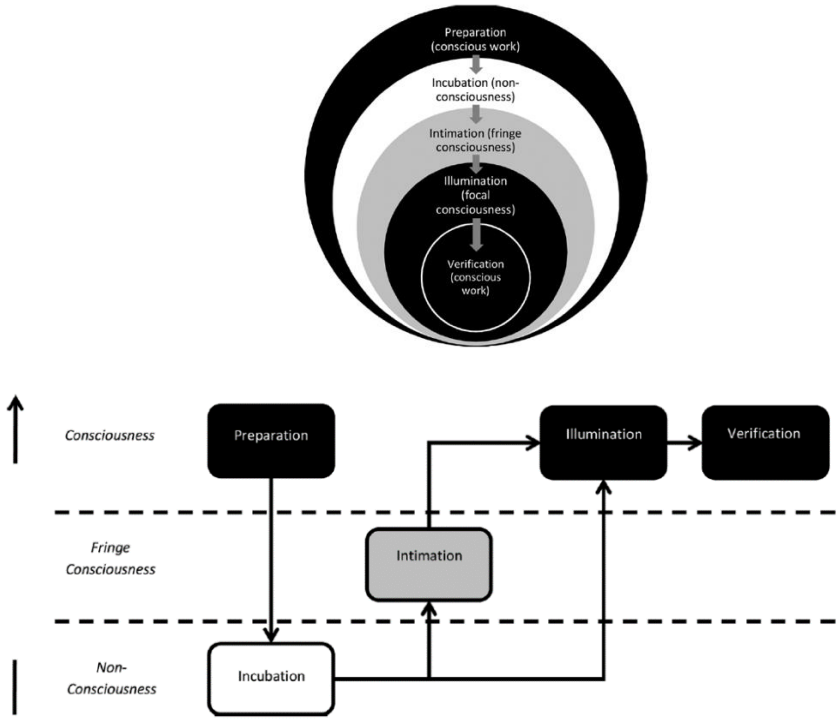


Figure 4 - Wallas' and Sadler-Smith's model of creativity (Sadler-Smith, 2015)

As shown in Table 2, many authors have used this model for their investigation and studies.

From these early models, creativity research has sought to investigate the components and sub-components of the construct.

A critique of this model of distinct and structured stages has been carried out by several authors who emphasize the simultaneous and integrated character of the creative process (i.e., Eindhoven and Vinacke, 1952; Ghiselin, 1985). Guilford (1950) also proposed a theory that distanced itself from this four-stage model, criticizing, in particular, the incubation phase. The author defined it as follows: *"it is not incubation itself that we find of great interest. It is the nature of the processes that occur during the latent period of incubation, as well as before it and after it"* (Guilford, 1950; p. 451). In 1967, Guilford emphasized the importance of several sub-components of the process, which will be better explained in the definition of divergent thinking.

Stage	*Related Concepts*	*Relevant Sources*
Preparation	Domain	Csikszentmihalyi (2006)
	Complex domain relevant schemas	Dane and Pratt (2007)
	Expertise	Ericsson, Prietula, and Cokely (2007); Klein (2013)
Incubation	Spreading activation	Bowers, Regehr, Balthazard, and Parker (1990)
	Unconscious thought theory	Dijksterhuis and Meurs (2006)
	Blind variation/selective retention	Simonton (1999)
	Neural cliques and neurds	Gabora (2010); Gabora and Ranjan (2013)
Intimation	Creative intuition	Dane and Pratt (2009); Gore and Sadler-Smith (2012); Policastro (1995); Thagard (2014)
	Feelings of knowing	Koriat and Levy-Sadot (2001)
Illumination	Anterior superior temporal gyrus activation	Jung-Beeman et al. (2004)
	Neural cliques and neurds	Gabora (2010); Gabora and Ranjan (2013)
	Neural representation, recursive binding, semantic pointer competition	Thagard (2014)
Verification	System	Amabile (1996)
	Field	Csikszentmihalyi (2006)
	Aesthetic intuition	Dirac (1963); Wild (1938)

Table 2 - Review of the literature: studies that used Wallas' Model of creativity (Sadler-Smith, 2015)

Mumford and colleagues (1991) also investigated a set of critical processes for creativity. They identified a dynamic model in which the combination of elements, the reorganization of ideas, the selection and combination of categories, analogies, and divergent thinking come into play.

Finke and colleagues (1992) proposed the Geneplore model in the following years, in which the focus is characterized by two main processes and not by different subcomponents of a unique action: generative and explorative. The processes included in the two phases contribute to obtaining a creative outcome. The generative phase concerns the construction of ideas starting from the recovery, association, and synthesis of ideas, transforming them. The exploratory phase concerns examining, processing, verifying, and interpreting pre-inventive structures (Lubart, 2001).

In addition to these models, Dietrich (2004) proposes a new approach to creativity and a challenge to better describe the types of creativity that can be defined from the study of this construct by outlining future lines of research. According to the author, creative products can be generated through three modes of information processing: deliberative (DM), spontaneous (SM), and flow (FM). In the first mode, creative products are generated by continuous, deliberate trial and error; in the second mode, creative products and ideas arise suddenly, involuntarily in the subject; in the third mode, the creative product is generated by a non-conscious flowing movement (Dietrich, 2004). The first two models

are related to the previously described modes of research and thinking: analytical and intuitive (Simonton, 1975). About thought patterns, the deliberative mode is associated with conscious processing, the feeling of autonomy, executive attention, effort and control, intentionality, and planning, as with the analytical mode of thought. In contrast, the spontaneous mode is associated with unconscious processing, inattention, effortlessness in an intuitive, automatic, and accidental mode (Dietrich, 2004). Finally, the third modality related to flow is characterized by a different peculiarity, physical movement (Csikszentmihalyi, 1999). According to the author, the experience of flow occurs when one is intensely concentrated on a task (reading, listening or playing music), and time and everything else seems to disappear.

Neuroanatomy underlines the differences between the three models of creative production, particularly in the function of the prefrontal cortex activity, the configuration of the neural network or task set, and explicit-implicit systems, as explained in the following paragraphs (Monsell, 2003). Although there is no clear-cut specialization, we increasingly talk about connections and neural networks (Dietrich, 2004; 2019). The deliberate mode is mainly characterized by activity in the prefrontal cortex and is associated with social norms, beliefs about the world and social schemas (Dietrich, 2004; Miller and Cohen, 2001). The spontaneous mode can be considered a part of the explicit mode but associated with the default mode network (Dietrich, 2019), whereas the flow mode requires automation of movement and action (Dietrich, 2015) and a general state of transient hypofrontality [Figure 5].

	Anatomy	Processes	EAs
DM	Explicit System	HCF Online	Higher Sightedness
	PFC Activation	Foresight and Agency	
	Hierarchical Network	Close Associations	
SM	Explicit System	HCF Weakened	Lower Sightedness
	Mild TH	No Foresight and Agency	
	Even Network	Remote Associations	
FM	Implicit System	HCF Offline	Blindness
	Strong TH	No Foresight and Agency	
	Implicit Network	Motor Effciency	

Figure 5 - Dietrich's Model of Creativity (Dietrich, 2019)

A final mention to The WCR model of Creativity (Antonietti et al., 2011) defines three mechanisms (widening, connecting and reorganizing) of creativity and general mental operations that seem to rely on creativity. Widening represents open-mindedness and the ability to handle several elements at once; connecting, establishing relationships between different elements; and reorganizing, the readiness to change one's point of view and thus reorganize one's thinking.

2.2 Divergent thinking and creative potential

The first time that DT appeared in literature was in 1956 by Guilford. He based his studies on thought and intellect on factorial theory, and he described the construct of DT as one of the five operations that contribute to intelligence within the Structure of Intellect (SOI) model (Guilford, 1967).
Guilford (1967) delineated a complex model consisting of several factors, of which the two main ones were *memory* and *thinking*. The first refers to different memory capacities (e.g., auditory, and visual memory). The second factor has some main sub-components that the author defined upon the kind of action performed, and they are the cognition (or discovery capacity), the production and the evaluation factors (Guilford, 1957) [Figure 6].

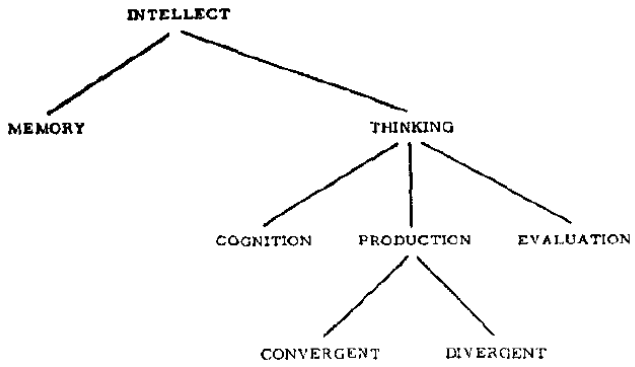


Figure 6 - Structure of Intellect (SOI) model (Guilford, 1967)

He describes three aspects that contribute to individual intelligence: content, operations, and products in his book. The contents refer to the sum of the knowledge acquired over time by the subject; operations refer to how knowledge is used; finally, the products represent all the new knowledge and ideas that human beings can obtain and realize because of thinking (Guilford, 1956).
According to the author, a creative act involves all three aspects of thinking: cognition, production and evaluation (Guilford, 1957). Inquiring into the production factor, Guilford (1950; 1967) distinguishes two different types of tasks that lead, consequently, to two different ways of thinking, convergent thinking (CT) and divergent thinking (DT). While the former is activated in the case in which only one relevant response is requested and is limited to the situational context, the latter focuses on generating multiple solutions and multiple alternative ideas in response to a stimulus or problem, situations that allow multiple ways out overcoming the closure of the initial data (Eysenck, 1995; Antonietti and Colombo, 2013).

DT can be defined as the ability to break conventional or obvious thought patterns, adopt new and higher-order rules, and think conceptually and abstractly (Dietrich, 2019). This aspect is fundamental in a decision process, especially in uncertain or risky situations, and allows for generating new actions and new rules promoting the subject's adaptive and functional behaviour (Collins and Koechlin, 2012). The distinction between DT and creativity has not always been very clear; In fact, early research has sometimes confused DT's concept with the more general creative capacity (Piffer, 2012). Despite this, it is now accepted that DT is not synonymous with creativity but is one of the most significant creative thinking proxies (Runco and Jaeger, 2012; Runco and Acar, 2012).
The first author who expressed this idea could be considered Wallach, in 1970, who described DT tasks as a predictor rather than a criterion of creative performance. Therefore, DT tasks are considered estimates of the potential for creative problem solving, and it has been shown to predict creative achievements over other variables such as intelligence (Runco and Jaeger, 2012; Runco et al., 2010). Furthermore, some research shows that children with a higher DT ability are more successful in various academic, arts, and sciences fields (Torrance, 1988; Furnham and Bachtiar, 2008). In addition, DT is believed to stimulate the cognitive processes that lead to creative responses through alternative thinking and associative cognitive pathways (Barbot and Reiter-Palmon, 2019; Runco et al., 2016).

Guilford (1956) identified three indicators that characterize divergent thinking: fluidity, flexibility and originality. The first indicator, fluidity (or *fluency*), is defined as the number of possible ideas that are generated by the subject; the second *flexibility* instead refers to the number of different categories to which the ideas belong; finally, *originality* focuses on the probability of giving unconventional and unusual, but in any case, feasible responses (Guilford, 1956). More recently, *elaboration* has also been included as the ability to elaborate an idea through details. Thanks to these characteristics, the DT is often made to coincide with the definition of "creative potential" (Runco et al., 2016; Acar and Runco, 2019), highlighting a difference between this concept and creative behaviour/thinking (Karwowski and Beghetto, 2019).
Creative potential can be defined as the ability to produce original ideas that have value in their context. This capacity can be measured in three different ways: by examining the actions/performances produced by subjects, by investigating the skills and traits underlying creativity, and through contextualized tasks that simulate real-world creative work (Lubart et al., 2019).

2.3 Assessment

Starting from the definition of creativity and its sub-components, authors have attempted to create standardized psychometric instruments to measure and investigate this construct (Mednick, 1962; Torrance, 1974). In this field, there was a "watershed" around the 70s. Before this date, the studies had focused more on the output and the creative products - considering creative the productions of individuals emerging in science, art, music and theatre- after (Fusi et al., 2020). Then the interest in the processes underlying creative output has grown. As a result, several authors have begun to question themselves about possible questionnaires and tests to evaluate the construct of creativity (Fusi et al., 2020). In this direction, divergent thinking (DT) became fundamental (Barbot and Reiter-Palmon, 2019). Psychometric tools can easily measure DT in its components of fluidity, flexibility and originality, although there are still debates regarding the scoring of responses, the actual divergence of thought and the use of associative cognitive pathways (Runco et al., 2016).

From these premises, it is clear that assessing creative skills is a complex process and could benefit from using different methods and tools (Piffer, 2012; Runco et al., 2016).

One of the crucial and most critical aspects of creative thinking assessment is the reliability, validation, and replicability of measures of creative potential, activities, and outcomes (Forthmann et al., 2021). Recently in the literature, there has been a growth of theoretical and empirical work that has focused on improving the evaluation of creativity (Reiter Palmon et al., 2019; Forthmann et al., 2021).

Moreover, one of the trickiest aspects of evaluating creativity is that it often coincides with tests that measure the construct of DT (Acar and Runco, 2014, 2015). However, the latter is not an index of general creativity, nor the creativity of a product, but, as mentioned, an index of "creative potential" (Runco, 2008). Moreover, the answers requested and provided in divergent thinking tests are often not creative products per se, but rather ideas which, following selection and processing, may or may not lead to creative products (Piffer, 2012).

Interest in assessing creative thinking and its core cognitive processes is steadily increasing in the scientific literature despite the difficulties mentioned above. Indeed, researchers have turned towards this field of research due to the improved use and development of more effective statistical methods that allow the assessment of complex relationships (Karwowski et al., 2017; Silvia et al., 2014). Furthermore, the evaluation of creative potential is becoming increasingly precise and timely, defining the terms that constitute it (fluidity, flexibility, originality, elaboration) (Benedek et al., 2013; Forthmann et al., 2018).

In this way, the conceptualization of creativity focuses on creative abilities or cognitive potential, and the psychometric assessment of this creative ability is mainly based on divergent tasks (Benedek et

al., 2014c). These tasks typically require the generation of creative ideas to solve open-ended problems, and the responses are assessed for fluency (the number/quantity of responses), flexibility (shifts into different categories), and originality (unconventional or remotely associated responses problems (Kaufman et al., 2008). There is evidence in the literature that DT has validity concerning real-life creativity (e.g., Benedek et al. 2014a).

From these studies, the concept of DT has become the most widely used standard experimental paradigm for investigating creativity (Dietrich, 2019). An example of a way to measure DT is the Alternate Uses Task (Guilford, 1967) that involves asking participants to generate as many original uses as possible in response to verbal prompts (i.e., as many novel uses of a bottle) with a time-constrained.

2.3.1 TTCT, ATTA and Figure Task

This paragraph presents the most widely used tests for assessing creativity and DT, and a figurative task that will be better described in the experimental chapter (Chapter 4).

The *Torrance Tests of Creative Thinking* (TTCT) (Torrance, 1987; 1998) is one of the most frequently used tests to investigate creativity and the component of DT (i.e., unusual uses tasks (UUT), Torrance, Ball, and Safter, 1992). The TTCT (Torrance, 1987; Torrance, 1998) comprises two forms, A and B, and verbal and figural tasks further investigate differences in creative performance (Dietrich, 2019). There are three figural tasks in the TTCT in which the subject must construct one or more designs based on different stimuli, with consequent scores for fluency, flexibility, originality and elaboration. The verbal tasks are based on the principle of alternative uses (Clapham, 2011).

However, the test has some limitations, such as the length of the test (45 minutes for the verbal part and 30 minutes for the figurative part) and the cognitive effort required, which makes it challenging to use in specific contexts, for example, in the workplace (Al-thuizen et al., 2010), in the clinical field, or on specific populations such as healthy older adults or those with diseases. For this reason, Torrance and collaborators developed an abbreviated version of the test for a population of adults, first proposing in 1980 the Demonstration Form of the Torrance Test and, later, the *Abbreviated Torrance Test for Adults* (ATTA; Torrance and Goff, 2002), in which three of the nine tasks of the original TTCT are proposed.

The advantages of this shortened form are the shorter time required (15 minutes) for completion and the ease of administration. The ATTA test includes three simple tasks: a verbal task and two figurative tasks, each of which is given a time limit of three minutes.

This instrument is based on the same theoretical assumptions of TTCT, the studies on intelligence and creative thinking proposed by Guilford (1950, 1968), in particular on divergent thinking and problem-solving skills (Sternberg and Lubart, 1999). Moreover, this test, thanks also to repeated longitudinal studies (Torrance, 1972), has shown good predictivity of people's creative success in everyday life situations (Torrance and Goff, 2002).
The literature shows that figurative tasks elicit higher originality scores than verbal tasks, probably because the latter is more constrained or familiar and allows for routine associations (Runco and Albert, 1985).

One of the recent figurative tasks found in the literature is the *figure task* (Agnoli et al., 2016; see Chapter 4). This task includes three figurative tasks (three abstract black and white drawings), very similar to those used by Wallach and Kogan (1965). Participants are asked in three minutes for each figure task to list all the things they can think of each figure might represent. A crucial aspect of figurative tasks is that they tend to elicit higher originality scores than verbal tasks. This is because verbal tasks are more constrained or familiar and allow for routine associations (Runco & Albert, 1985).

Instead, a widely used test in the literature to measure divergent thinking is the Alternate Uses Task (AUT), designed by Guilford in 1967. The AUT requires thinking about and naming as many uses as possible for a simple, commonly used object, such as a brick. Scoring is done by considering scores on fluency, originality, flexibility, and elaboration.

2.3.2 Scoring methods

Csikszentmihalyi (1999) argued, *"If creativity is to have a useful meaning, it must refer to a process that results in an idea or product that is recognized and adopted by others. Originality, the freshness of perspective and divergent-thinking ability are all well and good in their own right as desirable personality traits. Nevertheless, without some public recognition, they do not constitute creativity (...). The underlying assumption [in all creativity tests] is that an objective quality called 'creativity is revealed in the products and that judges and raters can recognize it"* (p. 314).
In the literature, three main scoring methods are distinguished concerning DT: traditional methods that involve scoring participants' output on fluency, flexibility, originality, and elaboration; a subjective method that implicates scoring the individuals' output directly on "snapshot" creativity; the definitional approach that means scoring output separately on novelty and usefulness (Vartanian

et al., 2020). Furthermore, about the component of DT, the scoring of originality is the trickiest one, as mentioned below. One of the most used techniques to score DT is the Consensual Assessment Technique (CAT), initially developed by Amabile (1982, 1983, 1996).
This technique assesses creativity by asking experts to rate the creativity of a set of artefacts from any domain. The experts work independently, judging the responses and not having the opportunities to communicate or influence each other. As a result, the inter-rater reliability using CAT is typically relatively high, most often 0.80 or higher (Amabile, 1996; Baer et al., 2004; Hennessey, 1994; Kaufman et al., 2013).

Considering CAT, creativity assessment is always local because it depends on its norms and individuals collaborating in this evaluation. However, the local character of creativity poses a problem for tests of creativity, such as that of Torrance (1974), because such tests assume that there is some universality to creativity—that it is possible to score the tests and then provide scores that will apply in any time or place, but the debate is open nowadays.
In a recent review, Reiter-Palmon and colleagues (2019) identified several aspects that can affect the assessment of DT, including the choice of dimension, instruction-scoring fit, adequacy of responses, objectivity and subjectivity, level of scoring and the method of aggregation.

2.4 Creativity and cognitive processes

The literature reports positive relationships between intelligence and creativity (Batey and Furnham, 2006) and, in particular, intelligence seems to be correlated with some cognitive indicators of creativity, e.g., divergent thinking (Batey et al., 2010).
Creative thinking skills thus involve both executive (control) and associative (spontaneous) processes (Marron et al., 2018). Specifically, executive processes include working memory skills (Benedek et al., 2014b), fast-processing speed (Dorfman et al., 2008), switching ability, and inhibition of responses irrelevant to the purpose of the task (Benedek et al., 2012; Zabelina et al., 2012). Associative processes related to creative thinking include a propensity for mind wandering (Baas et al., 2008), disinhibition of inhibitory control mechanisms (Radel et al., 2015), concatenation of multiple responses (Benedek et al., 2013), and retrieval of personal episodes from episodic and semantic memory (Madore et al., 2015; Crepaldi et al., 2020). Furthermore, recent studies, e.g. Frith and colleagues (2021), emphasised the role of attention and intelligence in DT.
A first insight should be made bearing in mind that intelligence can be understood in the two components of fluid and crystallized intelligence: the latter seems to predict creativity and the generation of creative ideas (Gilhooly et al., 2007; Nusbaum and Silvia, 2011).

Growing evidence confirms a link between executive functions and creativity, mainly updating, shifting and inhibition, and these functions contribute to performance in complex cognitive tasks and support general intelligence (Benedek et al., 2014c).

In particular, the study conducted by Frith and colleagues (2021) emphasized the role of attentional control in the relationship between fluid intelligence and divergent thinking.

Executive functions are basic cognitive processes that control thought and action; they are closely linked to the neural substrates of the prefrontal cortex, and their impairment, caused by brain injury, is often the cause of alterations in cognitive control. Furthermore, executive functions are thought to be crucially involved in all types of higher-order cognition (Miller and Cohen, 2001).

Updating refers to the concept of working memory (Jonides and Smith, 1997) and suggests monitoring and revising incoming information, replacing the old ones with those more valuable to the current task. *Finally, shifting* indicates the process of continuous switching between different tasks (Monsell, 1996). For example, situations often require a change of rules and responses to be approached positively and shifting is the ability to shift between different information to find the most appropriate ones.

Inhibition can be defined as suppressing dominant response tendencies but irrelevant to the task asked (Friedman and Miyake, 2004). In this regard, Benedek and colleagues (2014c) investigate the different roles of the three executive functions mentioned before and creativity, considering the link between the latter and intelligence more systematically. According to the authors (Benedek et al., 2014c), these three executive functions mainly update and inhibit creativity (i.e., the ability to think divergently), not so much shifting. Furthermore, the literature suggests that creativity correlates with overbearing response inhibition; this process facilitates creative weighting by suppressing interference caused by dominant response tendencies (Benedek et al., 2012; Gilhooly et al., 2007).

Going deeper, Benedek and colleagues (2014b, 2019) proposed a neurocognitive framework of creative cognition. This model integrates creative cognition with specific cognitive functions such as memory, attention, and cognitive control [Figure 7].

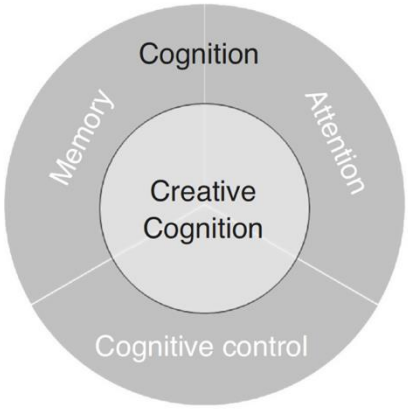


Figure 7 - Neurocognitive framework of creative cognition (Benedek et al., 2014b; 2019)

Cognitive control is closely related to *executive functions* and neural substrates in the prefrontal cortex (Miller and Cohen, 2001). It is linked to creativity since research has shown how people can reliably generate various ideas about open-ended problems and do so in a largely goal-oriented way and not simply by producing ideas "out of control" (Benedek and Fink, 2019) or responding chaotically. This control mechanism can help maintain the balance between quantity and quality of various products of thought processes (Groborz and Necka, 2003). In the literature, cognitive control in creative thinking has often been studied, considering two fundamental processes of creativity: the generation and evaluation of ideas. Although these two processes seem to require cognitive operations of a contradictory nature, according to Groborz and Necka (2003), maintaining the balance between these contradictory operations is one of the creative people's characteristic features.

Neuroscience and neuroimaging studies have helped researchers to understand this link. For example, Zabelina and Andrews-Hanna (2016) showed that the executive control network and the default network are associated with controlled and evaluative processes. Generative and constructive processes work together to produce creative ideas, indicating controlled and spontaneous cognitive processes interact in creative performance. Furthermore, Beaty and colleagues (2018) demonstrated that creative thinking tasks involve brain structures implicated in cognitive control.
Individuals who show high cognitive control in tasks manage to resist interference and inappropriate responses that may arise (Beaty and Silvia, 2012).
Creative performance seems to be supported by functional cognitive control; sometimes, a reduction in cognitive control can improve some creative performances; on the contrary, it does not seem to benefit from low cognitive control. This is supported by brain lesion studies that indicate that impaired frontal cortex function (related to cognitive control) is typically associated with reduced

creative ability. However, some focal lesions or stimulation-induced suppression may also enhance specific aspects of creative cognition (Abraham et al., 2012).

The role of *memory* in creative thinking has been supported by both behavioural and neuroimaging research showing that, for example, DT includes episodic and semantic memory (Abraham and Bubic, 2015; Beaty et al., 2020). New ideas arise from significant variation and recombination of available knowledge (Benedek and Fink, 2019). According to the authors, memory plays a key but controversial role in creative thinking (Benedek and Fink, 2019).

Furthermore, in order to produce something different and new, if, on the one hand, it is necessary to recall specific information in memory, on the other hand, it is necessary to recombine known concepts that are distant from each other (Campbell, 1960).

In support of this, it has been shown that thinking about future situations activates brain regions like those associated with remembering past events at a neuroscientific level. Similarly, creating new ideas requires brain structures like recalling known and original solutions (Benedek, 2018).

Gilhooly and colleagues (2007) first proposed a link between episodic memory and divergent thinking. During the DT task proposed to participants, the hippocampus, a brain structure involved in episodic memory, was active (Beaty et al., 2016). In addition, the two tasks shared a bilateral activation of the parahippocampal and medial prefrontal cortex (mPFC) (Mullally and Maguire, 2014).

Sheldon and colleagues (2011) pointed out that detail retrieval and episodic simulation can contribute to open-ended problems such as divergent thinking. Thus, these processes imply episodic memory. Madore and colleagues (2015, 2016) also emphasized the link between episodic memory and creative thinking; their studies demonstrated the positive effects of episodic-specificity induction (ESI) on DT performance.

Beaty and colleagues (2020) observed that distinct regions within the default mode network (DMN) are usually associated with spontaneous and self-generated thinking that support specific memory-related processes during divergent thinking tasks. Furthermore, researchers have confirmed the involvement of both the semantic control network (SCN, Noonan et al., 2013), which is considered crucial for flexible retrieval of stored knowledge (Cogdell-Brooke et al., 2020) and the DMN (Beaty et al., 2016; 2018) during DT tasks, highlighting their central role in the creative process (Ovando-Tellez et al., 2019). In addition to episodic memory, semantic memory also plays a crucial role in the creative process. Semantic memory refers to semantic distance, and the latter is investigated in creative cognition (Benedek and Fink, 2019).

Research shows that the further one moves away from a concept in a semantic space, the greater the possibility of generating an original and creative idea. Thus, when individuals try to create a new idea, they must try to go beyond knowledge constraints, which refers to overcoming the influence imposed by the semantic structure of knowledge (Abraham et al., 2012).

Creative cognition is thus built on both episodic and semantic memory processes emphasizing that these processes must interact with other functions such as attention and different types of cognitive control functions to produce new and creative ideas (Beaty et al., 2019).

Regarding *attention* and its role in creative thinking, it was investigated in its different components with varying results: selective attention (i.e., actively selecting and responding to relevant information whilst ignoring distractions and irrelevant stimuli), divided attention (i.e., reacting concurrently to the demands of two or more tasks), broad attention, flexible attention, leaky attention, sustained attention (i.e., maintaining focused attention, vigilance, and response consistency over a while) and focused attention (i.e., identifying and responding to single items of task-relevant information) (Benedek and Fink, 2019).

For many years, it has been recognized that the primary function of attention is usually to select adequate information for the context or tasks to be completed (Posner, 1988). Research in this area is also controversial, but studies point out that different aspects or measures of creativity are associated with different types of attention (Benedek and Fink, 2019), showing that creative behaviour can depend on attentional mechanisms (Golden, 1975).

Dellas and Gaier (1970) claimed that creative people *"deployed their attention more widely, were more aware of and receptive and retained more prior stimulus experience in usable form, tending not to screen out the irrelevant"* (p. 55). In brief, it appears that creative people use information not relevant to the task when they are performing by detecting more intrusive ideas and making more typical errors in attention tasks (Carson et al., 2003). Mendelsohn (1976) has shown that creative individuals use perceived stimuli without conscious attention

According to Zabelina (2018), making these mistakes and being more prone to intrusions and irrelevant thoughts may lead subjects to produce more creative responses. Kasof (1997) has shown that creative people are characterized by greater broad attention. Different authors show that individuals with more broad attention were more likely to make remote, original associations between the stimuli that were distracting them, whereas those with a narrow focus of attention were less likely to spot these opportunities (Ansburg and Hill, 2003; Friedman et al., 2003; Kasof, 1997; Vartanian et al., 2007).

In contrast, Nusbaum and Silvia's (2011) focused on attention to details: creative people appear to have more focused attention. Finally, some studies in the literature investigate attentional shifting,

pointing out that the most creative people are also those who can shift more easily from focused on diffusing attention and vice versa (Vartanian et al., 2007; Zabelina and Robinson, 2010).
Neuroscience has also emphasized the importance of "internally directed attention", a concept linked to the role of the Default Mode Network (see 2.5 paragraph): high creative performance has been related to increased EEG alpha activity (Fink and Benedek, 2014; Kounios and Beeman, 2014). It is in line with the idea that creative cognition is based on imagination and requires direct attention to self-generated thought processes (Benedek, 2018).

2.5 Recent studies in the neuroscience of creativity and divergent thinking

Recently, the discoveries in cognitive neuroscience, which add an entirely new perspective concerning the study of neurocognitive mechanisms (Dietrich and Kanso, 2010), give a strong impulse towards experimental research of a complex construct such as creative thinking. The first studies on the neuroanatomy of creativity focused on the distinction and lateralization of this construct, attributing the right hemisphere's dominance in creative thinking (Bowden and Beeman, 1998; Torrance, 1982). However, over the years, this distinction has become more moderate, and the hemispheric lateralization for creative thinking has become a controversial topic, in which the left hemisphere also seems to play an essential role in this process (Dietrich and Kanso, 2010; Chen et al., 2019). However, a more moderate theory instead emphasizes the brain's activation mainly in figurative or metaphorical thinking tasks (Beeman et al., 2000; Folley and Park, 2005).

More recent studies that consider the integration and interaction of the two hemispheres show that the right hemisphere is engaged during visuospatial (i.e., figural) creative thinking (Bhattacharya and Petsche, 2002) and that this can attenuate inhibition in the left hemisphere (Mayseless et al., 2014).
However, during creative tasks involving visuospatial skills, the frontoparietal brain regions, premotor cortex, and inferior frontal cortex are active. In addition, the lateral occipital gyrus of the left hemisphere indicates the importance of these areas in creative tasks (Aziz-Zadeh et al., 2013; Saggar et al., 2015). For this reason, some recent studies to investigate the activation of specific neural areas have considered the differences in visuospatial DT (VSDT) or verbal DT (VDT) (Chen et al., 2019) [Figure 8]. Individuals with high VSDT showed more substantial segregation within the right visual network, VN (middle occipital gyrus, lingual gyrus and fusiform gyrus), sensorimotor network, SM, (precentral gyrus, supplementary motor area, and part of middle frontal gyrus) and parts of DMN (parahippocampal gyrus, middle temporal gyrus, inferior temporal gyrus and medial frontal cortex).

On the other hand, verbal DT seems to rely on both hemispheres, exploiting the interaction and integration skills, indicating that verbal creativity may be more likely to rely on hemispheric interaction than a dominant hemisphere. Furthermore, in people showing higher VSDTS, more excellent functional connectivity emerged within VN, SM, and DMN (Chen et al., 2019).

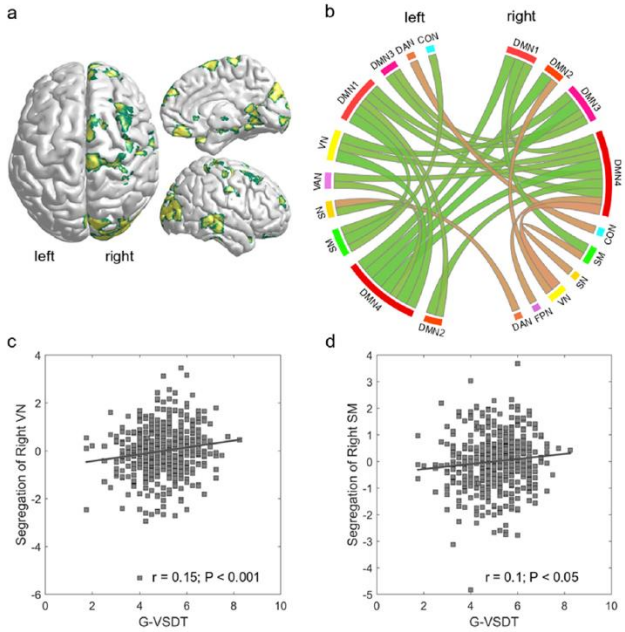


Figure 8 - Activation of specific neural areas (Chen et al., 2019)

a) The most important regions for predicting VSDT and segregation in brain networks associated with VSDT. The most important contributing regions in right hemisphere for VDST prediction models. b) The chord diagram of network composition showing significant differences in functional connectivity of intra- and inter-hemisphere across 11 networks between high-VSDT group and low-VSDT group. Green edges refer to higher connectivity in low-VSDT than high-VSDT group, light red edges refer to higher connectivity in high-VSDT group than low-VSDT group. c/d) Correlation between the actual general VSDT (regressing out session, sex, age, and FD) and the segregation of right VN (c), the segregation of right SM (d).

Neuroscientific research agrees on the central role of the prefrontal cortex (PFC, Dietrich and Kanso, 2010) in creativity tasks which was subsequently confirmed by studies of patients with lesions in this area which found a negative correlation between the extent of damage to the right medial PFC (mPFC) and divergent thinking. In contrast, these studies found that damage to the left mPFC and posterior temporoparietal area appeared to lead to creative impulses (Shamay-Tsoory et al., 2011).
Neuroimaging and EEG studies have also recently investigated the neuroanatomical areas active during divergent thinking tasks. In these tasks, neural activity is typically characterized by an increased right alpha-parietal synchronization in EEG and reduced activation of the ventral salience network in fMRI (Fink and Benedek, 2013; Benedek et al., 2014b). These studies showed widespread

alpha synchronization, mainly extended to the posterior regions (Mok, 2014) and more significant for the more highly original ideas (Takeuchi et al., 2012). In addition, more recent fMRI studies have identified bilateral activation clusters at the occipital, parietal, frontal, and temporal levels (Boccia et al., 2015), confirming the hypothesis of the hemispheres' extensive involvement in creative tasks.

From these studies, the following areas seem to play a fundamental role: the inferior frontal gyrus (IFG), middle (MFG) and superior (SFG) gyrus; the anterior (ACC) and posterior cingulate cortex (PCC); the precuneus (PCN) and the inferior parietal lobule (IPL), which includes the angular (AG) supramarginal gyrus (SMG). In addition, inferior (ITG), middle (MTG) and superior (STG) temporal gyrus, insula and hippocampus are also involved (Gonen-Yaacovi et al., 2013; Kleibeuker et al., 2013). Some are closely linked and active in DM tasks, as described in the previous chapter.

As seen before, in recent years, studies on creativity and DT have increasingly shifted to explanations that consider not separate areas but broader brain networks in interaction with each other (Vartanian et al., 2018). Three networks are considered: the Default Mode Network (DMN), a network that shows consistent deactivation when an external task is presented and instead activation in the absence of these (Raichle et al., 2001); the Executive Control Network (ECN) or Frontoparietal Network (FPN), of which a crucial node is the dorsolateral prefrontal cortex (DLPFC) as well as lower anterior parietal regions (Zabelina and Andrews-Hanna, 2016, cited in Beaty et al., 2015); and the salience network (SN), responsible for the relocation of attentional resources towards salient environmental events (Bressler and Menon, 2010); SN has a central role in the dynamic switch between DMN and ECN (Beaty et al., 2015). The DMN is mainly involved in situations requiring an internal focus of attention, e.g., during mind wandering, imagining the future and mental simulation tasks, prospective thinking tasks and autobiographical data retrieval, and imaginative, creative-thinking tasks (Beaty et al., 2015). The second network, ECN, is implicated in working memory, inhibition ability, task switching, and divergent thinking tasks (Beaty et al., 2015). DMN, ECN, and SN, the three brain systems described, dynamically interact to support creative performance. From studies on dual-process theories, it appears that DMN supports idea generation, ECN supports idea evaluation, and SN contributes to the identification of behaviorally relevant stimuli and facilitates dynamic transitions between the other two networks (Zabelina and Andrews-Hanna, 2016).

Beaty and colleagues (2015) proposed a study investigating functional connectivity during divergent thinking from considering these three major connection networks. This study reported the coupling between DMN and SN that preceded the coupling between default and executive regions, potentially reflecting (Beaty et al., 2015).

Following this study, the authors hypothesized that individual variation in the ability to engage the default, executive and salience brain systems simultaneously and salience brain systems might

provide a neurophysiological marker of creative thinking ability (Beaty et al., 2018). In this regard, the high creativity network showed dense functional connections in predominantly frontal and parietal cortices [Figure 9].

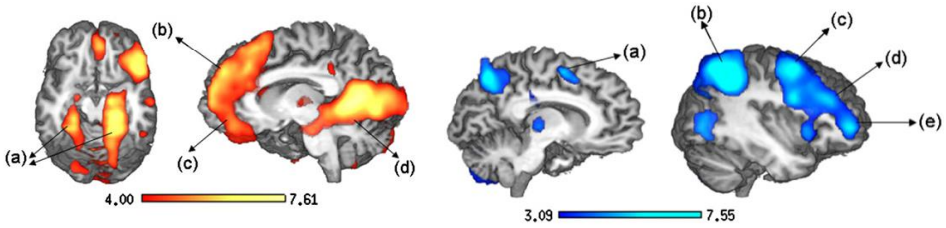


Figure 9 - High creativity network showed dense functional connections in predominantly frontal and parietal cortices (Beaty et al., 2018)

From studies of these networks, Beaty and colleagues (2018) showed that the high creativity network showed dense functional connections in predominantly frontal and parietal cortices, whereas the low creativity network showed widespread connections throughout the brain (subcortical structures, brainstem, and cerebellum)

2.6 Creativity and divergent thinking in lifespan

Creative processes seem to be potential resources for positive ageing in the perspective of active ageing, contributing to supporting cognitive functions and potentially useful as an aid in problem-solving skills (Fisher and Specht, 2000).

Strengthening and preserving creative thinking skills would be necessary for the elderly to counteract the perseverations and difficulties frequently encountered in this phase of life. As well as helping to give meaning and significance to the same, to obtain satisfaction (Loren-zen-Huber, 1991) and, finally, to promote a good perception of quality of life, both from a social and cognitive point of view (Hannula et al., 2006; Palmiero, 2015; Crepaldi et al., 2020).

Even if investigating the relationship between well-being and TD in older adults is a relatively new approach, it may have important implications for active ageing and how older people manage their well-being and autonomy. For example, well-being implies facing challenges and making efforts to achieve proposed goals (Alfonso-Benlliure et al., 2021).

Creative processes evolve during the lifespan, but they are expressed differently depending on age; children, adolescents, adults, and the elderly manifest creativity differently (Woodel-Johnson et al., 2012). In line with these premises, González Restrepo and colleagues (2019) point out that

experience, education and social environment can cause the subject to have a greater or minor capacity for creativity. Considering the Lehman (1953) lifetime evaluation of creative products, he showed that most of these appear to be produced at the age of 30-35, but the results of studies investigating creativity in the Lifespan and particularly in the elderly are highly controversial.

In the literature, several cross-sectional studies investigate the changes in creative thinking in the lifespan, indicating the presence of peaks and declines during the stage of adult life (Jaquish and Ripple, 1981; McCrae et al., 1987; Palmiero, 2015). There appears to be a general trend in developing creativity peaking in young and middle adulthood to decline late adulthood. Palmiero (2015) studied age-related changes in creative performance by dividing participants into six age groups: youth (20-29 years), young adults (30-39), middle-age (40-49), adults (50-59), old (60-69) and old-old (70-80). Again, the results confirmed a peak in creative thinking before 40, which remained relatively stable from 40 to 70, followed later by a decline after 70.

Along these lines, some studies show that some components of creativity also change over time; in particular, Delvecchio and colleagues (2016) stated that originality is more remarkable in younger children (4-5 years of age) than in older children (10 years of age). Madore and colleagues (2016) showed that originality is also higher in people over 65 by comparing scores with subjects of other ages (Madore et al., 2016). Considering the other two main components, fluency, and flexibility, although some studies find no differences by age (Madore et al., 2016; Palmiero et al., 2014), others show favourable differences in older subjects (Alfonso-Benlliure and Santos, 2016).

Cassotti et al. (2016) showed that older subjects have lower fluency and flexibility scores if given a concrete example. In line with these studies, Meléndez and colleagues (2016) stated that in subjects aged 55-84 years, the differences might depend more on cognitive reserve and openness to experience. Therefore, considering the potential of creative thinking in the elderly is fundamental from an active ageing perspective with attention to extended working life, inclusion, social commitment, and physical and psychological health improvement (Dickens et al., 2011; Findsen and Formosa, 2011; Price and Tinker, 2014).

Price and Tinker (2014) suggest that *"through creativity, older people could potentially explore new ones strives, develops his sense of identity and copes better with the ageing process"* (p. 282). Likewise, Cohen (2006) stated that creativity could support the capacity for growth and happiness throughout life.

2.6.1 Behavioral and cognitive aspects

Many researchers have found that fluid intelligence (Gf) and processing speed (Gs) are two components that are extremely sensitive to advancing age. On the contrary, crystallized intelligence (Gc), or the set of knowledge, is maintained relatively constant throughout adult life (Cattell and Horn, 1978; Salthouse, 1985).
Another relevant cognitive ability in the creative process is imaging and generating multiple possibilities, ideas, and solutions to a problem. It is estimated that this ability progressively declines after the '40s (McCrae et al., 1987), probably because fluid reasoning and executive functions play a fundamental role in this ability, and therefore the decline directly influences the decline of divergent thinking (Batey et al., 2009; Silvia and Beaty, 2012). Despite this, older subjects may maintain their level of originality if they can use different cognitive strategies and rely on declarative memory to improve their performance (Leon et al., 2014). Although, the studies in this field can be divided into two main groups (Palmiero, 2015): the deficit approach, *peak-decline-hypothesis* (Lindauer, 1998) and the *no-decline hypothesis* (Sasser- Coen, 1993).

The first model describes creativity as a “construct decline” in lifespan, where individuals produce the best creativity performance before the '40s and then it starts to decline (McCrae et al., 1987). On the other hand, the second hypothesis assumes that creativity changes during the life span might result from the changes in the underlying cognitive processes (e.g., fluid intelligence, speed of elaboration). Consequently, it considers creative thinking (creativity) and creative productivity as two distinct concepts, focusing not so much on the number of ideas generated (fluidity) but instead on their originality (Palmiero et al., 2017).
According to the *no-decline hypothesis* (Sasser-Coen, 1993), the elderly could think divergently in the same way as younger participants if different intervening variables are considered (Palmiero et al., 2017).
The controversial aspects of age on DT have been summarized in a review conducted by our research group, “The Controversial Effect of Age on Divergent Thinking Abilities: A Systematic Review” (Fusi et al., 2020). The review was conducted, selecting 16 peer-reviewed scientific articles from 1970 to 2018 to assess the role of the ageing process on DT skills (for further details about the methodology of the review, see Fusi et al., 2020). Several articles considered in the review consider different covariates in the study of ageing and DT, such as intelligence (Alpaugh et al., 1982; McCrae et al., 1987), verbal skills (Leon et al., 2014), speed of processing (McCrae et al., 1987), working memory (WM) abilities (Leon et al., 2014; Roskos-Ewoldsen et al., 2008), or predisposition and

activity engagement (Parisi et al., 2009). Most of the studies that observed differences in creative performances showed a decline in DT abilities. McCrae and colleagues (1987) longitudinal study show a decline in DT abilities in later adulthood. Furthermore, the young showed a general increase while the elderly (69-74 years) declined all DT indexes.

Taking up the two theoretical hypotheses considered previously, some studies, according to the peak-decline-hypothesis (Lindauer, 1998), have found a peak of DT performance in the middle age (Jaquish and Ripple, 1981; Reese et al., 2001) but no differences between young (17–22 years) versus older old subjects (75+ years; Reese et al., 2001). According to the no-decline hypothesis (Sasser-Coen, 1993), other studies did not find any difference between young and old considering specific moderator/mediator factors (Addis et al., 2014; Sharma and Babu, 2017; Foos and Boone, 2008; Leon et al., 2014).

In the review (Fusi et al., 2020) emerged that authors had found a peak in middle-aged adults or before the ‘40s and then a stabilization (Palmiero et al., 2017; Ruth and Birren, 1985). Despite the controversies, the results of more recent studies appear to be encouraging for older populations (Fusi et al., 2020). It seems that older adults performed worse than middle-aged adults, but later their performances seemed to stabilize, highlighting the potential to think as divergently as adults (Fusi et al., 2020) or even as younger subjects, especially if they have enough time to perform the task (Foos and Bone, 2008) and if the required workload is not too high (Leon et al., 2014). The review revealed that the discordant results are due to the three classes of differences: the research design and the sample characteristics, the tools used and the scoring methods, how the data analyses were carried out (Fusi et al., 2020).

2.6.2 Changes in neural substrates and network

Although in the literature it is known that functional neural networks and their interactions change with age (Damoiseaux, 2017), there are still few studies on the link between changes in neural functioning in the elderly and creativity.

Evidence in this field shows that older adults have reduced functional connectivity within predefined (Dennis and Thompson, 2014) and executive control (Damoiseaux, 2017) networks and increased connectivity between networks (Geerligs et al., 2015).

In this regard, some authors have proposed a new hypothesis of a neural network of cognitive ageing: the hypothesis of the default-executive coupling of ageing (DECHA; Turner and Spreng, 2015; Spreng and Turner, 2019). DECHA suggests that reduced modulation of the lateral prefrontal cortex

and attenuated suppression of the predefined network are functionally coupled with ageing (Adnan et al., 2019). Furthermore, Adnan and colleagues (2019), supporting the DECHA model, investigated functional connectivity interactions of both default and executive networks associated with DT in the young and elderly with fMRI. It emerges that both young and old show task-driven coupling between the two regions considered during creative cognition, particularly in tasks requiring divergent thinking (Chen et al., 2019; Gonen-Yaacovi et al., 2013; Vartanian et al., 2018; Beaty et al., 2015; 2018).

Despite equivalent behavioural performance with young adults in this experiment, functional coupling between default and executive control regions was associated with creative cognition in older adults. It indicates that default-executive coupling is related to creative cognition. Moreover, in the elderly, crystallized intelligence seems to play a fundamental role. Past knowledge, accessible through the DMN, can contribute to creative production in the elderly (more than young). (Adnan et al., 2019).

In conclusion, DT may be maintained even in old age; although flexibility and fluidity may decrease, originality can remain as stable and effective as young age (Palmiero, 2015).

2.6.3 Divergent thinking, creativity, and cognitive reserve

Cognitive reserve (CR) is a dynamic and multifactorial construct. It is influenced by many variables, including education, intelligence, the profession carried out during life, the years spent in the profession, recreational activities, and bilingualism and nutrition (Wöbbeking-Sánchez et al., 2020). CR is defined as "*the ability to optimize or maximize performance through differential recruitment of brain networks, which perhaps reflect the use of alternate cognitive strategies*" (Stern, 2002, p.451). The reserve hypothesis refers to two different models: the passive and the active one (Stern, 2002, 2006, 2009). In the first case, reference is made to "Brain Reserve', which proposes a definition of reserve linked to the amount of damage that the brain can counteract before it reaches a threshold limit beyond which there is the emergence of clinical expression; it thus defines a positive relationship between the structure of the brain and the ability to cope with pathology without showing signs of clinical impairment (Stern, 2009). In contrast, the active model is referred to as "Cognitive reserve" and emphasizes several aspects that can compensate for and slow down cognitive decline in pathological and physiological ageing (Stern, 2009). CR is also defined as the ability to recruit different networks to optimize performance, and this reflects the ability to implement different cognitive strategies to carry out tasks in the most functional way possible (Roldán-Tapia et al., 2012). Cognitive reserve, in this sense, is a construct that cannot be measured directly but can be assessed

through proxies, for example, education, employment, cognitively stimulating leisure activities, and creativity (Colombo et al., 2018). These two approaches are not mutually exclusive, and a combination of them might best describe the empirical observations (Stern, 2002). The processes described before can be influenced by the interaction of innate individual differences and experiences in life; for this reason, CR is not fixed and immutable, but several and relevant lifetime exposures could influence this construct: intelligence, education, occupation, leisure activities, social engagement, motor and physical exercises (Stern et al., 2018). Some studies show a possible relationship between CR and creativity and that these constructs have some common basic cognitive aspects, particularly the concept of cognitive flexibility and fluidity of thought (Antonietti and Colombo, 2013, 2016; Colombo et al., 2018). Flexible thinking is considered a critical trait of human cognition, distinguishing humans from other living beings, and it is a distinct aspect of intelligence (Boroditsky et al., 2010; Guilford, 1962). Cognitive flexibility is defined as the ability to consider a different/alternative perspective of a topic than the standard view; it involves distancing oneself from one idea to explore another, evading thinking habits and breaking out of a stereotypical way of seeing or solving a problem. Flexibility is the opposite of rigid thinking, which characterizes a fixed/blocked way of thinking, and which often does not help solve problems and consider possible alternatives to the situations to be faced (Lubart et al., 2019). CR is closely linked to the construct of creativity because it has to do with the ability to use alternative strategies, especially in old age, to better deal with brain damage and age-related cognitive decline (Colombo et al., 2018) and Palmiero and colleagues (2016) confirmed that creativity could be a proxy for CR.

A starting point for this link can be found in the creativity model proposed by Antonietti and colleagues (2011), the WRC model, explained previously in the chapter. Furthermore, it is possible to observe that cognitive reserve can fit into this context as a factor that allows the elderly population to use alternative strategies so that they can better cope with the changes linked to old age by employing the three processes attributed to creativity in tasks (Colombo et al., 2018). This means that creativity can represent a good indicator of older people's capacity to use alternate paradigms or processes when standard approaches become unavailable to face difficulties that occur in daily life (Palmiero et al., 2016).

Therefore, assuming that cognitive reserve can be continuously modified by life experiences, even when the brain is already affected by neuropathology (Liberati et al., 2012), activities that involve verbal creativity can also actively help older people to cope with cognitive decline.

Chapter 3 Divergent thinking, risk taking and decision making

After exploring the DM process, RT, creativity and DT, the relationship between these constructs and their subcomponents is now investigated by showing how they relate to each other. First, the chapter presents a narrative discussion of the relationship between DM and creativity, and in the second part, a systematic review of the literature between RT and creativity.

It emerges from the literature that creativity influences DM and RT at several levels, although the direction of this relationship is not always clear, as will be explained in the following sections (Charyton, 2005; Charyton and Snelbecker, 2007; Collins and Koechlin, 2012). As described previously, DM is essential in everyday life, health, safety, work, economics, and finance (Leder et al., 2018). However, as will be described later, often in the literature, the DM process has been equated with finding solutions to solve a problem.

The strategies that people may implement to deal with making decisions can be described as "standard," "typical," or "creative" (Okoli et al., 2013). When faced with complex situations or problems, individuals must continually shift from adjusting and using known "task sets" to implement other sets of learning activities to create new task sets to guide action (Collins and Koechlin, 2012). For this reason, reasoning, learning, and creativity are characteristics of human intelligence involved in making decisions under conditions of uncertainty or in open-ended situations, considering risk as a fundamental component of these circumstances (Collins and Koechlin, 2012; Charyton et al., 2013). The relationship between DM, risk-taking, and creativity is particularly important and interesting in today's context because these constructs are crucial to maintaining social harmony, autonomy in various fields of daily life, and the development of scientific technology (Shen et al., 2018). Therefore, systematically investigating the relationship between DM, RT and creative thinking and its direction could open fields of study and intervention to enhance DM in everyday life.

3.1 Decision making and creativity

3.1.1 The role of creativity in the decision-making process

The first note that we could consider investigating the link between creativity and the DM process in the literature is that the definition of the two constructs is tricky.
Searching Scopus for "decision making" and "creativity", selecting the English language, psychology, social sciences, and decision sciences, we can find about 500 papers. Scrolling through the titles and abstracts of these articles, it is immediately clear their heterogeneity. Many articles investigate the role of creativity in sports decisions (e.g., Roca and Ford, 2021; Fink et al., 2018); others investigate decisions in management and business (e.g., Pellegrin et al., 2021) or decisions in the arts (e.g., Fonseca et al., 2020). Despite this, creativity remains one of the skills most associated with DM and problem solving considering the DM process. Some articles investigate DM considering the act generation (i.e., Engelmann and Gettys, 1985; Leder et al., 2018), the negotiation process (i.e., Kurtzberg, 1998), or the DM styles (i.e., Guastello, 1998; Palmiero et al., 2020). Furthermore, the tools used to investigate the DM process are often different, and this makes it difficult to compare results: many studies use self-report questionnaires or ad hoc tasks (i.e., Niepel et al., 2015; Engelmann and Gettys, 1985), only a few of them (especially those who consider DM styles) consider standardized tests (GDMS) (i.e., Palmiero et al., 2020).

The first studies indicate that DT seems to be a significant predictor of DM, especially considering the DM act and the act generation process (Engelmann and Gettys, 1985). Leder et al. (2018), declining more precisely divergent thinking, shows that option generation correlates with ideation fluency and verbal fluency, but it seems that it is not correlated with idea originality.
The World Economic Forum's Future of Jobs Report (2018) listed creativity, innovation and ideation as crucial competencies and skills needed for the future workforce. Furthermore, it points out that these skills, alongside analytical thinking and problem-solving, could replace manual tasks that will become increasingly automated in the future.
Regarding open-ended situations, we know that they are characterized by "ill-defined" problems (Taylor, 1974), and this situation can be very similar to the circumstances in which the individual finds himself making most decisions.
There is no defined structure to the situation and possible alternatives to choose from, no clear goal, and no unambiguous options for achieving the goal (Engelmann, 1985).

DT is closely related to the concept of an "ill-defined" problem/situation because it has been defined as an open-ended mental process aimed at generating multiple responses to a given open-ended problem (Palmiero et al., 2020). For example, these undefined problems that people encounter daily could be the lack of parking in a city, identifying ways to save energy at home, and raising money for a charity (Del Missier et al., 2015).

According to Engelmann (1985), the subject, when faced with these open and ill-defined situations, can initially operate in a divergent mode, generating multiple possible actions and considering many alternatives and variables, and then switches to a convergent process in which the preferred action that is more appropriate and considered more functional is selected from the actions generated (Engelmann, 1985).

The most interesting aspect of DM behaviour is the flexibility with which individuals respond to various situations. The possible alternatives presented, the uncertainty of the circumstances and the preferences expressed are some of the elements that characterize this flexibility (Laureiro-Martínez and Brusoni, 2018). When alternatives are limited, and people have to manage two or three alternatives, rational analysis is often employed, reflecting the theories of the normative model and the notion of expected value (see Chapter 1; Von Neumann and Morgenstern, 1947, 1974). Then, the relevant information is selected through precise analysis, allowing a compromise between desired options (Payne et al., 1993).

On the contrary, when dealing with complex choices involving several alternatives, people adopt simplifying strategies, i.e., heuristics, to limit this complexity (Payne et al., 1993). For example, Tversky (1972) refers to a strategy that he noted was frequently used, consisting of exemplification through rejection, which leads to preferring choices characterized by a specific value and lacking another because it is ineligible.

Collins and Koechlin (2012) proposed a model in which the new created sets are provisional, they are helpful and adapt to external contingencies, and then they could be discarded when they are no longer needed. What is left to the individual are the associated strategies that remain memorized in the long-term memory as a resource that can guide subsequent actions (Collins and Koechlin, 2012). For this reason, creative thinking is an integral part of DM and problem solving, especially in the idea generation phase, evaluation, and selection of the idea (Finke et al., 1992; Runco and Chand, 1995). Different stages can be distinguished in this process. For example, understanding and defining the circumstance solve a problem; a generative phase of ideas and exploration of more possibilities (with the contribution of DT, which allows generating many alternatives); the evaluation of ideas by comparing them with different alternatives; action planning and implementation of the selected idea

(convergent thinking, CT, that allows people to focus on a single possibility) (Allwood and Selart, 2010, Forgionne and Newman, 2007).

3.1.2 The role of creativity in decision-making styles

Several authors studied the relationship between DM styles and creativity or divergent thinking. The cognitive adaptive-innovative style (Kirton, 1976) has numerous correlations with creativity. Individuals defined as "adapters" use goal-directed styles, proceeding cautiously, examining the variables and aspects of the problem, taking into significant consideration the rules and principles already provided and sticking meticulously to them without questioning them. On the other hand, "innovators" tend to question the rules and principles because their goal is not to do something better but to do it differently. They are less meticulous and hurried but tend to face more risks and uncertainties, bringing new views.

The cognitive style of assimilators-explorers (Martinsen, 1994) describes character differences towards certain predispositions in problem-solving and DM strategies. Assimilators apply existing mental schemes to new situations, have more rigid strategies and are considered more logical and analytical. In contrast, explorers have a greater predisposition to search for novelty and manifest this by searching for new solutions and strategies to solve problems. For the explorer style, significant positive correlations were found with high scores in the creative tasks.

Scott and Bruce (1995) showed that the intuitive DM style correlated positively with evaluations of innovativeness and originality of the responses to the steps mentioned above. On the other hand, both the rational and dependent DM styles correlated negatively with innovativeness or creative behaviour evaluations.

Individual differences in DM styles may reflect individual differences in DT. Indeed, rational thinking style plays a crucial role in divergent thinking (Vosburg, 1997). Some research shows a poor association between rational thinking style and creativity (O'Hara and Sternerg, 2001), but the rational approach is related to a more logical and sequential working methodology and could support the creative process (Lau et al., 2011).

Indeed, according to Sim and colleagues (2007), intuitive and rational DM styles are crucial in formulating an initial idea and evaluating decisions. Rationality in DM seems to influence both the quantity and quality of information gathered through divergent thinking. Moreover, divergent thinking produces innovative solutions that need elaboration and refinement by rational thinking. Matzler, Uzelac, and Bauer (2014) investigated the relationship between DM styles and creativity in organizational settings; the authors showed that deliberative (rational) DM style appears to be related

to both exploratory (experimentation, risk-taking, and innovation) and exploitative success of organizations (Matzler et al., 2014).

The creative thinking observed during creative idea generation has a goal-directed strategic approach based on rational DM styles. On the other hand, DT uses a goal-directed approach (Benedek and Jauk, 2018). However, the dependent and avoidant styles do not seem to be involved in DT. The effects of intuitive and rational styles on DT are varied but combining these two styles produces the highest creativity scores (Meneely and Portillo, 2005). Furthermore, Palmiero and colleagues (2020) investigated the relationship between DM styles and DT (both verbal and figural). In line with previous research, the author found that rational DM style plays a crucial role in divergent thinking (Vosburg, 1997).

3.2 Risk taking and creativity

Alongside the concept of risk, the notion of creativity often appears in the literature. Despite this, it has not been systematically investigated which procreative attributes predict greater cognitive risk tolerance and conversely whether a risk can be understood as a mediator/moderator of creativity (Shen et al., 2018). Some studies regarded risk as a mediator and moderator of creativity, showing negative or positive relationships depending on the measured creativity. Other studies found no relationship between the two constructs. Again, others linked creativity to risk as a personality trait.

It seems to emerge in the literature that a person who is more likely to demonstrate risk tolerance is more likely to demonstrate attributes of creativity (Charyton and Snelbecker, 2007): being creative involves tolerating a certain degree of risk, allowing people to promote creative inventions or make entrepreneurial profits (Baas et al., 2015; Sternberg and Lubart, 1992).

Additionally, creative people often exhibit risk-taking (Lubart and Sternberg, 1998; Ucar, 2018) and prefer challenging and risky situations (Harada, 2020). For these reasons, the construct of cognitive risk tolerance has been even hypothesized as a component of general creativity (Charyton and Snelbecker, 2007). It emerged that high levels of creative abilities predict higher risk tolerance levels (Charyton et al., 2013a). A greater willingness to take risks and the ability to tolerate ambiguity can be linked to the possibility of generating new and original ideas by confirming that these are two factors of the creative thinking process (Cummings and Mize, 1968; McGrath et al., 1992).

Over the years, as described above, risk attitude has been considered a personality trait or a general domain, but several studies have introduced the hypothesis that risk is context-specific and domain-specific (MacCrimmon and Wehrung, 1986, 1990). Consequently, individual differences derive from the differences in risk perception considering multiple alternatives during choice in different contexts, such as gambling, financial investment, business decisions, and personal decisions (healthy, social,

ethical) (MacCrimmon and Wehrung, 1986, 1990; Weber et al., 2005; Blais and Weber, 2006) both in terms of gains (risk as something desirable) or losses (risk as something to be avoided).

The difference between considering a general factor of risk attitudes versus considering specific risk domains explains a significant amount of variance within self-reported measures but not within behavioral measures (Frey et al., 2017). This suggests some amount of convergent validity for self-reported measures but not for behavioral measures (Konig, 2020). Moreover, the risk construct appears to include both universal and domain-specific components (Frey et al., 2017; Konig, 2020). Furthermore, in predicting uncertain future events, the risk is the variability concerning what is predictable in terms of loss or gain (Lubart and Thornhill-Miller, 2019), and it is linked to the possibility of expressing judgments without knowing the actual outcome/consequences of the actions (Kahneman, 2003).

In Chapter one it was described that among risk components, there are three main aspects: *tolerance to uncertainty (ambiguity)* (Ladouceur et al., 1997*), cognitive risk tolerance* (Snelbecker, 1967; Charyton, 2005; Charyton et al., 2008) and *willingness to risk-taking* (i.e., risk propensity) (Sitkin and Pablo, 1992). As has already been mentioned, ambiguity tolerance and cognitive risk tolerance play a central role in creative thinking and positively correlate with the scores obtained on indices measuring creativity on various tasks (Charyton and Snelbecker, 2007; Zenasni et al., 2008; Charyton, 2005; 2008). "Tolerance for ambiguity is often mentioned as a personality characteristic of creative individuals" (Plucker and Renzulli, 1999, p. 42). Furthermore, creative people show that they tolerate ambiguity more than people with low creativity scores; they do not feel high discomfort in tasks of uncertainty and ambiguity, and they can keep the attention focused on the problem to be solved and on the alternatives to be considered, without prematurely closing the search for possible solutions (Allwood and Selart, 2001; Tegano, 1990). Consistently, individuals characterized by rigid and absolutist reasoning, such as intolerance of ambiguity, perform worse on creative problem-solving tasks (e.g., Salvi et al., 2021; Salvi et al., *submitted*). Overall, it can be said that the link between risk-taking and creativity is confirmed by many studies (Dewett, 2007; Eisenman, 1987; Sternberg and Lubart, 1992), but despite such evidence, the actual direction of the relationship between creativity and risk-taking is still unclear and debated. Research that has attempted to investigate the link between risk-taking and creativity has had several focuses. The former might be a prerequisite for the latter or vice versa creativity might be a crucial aspect in risk taking (as in the investment theory or considering the willingness to take a risk) (Williams, 1980; Dewett, 2006; Zhou and George, 2001; Sternberg, 2006; Sternberg and Lubart, 1992). On the other hand, it is known that

the generation of novel and original ideas is enhanced by higher levels of metacognitive control through a deliberate and cautious application of appropriate strategies to widen the mental field (e.g., Antonietti et al., 2021).

Considering these premises, the purpose of the review was twofold. On the one hand, to highlight the conflicting results of the relationship between creativity and risk-taking. But, on the other hand, starting from these critical issues proposes future direction in this methodological and practical nature. For this reason, the articles presented were discussed following this double line.

3.2.1 The systematic review: method and search strategy

The review was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines (PRISMA; Liberati et al., 2009). Two authors performed it through three different electronic databases (PubMed, Scopus, and PsychINFO) from October to December 2020. Therefore, the discussion is limited to the articles that focus on the relationship between creativity, divergent thinking, and risk. The search was conducted using the following keywords: "creativity AND risk-taking," "divergent thinking AND risk-taking", "convergent thinking AND risk-taking". For the search in Scopus database, we selected some specific subject areas: "Article, English"; while in PsychINFO, we selected "Academic Journals" and "English". Cross-references of the selected studies were also considered to identify possible supplementary significant articles.

3.2.2 Inclusion and exclusion criteria

The inclusion criteria were articles, English language, human (i.e., child, adult, ageing), and healthy subjects. The selected articles involved both children/young people and adults. We kept these results together because there is no significant difference in the trend regarding age. The exclusion criteria were studies that considered data by neuroimaging and stimulation techniques (i.e., EEG, Eye Tracking, etc.), genetic studies, articles that considered a pathological sample (i.e., patients with schizophrenia). In this review, only the articles that considered direct measures of creativity and risk are reported; those that use indirect measures have been excluded.

3.2.3 Study selection and data collection

The search identified a total of 1009 hypothetically related articles (sum of the results returned by all databases). After the first selection of titles (duplicates and articles that did not match the inclusion

criteria were deleted) and abstracts (not in line with the review's aim), we considered a total of 30 full texts. Initially, two authors independently examined the titles and abstracts of the database outputs, identifying which ones were not relevant to the research aim (i.e., investigating the link between risk-taking and creativity and which direction this relationship goes). Afterwards, the full texts of the selected articles were read and examined to check the inclusion criteria. Finally, 15 articles were selected.

3.2.4 Study design and sample characteristics

The studies' main characteristics are described in Table 3 (i.e., authors, year of publication, title, sample, evaluation tools, findings). This table also shows whether the article considered "general creativity scores" or explicitly "divergent thinking" / "convergent thinking" and if they considered risk as a general construct, a personality trait or if it consists of different specific domains. The selected articles were published from 1961 (Merrifield et al., 1961) to 2020 (Beghetto et al., 2020; Harada et al., 2020). No articles were found before this date.

The samples considered range from children (Pankove and Kogan, 1967), adolescents (Kurtzman, 1967; Jose, 1970), young people (Glover and Sautter, 1977; Glover, 1977; Pascual-Leone et al., 2010; Charyton et al., 2013a; Charyton et al., 2013b; Harada, 2020), young and adults (Tyagi et al., 2017; Shen et al., 2018; Beghetto et al., 2020), adults (Merrifield et al., 1961; Eisenman, 1987; Dewett, 2006).

Moreover, if almost all the articles considered similar DT tasks such as the Alternative Uses Test (AUT), or part of the Torrance Test (Torrance, 1987, 1998; verbal and/or figural forms) evaluating the same indexes, the difficulty in comparing these articles is due to the variability in the way risk-taking was measured (i.e. DOSPERT, IGT or ad hoc tasks) (Jose, 1970; Glover and Sautter, 1977; Glover, 1977; Eisenman, 1987; Pascual-Leone, 2010; Shen et al., 2018; Harada, 2020).

Furthermore, these difficulties concern the different measures of creativity that consider it as more general measures of creativity or creative personality (Pankove and Kogan, 1968; Dewett, 2006; Charyton et al., 2013a; Charyton et al., 2013b; Tyagi et al., 2017; Beghetto et al. 2020). For this reason, it was decided to dedicate a paragraph to the description of tools used to measure the two constructs considered in the articles (creativity and risk), according to the review's aim.

3.2.5 Results

Although from the 15 articles included in this review, it is clear that risk affects creative thinking and vice versa, the direction of this relationship is not so clear. Early studies that considered risk-taking and creativity (Merrifield et al., 1961) showed a positive relationship between some measures of DT and some components of risk assessment and risk-taking.
The contrasting results that emerged in this review seem to be due to two reasons:
- the plurality of definitions that have been given of the two constructs (Theoretical contributions)
- the variety of instruments used to investigate them (Methodological contributions)

Most of the studies considered in this review show a positive significant and direct relationship between risk-taking and creativity (Glover and Sautter, 1977; Glover 1977; Eisenmann et al., 1987; Dewett, 2006; Pascual Leone et al., 2010; Charyton et al., 2013a; Charyton et al., 2013b; Shen et al., 2018; Harada, 2020; Beghetto et al., 2020) but there are also some conflicting results (i.e., Jose, 1970; Pankove and Kogan, 1968; Tyagi et al., 2017).

Theoretical contributions
Defining and measuring creativity has been an exceptionally challenging task throughout the history of psychological research, as it was highlighted in the previous chapter. Alongside the different definitions that authors have given of creativity, one finds different assessment measures and different tasks used to investigate it.
Early studies that aimed to explore the relationship between creativity and risk-taking equated creativity with measures such as associative fluency, divergent thinking, tolerance of ambiguity, creative lifestyle, or intellectual achievement (Tyagi et al. 2017).
Several articles consider creativity as a general domain or creative ability/behaviour (Dewett, 2006; Charyton et al., 2013a; Charyton et al., 2013b), even though in some of them, the scores are often considered as indices of flexibility, fluency, originality, and elaboration, which are also proper to divergent thinking (Glover and Sautter, 1977; Glover, 1977, Pascual-Leone et al., 2010). Kurtzman (1967) refers to a general definition of creativity that starts with some categories important to creative thinking from Guilford's model (1960).
Others consider specifically the single component of DT (Pankove and Kogan, 1967; Jose, 1970; Eisenman 1987), both DT and CT (Shen et al., 2018; Harada, 2020) or as a multidimensional trait using both biographical and behavioural measures of creativity, including an index of creative

personality, creative performance across multiple domains, creative ideation, problem-solving, and divergent thinking tasks (Tyagi et al., 2017)

Merrifield, Guilford, Chnstensen, and Frick (1961) considered an associational fluency factor as a type of divergent thinking.

The same difficulty of definition can be found about the concept of risk; several authors consider the general domain (Pankove and Kogan, 1967; Jose, 1970; Glover and Sautter; 1977; Glover, 1977; Charyton et al., 2013a; Charyton et al., 2013b; Beghetto et al., 2020); others considered a risk as a domain-specific construct with different areas of risk (Dewett, 2006; Pascual-Leone et al., 2010; Tyagi et al., 2017; Harada, 2020).

Methodological contributions

This paragraph highlights how, over the years, very different tools have been used to measure and investigate the relationship between creativity and risk, and this may have contributed to conflicting and inconsistent results. Moreover, using the different tools concurs with a different definition than the authors give to the construct and show in the theoretical contributions.

Specifically, regarding measures of creativity, the authors employed a variety of tasks. However, it is possible to distinguish them into three categories: creative tasks measure, divergent and convergent thinking measures, and creativity measures related to personality or creative achievement aspects. Also, considering risk measures, it is possible to group the instruments into three categories: risk as a single domain or general aspect; risk-personality/trait or preference; risk in a specific situation or specific-domain risk; and a specific focus on Merrifield's study (1961).

Creativity measures

The authors used The Torrance Test of Creative Thinking (TTCT; Torrance, 1987; 1998) (Glover and Sautter, 1977; Glover, 1977; Pascual-Leone et al., 2010) of two forms: Figural TTCT and Verbal TTCT. The figurative form tasks are corrected for fluency, elaboration, originality, resistance to premature closure, and abstractness of titles, while the verbal form tasks are corrected for fluency, flexibility, and originality. Other measures have been detected with the Kit of Reference Tests for Cognitive Factors (French et al., 1963) (Kurtzman, 1967) [that considers different categories of creative thinking: Controlled Associations, Word Arrangements, Thing Categories, Word Beginnings and Endings, Utility, Gestalt Transformation, and Apparatus]; the adaptation task from George and Zhou (2001) and Scott and Bruce (1994) (Dewett, 2006), a scale that investigates the creative results from supervisors in the workplace; and a modified scale of the Creative Activity built starting from

ICAA (Dietrich et al., 2018) throughout life evaluates creative activity in literature, music, cooking, art and craft, sports, visual arts, performing arts and science and engineering (Beghetto et al., 2020).

DT measures: The main measure is the Guilford tests of creativity (Guilford, 1967), i.e. the Alternative Uses Task (AUT), also included in the TTCT (Pankove and Kogan, 1967; Eisenman 1987; Tyagi et al., 2017; Shen et al., 2018) and the S-A creativity test (Harada, 2020). However, Jose (1970) used two measures of DT taken from the Verbal and Figural Forms of the Minnesota Tests of Creative Thinking. In alternative-uses tasks, the subject is asked to list as many unusual uses as possible of everyday objects (e.g., glasses, shoes, bricks etc.). The test can be administered with or without a time limit, and timing also affects comparability data and results. Scores are attributed relying on originality, fluency, and flexibility of responses. S-A creativity is taken from the TTCT and foresees three different activities: AUT; imagine useful and desirable but unrealized functions of some objects; imagine the consequences of "unimaginable things" that happen. In this case, the answers are evaluated for fluidity, flexibility, originality, and elaboration (as in the TTCT). In addition to measures of divergent thinking, Harada (2020) and Tyagi and colleagues (2017) also considered measures of convergent thinking.

Other measures of creativity include the Creative personality Scale (CPS) of the Adjective Checklist (ACL; Gough, 1979) (Charyton et al., 2013a; Charyton et al., 2013b) that considers creativity starting from personality theory and personality attributes and Creative temperament Scale (Gough, 1992) (Charyton et al., 2013b). The self-report questionnaire Creative Achievement (Carson et al., 2005) investigates ten domains of creativity (Tyagi et al., 2017; Beghetto et al., 2020). Beghetto et al. (2020) measured creativity by considering The Global CC, as measured by the Short Scale of Creative Self (SSCS, Karwowski et al., 2018), a six-item Likert scale (1-7) that investigates trait-like creative self-efficacy and creative personal identity.

Risk as a general domain

Several authors consider risk as a unique domain or a general aspect of personality and temperament (Pankove and Kogan, 1967; Jose, 1970; Glover and Sautter, 1977; Glover, 1977; Charyton et al., 2013a; Charyton et al., 2013b; Beghetto et al., 2020). For example, in their study, Pankove and Kogan (1967) considered three different tasks: Draw a circle, Clues and Shuffleboard as a measure of risk. The "Draw a circle" test, a pencil and paper task (McClelland, 1973) aims to measure risk-taking, especially in the entrepreneurial field. The assignment is presented twice. First, the subject is asked to draw a circle on one side of the sheet (lined) previously folded in half and presented by the

experimenter. Then she/he is asked to flip the paper and draw a cross in the circle's centre, asking where he thinks the circle's centre would be if he could see the circle. The hypothesis is that risk-taking is therefore assumed to increase as the diameter of the drawn circle decreases. The second task used to measure risk is Clues, a task taken from Kogan and Wallach (1964). In the following task, 23 valuable clues about the identity of two elements (baseball bat and goat) are presented, one at a time, and the subject can choose when to answer. Each correct answer increases the score, and, in the end, there is a $ 1.00 prize for the person who gets the most points. This task was also used by Jose (1970). The last task used in this study was Shuffleboard, where the apparatus was very similar to the one previously employed by Kogan and Wallach (1964) to evaluate risk-taking strategies.

In addition to the task clues and in line with the previous study, Jose (1970) used ad hoc questionnaires as a risk measure. The first questionnaire, Ring Toss, is inspired by the "ring throwing experiment" (Atkinson and Litwin, 1966), in which you are asked to throw a certain number of rings at a peg (in this case, 10). The rung's launch distance indicates the greater risk that a subject can take, the shorter distance, the minimum risk. The second task used is Fortune Wheel, which measures one of the risk dimensions, explicitly gambling, although it is considered a general risk. The tool has been designed in such a way that the game involves losses and gains based on the assumption of risk; the areas of the wheel are, in fact, of different sizes, and the assumptions are that if the person "bets" on small areas he assumes more risks if he bets on larger areas, he can take less risk.

After these initial studies, the most recent ones used standardized tasks. For example, Glover and Sautter (1977) and Glover, 1977 proposed The Choice Dilemma Questionnaire (Kogan and Wallach, 1964) that measures risk-taking tendencies. Furthermore, Charyton and colleagues (2013a; 2013b) investigated risk with the Cognitive risk tolerance Scale -CRT (Snelbecker et al., 2001), which consists of 35 self-reported Likert scale elements (0-9), which aim to assess an individual's ability to formulate and express their ideas despite potential opposition.

Finally, Beghetto and colleagues (2020) proposed, as a measure of risk, the Intellectual risk-taking - IRT (Beghetto, 2009), a Likert scale (1-5) that measures people's general tendency to engage in situations that involve risk-taking. Thus, IRT represents an adaptive risk, which has also been related to creativity self-reliance beliefs.

Risk-personality/trait or preference

In contrast to previous studies, some researchers have considered risk a personality trait (Kurtzman et al., 1967; Eisenman, 1987; Shen et al., 2018). For example, Kurtzman and colleagues (1967) proposed the High School Personality Questionnaire (HSPQ) (Cattell and Beloff, 1962). It is a modification of the Cattell 16PF scale that measures 14 dimensions of personality. Together with the

Classroom Social Distance Scale (Cunningham et al., 1951) and the Student Opinion Poll (Getzels and Jackson, 1960), the authors consider this task an indirect measure of risk in the specific context of school. Eisenman (1987) also considered a risk preference for complexity and investigated it by a personal opinion survey (Eisenman, 1969). Moreover, Shen and colleagues (2018) considered the Risk-taking preference index (RPI; Hsee and Weber, 1997, 1999). This tool consists of 14 questions and is used to measure the level of risk-taking. The RPI score is calculated relying on the answers given on a scale (1 to 8).

Risk in a specific situation or specific-domain risk

The last group of studies includes articles that considered risk a domain-specific construct (Dewett, 2006; Pascual-Leone et al., 2010; Tyagi et al., 2017; Harada, 2020). For example, Dewett (2006) considered a specific risk-measure, the Willing risk-taking measure and the Sitkin and Weingart scale (1995). The first is an ad hoc scale comprised of eight elements, each designed to investigate two aspects of the WTR construct, the willingness to take a risk and the awareness of possible negative consequences. The second (Sitkin and Weingart 1995) is a risk propensity scale build-up of 5 items, intending to investigate the characteristic levels of risk-taking that an individual might exhibit in different situations.

In their study, Pascual-Leone and colleagues (2010) used the South Oaks Gambling Screen Revised scale (SOGS, Lesieur and Blume, 1993), which consists of 20 items and is used to screen the population gambling behaviour. Furthermore, Tyagi et al., 2017, used the Roulette Betting task (RBT, Studer and Clark, 2011) and a Domain-Specific Risk-Taking scale (DOSPERT, Blais and Weber, 2006) to evaluate risk in different domains. The first task is a behavioural risk measure that uses a wheel with ten segments (pockets), red (losses) or blue (winnings). For a total of 100 trials, participants are asked to select a bet from three boxes indicating the available bet options (low, medium, and high). The ratio of blue to red-coloured pockets determined the probability of winning. The task provides two measures of risk: financial gambling and gambling risk adjustment. The second task, DOSPERT, is a standardized questionnaire build-up of 30 questions investigating the five domains of risky behaviours: ethical, financial, health/safety, recreational, and social.

Harada (2020) specifically investigated the risk in a gambling situation with the Iowa Gambling Task (IGT). It is a task in which the participants are asked to make some choices between 4 decks of cards, two of which are advantageous (small losses and small gains) and two are not (significant wins and large losses) to maximize the profit.

Finally, Merrifield and colleagues (1961) deserve a separate discussion as he used aptitude and non-aptitude test (i.e., Associational Fluency, Expressional Fluency, Ideational Fluency, Word Fluency,

Originality, Adaptive Flexibility, Spontaneous Flexibility, Conceptual Correlates, Neurotic Tendency, Need for Freedom, Need for Variety, Adventure, Impulsiveness, Tolerance Of Ambiguity, etc.).

3.2.6 Discussion

The main purpose of the review was to analyze the theoretical and methodological factors that could explain the controversial results considering the relationship between risk and creativity. The link between creativity and risk emerged from Torrance's (1971) studies, in which he showed that the most creative people were also those who were able to cope better with frustration since they were able to break free from typical and habitual patterns of behaviour. Building on these studies, Glover and Gary (1976) also showed that creative people could tolerate ambiguity and solve problems in unusual ways. In addition to these studies, some authors had already speculated on the relationship between creativity and risk (Merrifield et al., 1961; Kurtzman, 1967).

Concurrently, as underlined in the previous paragraph, almost all studies used different assessment tools depending on the authors' definition of the constructs of creativity and risk.

Some studies show that creativity influences risk-taking (Merrifield et al., 1961; Kurtzman, 1967; Pankove and Kogan, 1967; Glover 1977; Glover and Sautter, 1977; Eisenman, 1987; Dewett, 2006; Pascual-Leone, 2010; Charyton et al., 2013a; Charyton et al., 2013b; Tyagi, 2017) while others show that the level of risk-taking can influence some components of creative thinking (performance, activities in DT and CT) (Harada 2020; Jose 1970; Beghetto 2020; Shen 2018).

As mentioned before, the inconsistent results on the link between risk-taking and creativity could reflect different tests and assessment methods and how creativity or risk are considered (Tyagi et al., 2017). If Merrifield and colleagues (1961) found a correlation between creativity (associational fluency) and risk-taking, measured as a score on the adventure, Pankove and Kogan (1967) found very low correlations between the two measures using different tools (only one task, the Shuffleboard, performed by the boys (not girls) show a correlation). These results emphasize how much the results can be related to the measure or task used. Another confirmation could be found in the study conducted by Jose (1970), who found no significant correlations between DT and risk-taking.

In general, it seems that a higher level of creativity (in particular DT) is linked with higher risk-taking and risk-seeking (i.e., Merrifield et al., 1961; Charyton et al., 2013a; Charyton et al., 2013b;). Vice versa, risk-taking and willingness to take intellectual risks could influence creative performance in two ways: in the exploration or manipulation of stimuli, or as a moderator in creative behaviour (Harada, 2020; Beghetto et al., 2020). People must be willing to take risks for creative confidence to

develop into creative behavior (Beghetto et al., 2020). Furthermore, efficient divergent thinkers tend to engage in risk-taking rather than risk-averse behavior (Harada, 2020). Finally, higher scores of flexibility and originality are more related to high risk-taking scores, while elaboration is linked to a low risk-taking score (Glover and Sautter, 1977; Glover 1977).

Besides, in the study conducted by Eisenman and colleagues (1987), a correlation between measures of creativity (creative attitude, DT, and creative preference for complexity) and risk-taking emerges. In this case, however, a different measure of creativity (personal opinion and not a task of creative performance) was used in addition to the more common task of alternative uses. Charyton and colleagues (2013a; 2013b) also found a correlation between creative personality, creative temperament, and higher cognitive risk tolerance in their studies. Dewett (2006) showed that willing risk-taking is positively and significantly related to employees' creativity. A positive relationship between originality and risk-taking scores, especially in the gambling domain of risk, was also demonstrated by Pascual Leone and colleagues (2010) in university students.

In line with these studies, Charyton and colleagues (2013) found that more general creativity measures (procreative attributes) were associated with cognitive risk tolerance; in particular, they were predictors of risk. An apparent exception to this tendency is the contribution by Tyagi and colleagues (2017). They found a specific relation between high-level biographical measures of creativity and social risk-taking, while a relationship between creativity, and RT did not emerge. However, they found a relation between risk-taking in the social and personality sphere. Again, high risk-taking scores in the social domain were predictors of a creative personality.

Even Shen and colleagues (2018) show the same trend: higher scores in risk-taking tasks correlate with higher DT scores, while CT abilities are higher in low-risk takers. However, in this study, risk-taking appeared to be negatively correlated with CT. These results contrast with Tyagi and colleagues (2017) that found no relationship, probably due to different RT measures and sample characteristics.

Finally, in the study conducted by Harada (2020), the concepts of exploitation and exploration were considered an integral part of the creative process. It was evidenced that DT plays an essential role concerning risk-taking precisely relative to these two aspects of the process (optimization of the task under general information and the broader search of a more excellent range of information. He also considered RT build-up of two main aspects: risk-taking preference and risk-taking attitudes that could be a helpful line of research for future works. This study shows slightly conflicting results with those reported by Shen and colleagues (2018), likely due to different assessment tools (especially in risk attitude). Shen and colleagues (2018) used the risk preference index, whereas Harada investigated risk attitudes by imposing a prospective utility function during IGT, thus highlighting different aspects of risk. Tyagi and colleagues (2017) also employed risk-taking measures like Shen and

colleagues (2018), finding that creativity was associated with elevated risk tendency in the social domain.

To summarize these last studies, Tyagi et al. (2017), Shen et al. (2018), and Harada (2020) found that creativity was linked with high RT tendencies in the social domain and, at the same time, social risk-taking was a predictor of a creative personality. It is worth noting that, as underlined in Harada (2020), the differences in DT or CT scores in these studies (Tyagy et al., 2017; Shen et al., 2018 Harada, 2020) could also be due to cultural influence.

Beghetto and colleagues (2020) proposed a preliminary study investigating the relationship between risk-taking (willingness to take a risk) and creativity in the component of creative confidence (CC) and creative behaviour (CB). Consistently, the study confirmed that the two constructs are related: the willingness to take risk seems to be a moderator between CC and CB, thus enhancing this link. On the contrary, at low levels of risk-taking, there was no relationship between CC and CB. This could indicate that good levels of creativity influence risk-taking and vice versa, and self-confidence in one's characteristics is crucial.

In Shen and colleagues (2018), it was underlined that some aspects of creativity seem to be related to risk-taking, but it depends on using different methods of assessing both constructs. Above all, creativity and DT seem to play a role in finding alternative solutions to solve a problem contrasting fixation and perseveration. DT is related to RT as it requires an individual to explore different cognitive pathways and choices that can sometimes involve taking some risks to generate multiple solutions in a situation, especially when it is open-ended. Convergent thinking, on the other hand, leads the subject to focus on finding a single solution, and this requires a lower likelihood of risk-taking. Furthermore, RT and creativity were found to influence each other with a one-to-one relationship. An important aspect is that personality, and cognitive correlations could predict risk behaviours and gambling attitudes in adults.

Another factor to be considered when studying risk taking preferences and creativity or divergent thinking is cultural differences (Ucar, 2018). Culture could affect risk-taking and risk tolerance differently depending on the state in which the research was conducted. Many of the conflicting results could be caused by this aspect. Moreover, Shen and colleagues (2018) pointed out the positive link between DT and decision-making, including risk taking. The same experiment conducted in the Netherlands revealed negative or close to zero correlations (Chermahini and Hommel, 2010), probably influenced by cultural differences.

3.2.7 Conclusions and future directions

The different results reported in the review are mainly due to three factors: the difficulty in clearly defining the multidimensional constructs of creativity and risk, the heterogeneous tools used in the studies and, hypothetically, the cultural differences. However, even if some results are conflicting or not very significant, it emerges that people with low levels of creativity and divergent thinking (flexibility and originality) tend not to assume risky situations and decisions, preferring the status quo. Studying factors related to risk and risk-taking seems particularly important nowadays, as it can help to understand the best ways to manage risk, to avoid risky behaviours in specific domains and contexts, and to allow individuals to benefit from risk taking by making profits (e.g., Platt and Huettel, 2008; Sternberg and Lubart, 1992). Moreover, investigating the DT role in risk-taking and risk perception can also help understand people's behaviour in risk situations, especially in safety-critical environments (Bourgeois-Bougrine, 2020). In these cases, where an open problem arises in an emergency, people do not know how to reach it; they are not yet aware of the best way to get there. This process requires a continuous transition between DT and CT (Bourgeois-Bougrine, 2020).
Systematically investigating this relationship could lead to developing interventions to improve creative thinking to influence risk-taking positively. This could be an asset in today's society that has been designated as a 'risky society' (Beck, 2002), to make people more and more autonomous in their daily lives even when they have to make decisions and judgements without knowing the actual outcome/consequence of actions (Kahneman, 2003) – a situation that characterizes most problems in everyday life (open-ended problems) (e.g. in the fields of health, safety, work, economics). Since a significant aspect of risk taking is gambling, studying the relationship between cognitive components (i.e., creativity, divergent thinking, cognitive flexibility) and gambling behaviour could help prevent dysfunctional conduct in adults (Pascual-Leone et al., 2010). In addition to this definition of “risky society” (Beck, 2002), modern society is constantly evolving and requires individuals to think creatively to respond adaptively in the face of unprecedented challenges. For this reason, given the importance of creativity in solving everyday problems, its role in decision-making and social progress, the interest in this construct is on the rise (Frith et al., 2021).

ID	Authors, year	Titles	Sample	Instruments	Risk	Creativity/ divergent thinking	Findings
1	Merrifield, Guilford, and Christensen 1961	Interrelationships between certain abilities and certain traits of motivation and temperament.	ADULT	aptitude and non-aptitude test	Personality trait	Creativity	Correlation between creativity (associational fluency) and risk-taking, measured as a score on adventure.
2	Pankove and Kogan, 1967	Creative ability and risk-taking in elementary school children	CHILDREN	*Risky measures*= Draw and circle, clues and Shuffleboard *Creativity measures*= Guilford tests of creativity	General domain	Creativity	Shuffleboard correlated with creativity only boys
3	Kurtzman, 1967	A study of School Attitudes, Peer Acceptance, and personality of creative adolescents	ADOLESCENTS	*Risky measures*= High School Personality Questionnaire (HSPQ) *Creativity measures*=	Personality/trait or preference	Creativity	Creativity is linked with tolerance of ambiguity

				Kit of reference tests for Cognitive Factors (1963)			
4	Jose, 1970	Convergent-divergent thinking abilities and risk-taking in children	ADOLESCENTS	*Risky measures*= Ring Toss /Fortune Wheel (gambling)/ Clues. The third measure of risk-taking Was called. Clues. *Creativity measures*= Verbal and Figural Forms of the TTCT Kuhlmann-Anderson Test (Form I)= convergent thinking.	General domain	Divergent thinking	No correlation between DT and RT
5	Glover and Sautter, 1977	Relation of four components of creativity to risk-taking preferences	YOUNG	*Risky measures*= The Choice Dilemma Questionnaire (1964) *Creativity measures*=	General domain	Divergent thinking	higher risks = higher on the flexibility and originality measures low risk-takers= scored significantly higher on the elaboration No significant difference in the fluency measure.

				Verbal forms of the Torrance Tests of Creative Thinking			
6	Glover, 1977	Risky shift and creativity	YOUNG	*Risky measures*= Six items Stoner's (1968) *Creativity measures*= TTCT, verbal form b ("Unusual uses" and "Ask and guess")	General domain	Divergent thinking	In risky shift group (risky preferences): increase flexibility, originality, decrease the elaboration
7	Eisenman, 1987	Creativity, birth order and risk taking	ADULT	Personal opinion Survey (Eisenman, 1969) Unusual- uses test Preference for complexity WAIS vocabulary Risk taking	Personality/trait or preference	Creativity	Risk taking correlated significantly with creativity measures.
8	Dewett, 2006	Exploring the Role of Risk in Employee Creativity	ADULT	*Risky measures*= Willing risk taking (WTR); risk propensity is a five-item scale	Specific domain	Creativity	WTR was positively and significantly related to employee creativity.

				adapted from Sitkin and Weingart (1995). *Creativity measures*= adaptation from George and Zhou (2001) and Scott and Bruce (1994)			
9	Pascual Leone, Gomes, Orr, Kauploun and Abeare, 2010	Affective and Cognitive Correlates of Gambling Behavior in University Students	YOUNG	*Risky measures*= South Oaks Gambling Screen—Revised (SOGS; Lesieur and Blume 1993) *Creativity measures*= Box Test, a verbal subtest of the Torrance Tests of Creative Thinking (TTCT; Torrance 1974),	Specific domain	Divergent thinking	Self-critical and creative/original= likely to gamble. creative originality = predicts gambling up to a certain level of risk positive relationship between gambling behaviour and creative originality held only for the middle range of gambling

10	Charyton, Snelbecker, Rahman and Elliott, 2013 (a)	College Students' General Creativity as a Predictor of Cognitive Risk Tolerance	YOUNG	*Risky measures*= Cognitive Risk Tolerance Scale (CRT), *Creativity measures*= Creative Personality Scale (CPS), Creative Temperament Scale (CT),	Unique domain	Creativity	Creative personality and creative temperament predicted higher cognitive risk tolerance.
11	Charyton Snelbecker, Elliott and Rahman, 2013 (b)	College students' creative attributes as a predictor of cognitive risk tolerance.	YOUNG	*Risky measures*= Cognitive Risk Tolerance Scale (CRT). *Creativity measures*= Creative Personality Scale (CPS)	Unique domain	Creativity	Procreative attributes predicted higher cognitive risk tolerance.

12	Tyagi, Hanoch, Hall, Runco, and Denham, 2017	The Risky Side of Creativity: Domain-Specific Risk Taking in Creative Individuals	YOUNG and ADULTS	*Risky measures*= Roulette Betting Task; DOSPERT *Creativity measures*= AUT; c-RAT; CAQ; RIBSs; CPS	Specific domain	Creativity	Strong link between risk taking in the social domain and personality and biographical inventory-based measures of creativity.
13	Shen, Hommel, Yuan, Chang, and Zhang, 2018	Risk-Taking and Creativity: Convergent, but Not Divergent Thinking Is Better in Low-Risk Takers	YOUNG and ADULTS	*Risky measures*= risk-taking preference index (RPI; Hsee and Weber, 1997, 1999) *Creativity measures*= Convergent thinking RAT AUT	personality/trait or preference	Divergent thinking	An inverse relationship between risk-taking and convergent thinking, Not significantly correlated with divergent thinking.

14	Harada, 2020	The effects of risk-taking, exploitation, and exploration on creativity	YOUNG	*Risky measures*= IGT; BFS; RL (reinforcement learning) *Creativity measures*= AUT; S-A; RAT; Reading span; Operation span; Matrix span	Specific domain	Divergent thinking	Divergent thinking related to risk seeking. Convergent thinking was not associated with risk attitudes or exploitation/exploration.
15	Beghetto, Karwowski and Reiter-Palmon, 2020	Intellectual risk taking: A moderating link between creative confidence and creative behaviour?	YOUNG and ADULTS 19-79 years	*Risky measures*= IRT (Beghetto, 2009) *Creativity measures*= Global CC, Short Scale of Creative Self (SSCS, Karwowki et al., 2018) Creative Achievement (Carson et al., 2005) Creative Activity (ICAA Dietrich et al., 2018)	Unique domain	Creativity	Not stronger relationships: intellectual risk seems to moderate the relationship between CC and ICAA A positive relationship between adaptive risk taking, CC and CB

Table 4 Articles included in the revie

Chapter 4 The experimental studies

The experimental phase was the most difficult to implement, mainly due to the health emergency caused by the new coronavirus SARS-CoV-2, which forced us to implement our experiment online using Qualtrics XM and Pavlovia (PsychoPy v3). The results presented below belong to a multicenter study conducted by three units: Champlain College in Burlington (Vermont, America), the Catholic University of the Sacred Heart in Milan, and the University of Bergamo.

The experimental research presented is structured in three studies; the first two focus on DM styles, the third on performance tasks. Precisely, the first two studies aim to investigate the link between decision-making styles, risk, and divergent thinking. Specifically, the first study investigates possible differences between a sample of young Italians and young Americans. Instead, the second study aims to investigate the differences that may arise in the lifespan considering the link between these constructs. Since the first studies showed a relationship between divergent thinking and decision-making styles, the third study proceeded to investigate more deeply the nature of this link by considering decision-making processes during well-known tasks, namely the Iowa Gambling Task (IGT) and the Ultimatum Game (UG). Each of the three research protocols and procedures were approved by the Hospital Ethical Committee of the Champlain College and were conducted according to the Declaration of Helsinki.

4.1 The relationship between divergent thinking, decision making styles and risk. Young Americans and Italians, differences due to cultural background

4.1.1 Brief introduction

Starting from previous evidence in the literature, this preliminary study investigated any potential differences in decision-making styles, risk propensity, and creativity in two samples of young adults (aged 18-30) from Italy and the U.S.A. considering the culture differences.
As was partly evident in the review presented in chapter three, the influence of culture in decision making and risk taking cannot be ignored (Guess, 2004). The value of culture and its differences in

people's lives are mainly studied by intercultural psychology. However, it is worth mentioning here to explain the preliminary study, which will compare Italians and Americans. This branch of psychology regarding DM mainly considers society's individualistic and collectivistic characteristics considering differences in ethical, financial DM and the role of intuition in this process (e.g., Hofstede, 2000; Kim et al.,1994; Guess, 2004).

In this study, we considered the decision-making styles described by Scott and Bruce (1995), comparing them also concerning creativity (DT). As described above (Chapter 1), DM styles fall into five types, rational, intuitive, dependent, avoidant, and spontaneous styles (Scott and Bruce, 1995; Palmiero et al., 2020).

According to Guess (2004), the characteristics of society and the values determine the influence of the decision-making process of individuals in three ways: they can influence the perception of the problem, the generation of strategies and the selection of possible alternatives. Therefore, considering these cultural differences becomes fundamental if we study how people make decisions in contexts.

4.1.2 Materials and methods

Participants

140 subjects were included in the present study (18-30; mean=22; SD=2.94). [gender: F = 99 (70.7%)]. 83 Italians (ITA) = (59.3%) (Mean= 23,5; SD= 2,83) and 57 Americans (U.S.A.) = (40.7%) (Mean= 19.9; SD= 1,49).

Experimental procedure

After signing the informed consent form, all participants filled out online self-report questionnaires (GDMS, DOSPERT, AUT) by Qualtrics. In addition, email contacts of experimenters were provided in the survey in case some of the participants would have questions about the experiment. Participants were recruited through direct sharing of the research link. All participants were asked to carry out the experiment in a quiet, distraction-free environment, preferably using a computer or tablet. All questionnaires were completed on Qualtrics XM, an online platform that allows gathering, analyzing, and acting on data.

Materials

Divergent Thinking Task: AUT

The “Alternative use task” (Guilford, 1967) was used to assess divergent thinking abilities. Participants were asked to list in 5 minutes as many different, original, or unusual usages as possible

for an empty plastic bottle. Responses were scored considering fluency (numbers of valid answers) and originality (1 point for original responses and 0 for not original ones). These criteria for scoring were derived from the Torrance Test of Creative Thinking (Torrance, 1974). Three researchers independently coded all the answers and computed originality scores by adding the number of original answers. Disagreements in the scoring procedure of the creative tasks were discussed and resolved case by case by the three researchers. Finally, the total score was calculated by adding the scores for originality and fluency.

Domain-Specific Risk-Taking: DOSPERT (Weber et al., 2002)

It is a risk-taking scale that allows researchers and practitioners to assess both conventional risk attitudes (defined as the reported level of risk-taking) and perceived-risk attitudes (defined as the willingness to engage in a risky activity as a function of its perceived riskiness) five commonly encountered content domains. Ethical (e.g., Cheating on an exam; Illegally copying a piece of software); financial (further divided into gambling (e.g. Betting a day's income on the outcome of a sporting event (e.g. baseball, soccer, or football) and investment (e.g. Investing 5% of your annual income in a very speculative stock); health/safety (e.g. Consuming five or more servings of alcohol in a single evening; Walking home alone at night in a somewhat unsafe area of town); recreational decisions (e.g. Going on a vacation in a third-world country without pre-arranged travel and hotel accommodations; Trying out bungee jumping at least once); social decisions (e.g. Approaching your boss to ask for a raise; Arguing with a friend about an issue on which he or she has a very different opinion; Taking a job that you enjoy over one that is prestigious but less enjoyable). The scale is composed of 40 items on a 5 points scale.

General Decision-Making Style: GDMS (Scott and Bruce, 1995)

GDMS was designed to assess individuals' approaches to decision situations. It distinguishes between 5 decision styles: rationale, intuitive, dependent, avoidant, and spontaneous. The Rational style is characterized by logical thought, logical evaluation of alternatives and a structured approach to decision-making (e.g., "I double-check my information sources to be sure I have the right facts before making a decision"). The Intuitive style is represented by a tendency to rely upon intuitions, feelings and sensations and emphasizes reliance on hunches and feelings (e.g., "When making a decision, I rely upon my instincts"). The Dependent style is characterized by the need for assistance and support of others, the search for advice and direction from others." (e.g., "I often need the assistance of other people when making important decisions"). Avoidant style is represented by attempts to postpone and avoid decisions (e.g., "I avoid making important decisions until the pressure is on"). Finally, the

Spontaneous style is characterized by the tendency to make decisions impulsively, a sense of immediacy and a desire to get through the decision-making process as soon as possible. (e.g., "I generally make snap decisions"). This scale presents 25 items using 5- points ratings (Likert scale), ranging from strongly disagree (1) to strongly agree (5).

4.1.3 Results

Statistical analyses were performed with Jamovi R-based software, version 2.0.0 (2021). Descriptive statistics regarding DOSPERT, GDMS and AUT in the two samples are reported in the following tables. For the DT measures, the following are reported: fluency, originality, mean originality (originality calculated net of fluency), and a total score given by the sum of fluency and originality.

DOSPERT		Mean	SD
Ethical	ITA	2.25	0.58
	USA	2.12	0.53
Financial Investment	ITA	2.75	0.65
	USA	2.85	0.74
Financial Gambling	ITA	1.45	0.63
	USA	1.39	0.55
Health/safety	ITA	2.86	0.65
	USA	2.75	0.82
Recreational decisions	ITA	2.74	0.77
	USA	2.82	0.84
Social	ITA	3.84	0.43
	USA	3.71	0.55

Table 3 - Descriptives DOSPERT

GDMS		Mean	SD
Spontaneous	ITA	2.55	0.94
	USA	2.98	0.96
Rational	ITA	3.86	0.51
	USA	3.95	0.58
Dependent	ITA	3.85	0.48
	USA	3.81	0.56
Avoidan	ITA	2.78	0.86
	USA	2.87	1.09

Table 4 - Descriptives GDMS

AUT		Mean	SD
Fluency	ITA	6.23	4.18
	USA	11.02	5.03
Mean_orig	ITA	0.71	0.25
	USA	0.80	0.14
Originality	ITA	4.70	3.58
	USA	7.12	3.91
Creativity	ITA	10.93	7.66
	USA	18.14	8.77

Table 5 - Descriptives AUT

		Statistic	df	p
Spontaneous GDMS	Student's t	-2.58	138	0.011
Fluency AUT	Student's t	-6.13	138	< .001
Originality AUT	Student's t	-3.79	138	< .001
Creativity AUT	Student's t	-5.16	138	< .001

Table 6 - Independent t-test

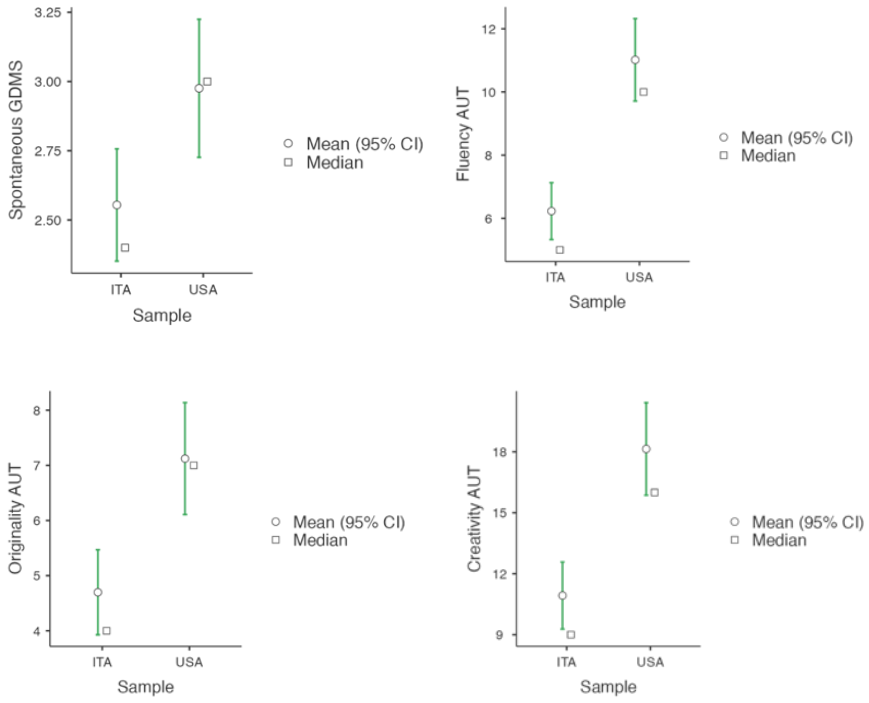


Figure 10 - Independent t test

According to our hypothesis, comparing Americans and Italians, we performed a series of **t-tests**. No significant differences emerged in the two samples on the risk perception scales. Instead, the two samples differ significantly at creativity scores (fluency, originality) and spontaneous DM style assessed with the GDMS. No differences emerge in the other decision styles.

Considering the two separate samples (Italian and American ones), correlation analyses were carried out between the three measures (creativity, risk and decision making) and cluster analyses were performed.

In the *Italian sample,* correlations emerge between scores on the GDMS and DOSPERT. Ethical scores correlated positively with Spontaneous (r= 0,30; p= 0,005), Avoidant (r= 0,24; p= 0,030) and Intuitive (r=0,27; p=0,012) styles of GDMS, and negatively with Rational style (r= -0,22; p= 0,048). Healthy/safety DOSPERT correlated negatively with rational (r= -0,22; p= 0,046) and dependent (r= -0,26; p= 0,017) styles and positively with intuitive style (r= 0,22; p= 0,048). Furthermore, recreational decisions in DOSPERT scale correlated positively with spontaneous style in GDMS (r= 0,24; p= 0,031). In addition to these significant scores, correlation trends emerge between Healthy/Safety DOSPERT and spontaneous GDMS scores (r= 0,21; p= 0,055) and between scores obtained at Financial Investment DOSPERT and dependent GDMS (r= 0,22; p= 0,050). No correlations emerged between creativity scores (fluency and originality) and those obtained in the risk and decision style questionnaires (DOSPERT and GDMS).

In the *American sample,* correlations emerge among the three variables; in particular, the spontaneous decision style (which is also the one that best discriminates the two groups) is negatively correlated with the mean originality scores (r= -0,51; p < 0,001), like the intuitive style (r= -0,45; p < 0,001). In contrast, scores on the social and health/safety DOSPERT scales correlate positively with originality and fluency scores. Specifically, Social DOSPERT correlates with both originality (r= 0,28; p= 0,032) and fluency (r= 0,31; p= 0,016), while the health/safety scale correlates with fluency (r= 0,28; p= 0,032). Spontaneous GDSM correlates positively with the financial gambling scale of DOSPERT (r= 0,29; p= 0,027). Rational GDMS correlates negatively with recreational decision DOSPERT (r= -0,27; p= 0,045). Dependent styles of GDMS correlates negatively with the scales of Healthy safety (r= -0,27; p= 0,040), Recreational (r= -0,34; p= 0,009) and Social (r= -0,33; p= 0,011) of DOSPERT. Intuitive style correlates positively with social DOSPERT (r= 0,29; p= 0,027). No correlation was found between Avoidant style of GDMS and the DOSPERT scales.

Cluster analyses with the K-means clustering method have been conducted to identify clusters in the two distinct samples, always considering two variables DOSPERT and AUT measures, and t-tests considering clustering and GDSM.

We find two clusters in the *Italian sample*. Cluster 1 (n= 43) corresponded to high ethical, financial, health/safety, recreational, social risk scales, and creative individuals. Cluster 2 (n= 40) is identified by low scores on all the DOSPERT scales and low originality and fluency scores on the AUT measures. T-tests considering GDMS show that clusters 1 and 2 differ significantly in intuitive style and emerged a trend considering spontaneous style. Cluster 1 has higher scores in both DM styles than Cluster 2.

Cluster	Ethical	Financial Investment	Financial Gambling	Healthy/ safety	Recreational decisions	Social	Fluency AUT	Originality AUT
1	-0.627	-0.342	-0.476	-0.577	-0.418	-0.413	-0.283	-0.221
2	0.674	0.367	0.512	0.620	0.450	0.444	0.304	0.238

Table 7 - Centroids of clusters Table

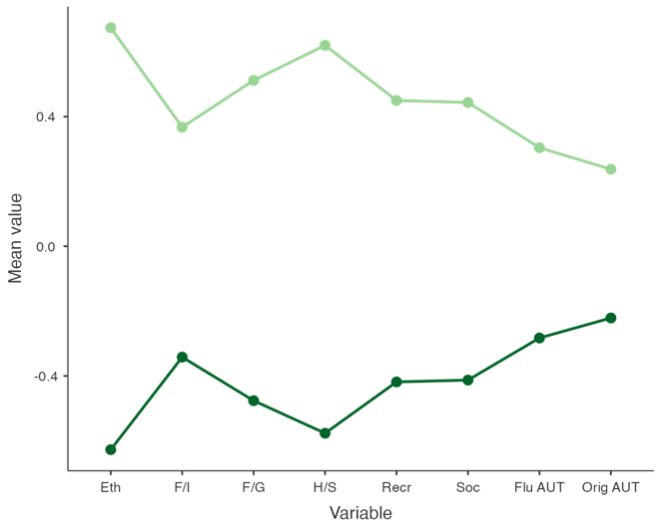


Figure 11 - Plot of means across clusters

	Clustering	Mean	SD
Ethical DOSPERT	1	1.88	0.39
	2	2.64	0.49
Financial Investment DOSPERT	1	2.53	0.62
	2	2.99	0.59
Financial Gambling DOSPERT	1	1.15	0.28
	2	1.77	0.74
Health/safety DOSPERT	1	2.49	0.50
	2	3.26	0.53
Recreational decisions DOSPERT	1	2.42	0.71
	2	3.08	0.68
Social DOSPERT	1	3.66	0.41

	2	4.03	0.36
Fluency_AUT	1	5.05	3.23
	2	7.50	4.72
Originality AUT	1	3.91	2.95
	2	5.55	4.02

Table 8 - Descriptives plot Cluster

		Statistic	df	p
Spontaneous GDMS	Student's t	-1.76	81.0	0.083
Intuitive GDMS	Student's t	-2.11	81.0	0.038

Table 9 - Independent Samples T-Test

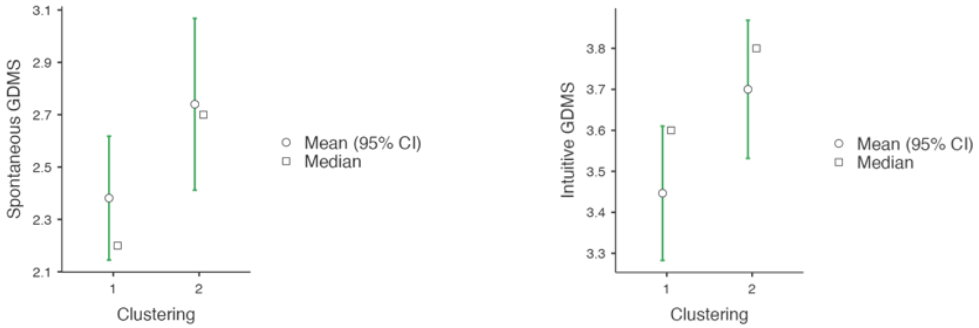


Figure 12 - Independent Samples T-Test

As in *the Italian sample*, we find two clusters in the *American sample*, one identified by high scores on risk scales and creativity scores (n=35). The second cluster (n=22) is identified by low scores on all the DOSPERT scales and the originality and fluency scores on the AUT.

Cluster	Ethical	Financial Investment	Financial Gambling	Healthy/ safety	Recreational decisions	Social	Fluency AUT	Originality AUT
1	-0.234	-0.078	-0.152	-0.492	-0.315	-0.526	-0.481	-0.477
2	0.372	0.125	0.242	0.783	0.501	0.837	0.765	0.759

Table 10 - Centroids of clusters Table

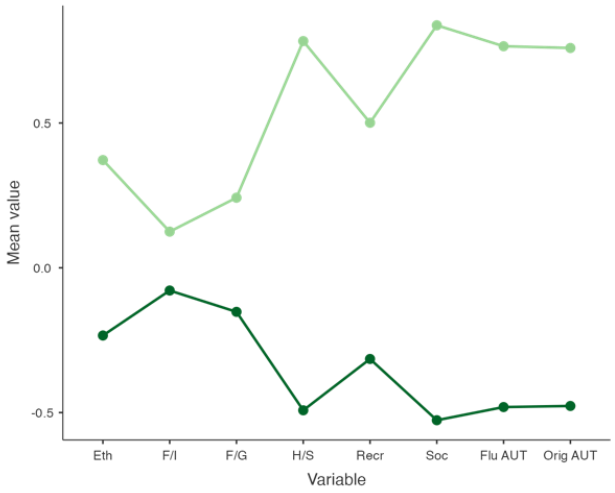


Figure 13 - Plot of means across clusters

	Clustering	Mean	SD
Ethical DOSPERT	1	1.99	0.46
	2	2.31	0.57
Financial Investment DOSPERT	1	2.79	0.76
	2	2.94	0.71
Financial Gambling DOSPERT	1	1.31	0.46
	2	1.52	0.65
Health/safety DOSPERT	1	2.35	0.57
	2	3.40	0.74
Recreational decisions DOSPERT	1	2.55	0.68
	2	3.24	0.91
Social DOSPERT	1	3.42	0.42
	2	4.16	0.40
Fluency AUT	1	8.60	3.64
	2	14.86	4.55
Originality AUT	1	5.26	2.62
	2	10.09	3.83

Table 11 -Descriptives of Clusters

T-tests considering GDMS show that clusters 1 and 2 do not differ significantly in any scale tasks.

4.1.4 Discussion

The main purpose of this study was to compare the two samples of Italians and Americans to find any differences in decision styles, risk attitude, and the role of DT in the two constructs. The two samples differ significantly in fluency and originality scores and spontaneous DM style. Thus, the first important point to discuss is the link between more adaptive decision styles and risk.

In the two samples (Italian and American), rational GDMS is negatively correlated with several domains of the DOSPERT scale; in contrast, spontaneous and avoidant GDMS styles positively correlate with several risk domains. The literature could explain this, the rational GDMS style is characterized by conscientiousness and labelled as "well adaptive" (Scott and Bruce, 1995); it is positively correlated with decision-making skills and avoidance of negative decision outcomes (Bruine de Bruin et al., 2007). This may be consistent with lower risk-taking, especially in the ethical and social domains. Rational decision-making style is also related to a lower sensitivity to decision bias, heuristics and paradoxes, while it seems to be more related to a decision maker's general ability to make choices that are logically correct or consistent with a normative ideal (Curşeu, 2006; Shafir and LeBoeuf, 2002).

The second aspect that emerged in the study was the difference between the two groups (Italian vs American) in creativity scores concerning spontaneous DM style. The results show that American participants are more fluent, original, and spontaneous than the Italian sample. However, no significant differences emerge in young people's propensity to risk investigated with the DOSPERT scale, neither in the subdomains nor considering the total risk score. The higher scores in the DT task obtained by the Americans despite Italians, especially about fluency, could be explained by the higher scores in the spontaneous style of the GDMS. Although the relationship needs to be more studied, by considering the impulsiveness and speed of the response given by the subjects, the higher number of alternatives proposed to the AUT could be caused by the higher spontaneity shown by the Americans. Moreover, the spontaneous style is characterized by immediate insights and a desire to make the decision as quickly as possible (Scott and Bruce, 1995). Considering originality, Americans seem to be more original than Italians as a total number of original answers given to the task. However, when we consider the measure of "mean originality" (originality calculated net of fluency), this disparity decreases (while remaining statistically significant). This finding is important because it allows us to understand how the number of responses even influenced original people. Considering the correlations within the two separate samples, if the Italians do not show correlations between DM, risk and creativity, the Americans show that spontaneous decision style is negatively correlated with measures of creativity.

This might explain the greater spontaneity of younger Americans, probably due to the greater impulsiveness and speed of response. However, it does not indicate greater creativity. The differences that emerged could also be due to the younger age of the American sample compared to the Italian sample, though still young. These results would seem to point toward a cultural bias that might be interesting to investigate further.

The final discussion concerns the cluster analyses and the profiles that emerged.

If no correlations seem to emerge between decision-making styles, risk and DT as far as Italians are concerned in this first study, relationships do emerge considering the profiles obtained with cluster analysis. Considering the cluster analysis, Italians are divided into two distinct groups in which one cluster is characterized by high creativity and risk scores, and the second by low risk and low creativity.

This seems to be in line with the literature that considers the risk part of creativity (Harada, 2021) as emerged in the review presented in Chapter 4. In fact, risk is defined as a determinant of creativity; in fact, creative people are more likely to be motivated by risky situations (Albert, 1990; Perkins, 1990), suggesting that risk-taking is closely related to creativity. The two clusters also appear to differ significantly in intuitive decision style with a trend in spontaneous style. The cluster that takes the most risk in all domains is also the most creative and the most spontaneous/intuitive.

The same trend can be seen in the U.S.A. sample, Cluster 1 is the more creative and risk seeking, the Cluster 2 is defined by low risk and low creativity. In this case, the two clusters differ most in creativity scores and where the risk scores that influence the difference are the health/ safety and social domains. No significant differences emerge from GDMS between the two groups, probably because Americans generally had high scores in the spontaneous style.

Starting from the theoretical findings considered for which the relationship between risk-taking and creativity is established, (Eisenman, 1987; Sternberg and Lubart, 1992; Feist et al., 1998; Dewett, 2007), a first insight that emerges from this research is that the relationship also emerges when considering empirical studies and profiles of styles and propensities. In the literature, most experimental studies reported that creativity and risk-taking were positively correlated as it emerges in the cluster analyses of the presented study (i.e Eisenman, 1987; Dewett, 2007; Tyagi et al., 2017; Harada, 2020).

From these premises, since creativity is a skill that can be enhanced, especially in flexibility, fluency, and originality, interesting scenarios of investigation on the change in risk perception and risk taking following creative stimulation programs could be considered. A critical point in this research is the importance of considering cultural background (Harada, 2021). As we have pointed out, additional aspects to consider are the different measures of assessment, in definitions of risk taking.

4.2 The relationship between DT, decision making styles and risk in lifespan in the Italian sample

4.2.1 Brief introduction

The literature regarding DM styles in ageing is controversial (Palmiero et al., 2020). Despite this, it appears that older people use more experience and emotion in making decisions and less reasoning than younger people (Peters et al., 2007). Furthermore, older adults performed better on the cognitive task requiring affect rather than deliberative processing strategies (Lockenoff, 2011). This is because fluid cognitive skills decline with age (Babcock and Salthouse, 1990). However, research in this area is still inconsistent (Mikels et al., 2015). The literature regarding DM styles states that although individuals may change because of their experiences and adaptation based on context, they tend to prefer style throughout their lives (Messick, 1976; Allwood and Salo, 2012).

Older people seem to be more likely than younger to present a more independent and self-controlled DM style (Delaney, 2015). In contrast, as was described earlier in chapter one, risk propensity depends on the context and the various domains investigated (economic, financial, health and safety, social etc.). For this reason, it is expected that it is the risk scales that change over time while DM styles remain stable over the life span (Messick, 1976; Allwood and Salo, 2012). Ageing stereotypes show older adults as more risk-averse and cautious than younger, but results are controversial considering both risks as a general domain or specifically domain (see for a review, Konig, 2020). Generally, literature reports a decline across the lifespan of risk attitudes (Dohmen et al., 2017).

This research investigates possible differences in decision-making styles in the life span and highlights the possible link to divergent thinking abilities.

4.2.2 Materials and methods

Participants

The total sample consisted of 174 Italian participants (18-75 years; mean= 38.2; SD= 16.9), [gender: F = 123 (70.7%)] who were recruited through direct sharing of the research link. All participants were asked to carry out the experiment in a quiet, and distraction-free environment, preferably using a computer or tablet.

Experimental procedures

After signing the informed consent form, all participants involved in the study filled out three online self-report questionnaires (GDMS, DOSPERT, AUT and Acronyms) by Qualtrics. In addition to the participants, email contacts and phone of the experimenters were provided so that they had the opportunity to ask questions and get information. All questionnaires were completed on Qualtrics, an online platform that allows gathering, analyzing, and acting on data.

Materials

AUT and Acronyms (from CoreT, Colombo et al., 2018)

Two tasks are used to assess DT in the component of the fluidity of thought and originality, AUT [see the previous study] and Acronyms (OMG; SOS; TGIF). The request to the acronyms task is, "In five minutes, try to find as many alternative meanings as possible for these three acronyms. The new meaning must make sense. Use all three acronyms, starting with SOS and moving on to the next one once you have finished all the options. Be creative - don't put limits on yourself". Responses at Acronyms were scored considering fluency (numbers of valid answers) and originality (1 point for original responses and 0 for not original ones). These criteria for scoring were derived from the Torrance Test of Creative Thinking (Torrance, 1974). Three researchers independently coded all the answers and computed originality scores by adding the number of original answers. Disagreements in the scoring procedure of the creative tasks were discussed and resolved case by case by the three researchers. Finally, the total score was calculated by adding the three Acronyms' scores for originality and fluency.

DOSPERT: (Weber et al., 2002) Domain-Specific Risk-Taking

[see the description of the previous study for details]

GDMS: (Scott and Bruce, 1995) General Decision-making style

[see the description of the previous study for details]

4.2.3 Results

Statistical analyses were performed with Jamovi R-based software, version 2.0.0 (2021). Descriptive statistics regarding DOSPERT, GDMS and DT measures are reported in the following tables.

DOSPERT	Mean	SD
Ethical	2.06	0.59

Financial Investment	2.79	0.74
Financial Gambling	1.40	0.61
Health/safety	2.56	0.73
Recreational decisions	2.40	0.83
Social	3.75	0.51

Table 12 - Descriptives DOSPERT

GDMS	**Mean**	**SD**
Spontaneous	2.52	0.88
Rational	3.91	0.48
Dependent	3.78	0.55
Avoidant	2.61	0.83
Intuitive	3.60	0.60

Table 13 - Descriptives GDMS

Creativity	**Mean**	**SD**
Originality tot	8.44	5.74
Fluency tot	10.33	6.38
Creativity tot	18.74	12.02
Fluency AUT	5.57	3.99
Originality AUT	4.20	3.55
Fluency Acronyms	4.78	3.42
Originality Acronyms	4.25	3.09

Table 14 - Descriptives Creativity

Correlations were conducted considering the following variables: DM styles, scores at DOSPERT, DT task scores. While decision-making styles (GDMS) do not appear to be related to age, the different domains of the DOSPERT scale correlate negatively with it. The older subjects are the less they tend to take risks and to be engage in risky behaviors in the ethical ($r= -0,34$; $p<0,001$), health and safety ($r= -0,49$; $p<0,001$), recreational ($r= -0,46$; $p<0,001$) and social domains ($r= -0,27$; $p= 0,003$). Age is also negatively correlated with creativity measures ($r= -0, 21$; $p= 0,006$): fluency ($r=-0,21$; $p= 0,005$), originality ($r= -0,21$; $p= 0,005$). The originality scores (mean originality AUT, $r= -0.15$; $p= 0.048$ and the mean originality tot, $r= -0.19$; $p= 0.012$) correlate negatively with GDMS avoidant style. Recreational decision correlates positively with Fluency scores of AUT.

		Avoidant GDMS	Ethical DOSPERT	Recreational decisions DOSPERT	Health/safety DOSPERT
Fluency AUT	Pearson's r	-0.07	0.04	**0.15***	0.09
	p-value	0.354	0.619	**0.049**	0.217
mean orig AUT	Pearson's r	**-0.15***	-0.04	0.01	-0.01
	p-value	**0.048**	0.635	0.902	0.897
mean orig acronyms	Pearson's r	**-0.15***	*-0.14*	-0.01	-0.04
	p-value	**0.053**	*0.064*	0.822	0.564
Originality acronyms	Pearson's r	-0.06	0.04	0.07	*0.14*
	p-value	0.427	0.582	0.346	*0.072*
mean orig t	Pearson's r	**-0.19***	-0.11	-0.01	-0.03
	p-value	**0.012**	0.140	0.951	0.654

Table 15 - Correlation between DOSPERT and creativity tasks

Regarding the relationship between decision-making styles and risk, positive correlations emerge between spontaneous style and risk in the areas of ethics (r= 0.16; p= 0.035), health/safety (r= 0.17; p= 0.025), and recreational (r= 0.17; p= 0.022). Rational style correlates negatively with ethical risk-taking; the more rational people are, the less they tend to engage in risky behaviours in the ethical field (r= -0.25; p<0.001). The latest significant trend involves intuitive style and risk-taking in health and safety. Scores on this scale of the GDMS correlate positively with scores on the health/safety of the DOSPERT (r= 0.16; p= 0.035).

Cluster analyses with the K-means clustering method have been conducted to identify clusters within the sample considering GDMS (Cluster 1, n=120; Cluster 2, n=54).

Cluster GDMS	Spontaneous	Rational	Dependent	Avoidant	Intuitive
1	-0.498	0.356	0.106	-0.184	-0.409
2	1.106	-0.792	-0.236	0.410	0.909

Table 16 - Centroids of clusters Table

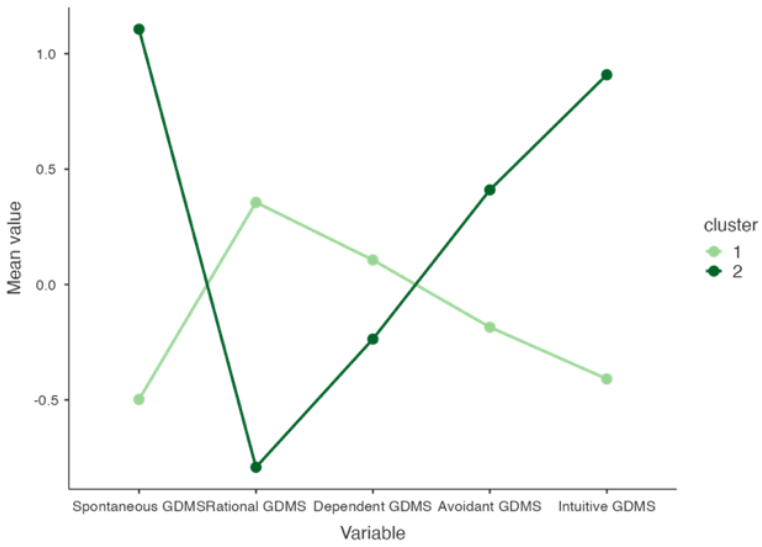


Figure 14 - Plot of means across clusters

GDMS	Clustering	Mean	SD
Spontaneous	1	2.08	0.53
	2	3.49	0.69
Rational	1	4.08	0.29
	2	3.52	0.59
Dependent	1	3.84	0.47
	2	3.65	0.69
Avoidant	1	2.46	0.80
	2	2.96	0.80
Intuitive	1	3.35	0.49
	2	4.14	0.43

Table 17 - Descriptives of clusters

DOSPERT		Statistic	p
Ethical	Mann-Whitney U	2476	0.013
Health/safety	Mann-Whitney U	2339	0.003
Recreational decisions	Mann-Whitney U	2550	0.025
Dospert tot	Mann-Whitney U	2488	0.014

Table 18 - Independent t-test

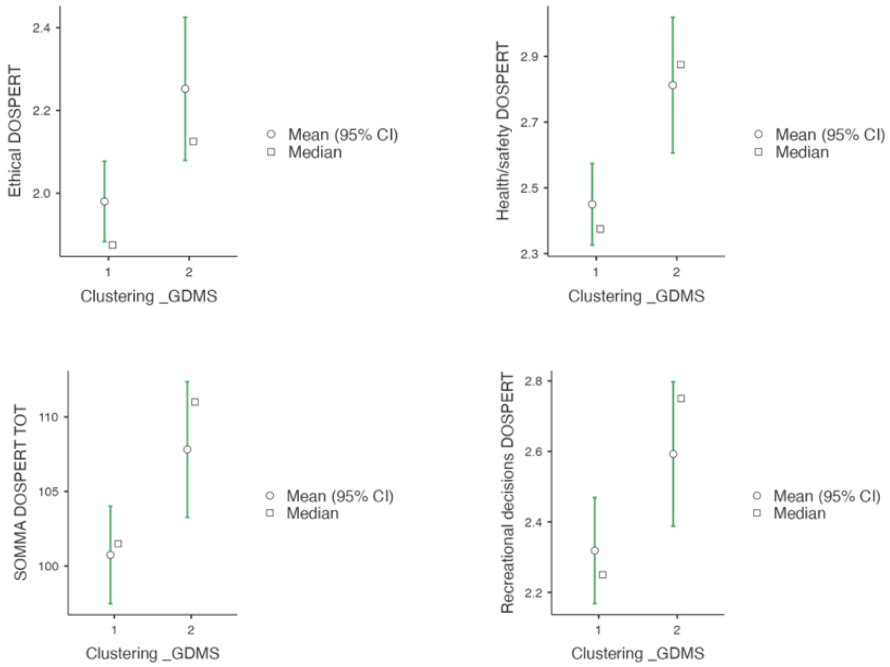


Figure 15 - Independent t-test

Two clusters emerge: the first more rational, the second with higher scores in the spontaneous and the intuitive styles. In addition, the clusters differ in risk-taking propensity, the more rational Cluster 1 has lower scores in ethical, health and safety, recreational, and general risk-taking in all domains.

4.2.4 Discussion

The study aimed to investigate the relationship between DM, RT, and creativity (DT) in the lifespan in an Italian sample. No correlation emerged between age and the DM styles, underlining no prevalent style about age. This result could be explained considering DM style as a stable and "habitual learned attitude" and "habitual pattern of learned response" exhibited in a situation (Scott and Bruce, 1995); DM styles are a sub-component of cognitive styles (Kozhevnikov, 2007) define how information is processed and processed. These styles are not rigid patterns but can be shaped by individual experiences and adaptation; individuals process information, act differently and identify different strategies. However, everyone tends to have a preferred style, but it is also true that specific tasks require certain styles (Messick, 1976). On the other hand, correlations emerge between age and risk. This could be explained because young people, adults, and the elderly behave differently towards risky situations (as highlighted in the literature, see Konig, 2015 for a review). It emerges that as age increases, the tendency to take risks decreases in almost all the areas investigated with the DOSPERT

(ethical, health and safety, recreational and social areas). The only areas that do not appear to be correlated with age are financial ones.

Age is also negatively correlated with measures of creativity, emphasizing that older subjects are less fluent and less original in creativity tasks in which they are asked to think divergently. Again, this is in line with the literature that emphasizes this discrepancy when older people are asked to perform divergent thinking tasks under the same conditions as younger people (e.g., time-constrained or when the workload is too high) (Fusi et al., 2020; Palmiero et al., 2015).

Two points would merit further investigation in future research.

1) Originality is negatively correlated with avoidant style, a style marked in the literature as dysfunctional (Bruine de Bruin et al., 2007). This may be a point to investigate further to understand whether enhancing originality can prevent avoidant decision-making behavior.

2) fluency appears to be correlated with recreational risk-taking. This result also deserves further investigation.

Regarding Cluster analysis, the sample is divided into two clusters. The first profile is more rational and the other more spontaneous and intuitive. Studies in the literature suggest that individuals differ in their habitual use of intuitive/spontaneous and reflective thinking and that these tendencies have trait-like stability over time and context (Betsch and Kunz, 2008; Marks et al., 2008; Pacini and Epstein, 1999). Besides, no significant differences emerge in the two clusters concerning age.

These two profiles correspond to the idea of dual-process models, with the intuitive, fast mode of decision making and the slower rational one (Epstein, 1994; Evans, 2008; Osman, 2004; Reyna, 2004). The first profile, more rational, consists of people who risk less considering the DOSPERT scale (particularly in the ethical, health and safety, and recreational domains), while the second profile consists of people who risk less in these DOSPERT domains.

This distinction is also in line with the literature that reports a negative relationship between rational and spontaneous styles, although there is often a balance between the two. This trend potentially indicates that rational decision-makers evaluate all alternatives more thoroughly than those and, therefore, take significantly longer to decide. Also consistent with the literature in the spontaneous cluster are high scores in the intuitive style; in fact, previous studies have shown a positive relationship between intuitive and spontaneous styles (e.g., Loo, 2000; Spicer and Sadler-Smith, 2005). This relationship indicates that intuitive individuals are more likely to make decisions under pressure (Spicer and Sadler-Smith, 2005). No significant differences emerge in the two clusters concerning the creative tasks.

In summary, an interesting research point emerges from the cluster analysis and the negative correlation between originality and avoidant style. Since avoidant DM style is maladaptive and related to procrastination (Bruine de Bruin et al., 2007; Mann et al., 1997), considering the cluster with higher scores in this style would be interesting to investigate whether increasing originality (especially in old age where) would support more functional and adaptive DM strategies.

4.3 The relationship between divergent thinking and decision-making approach in the Ultimatum Game and Iowa Gambling Task

4.3.1 Brief introduction

The literature regarding decision making and risk increasingly state that it is important to investigate these constructs with tasks that mimic everyday dynamics. One of these is the Iowa Gambling Task (IGT), in which participants have to continuously integrate information obtained as feedback from the game and must also remember and manipulate information about the obtained gains and losses (Horat et al., 2018). Similarly, the Ultimatum Game (UG) provides valuable assistance in investigating these constructs by emphasizing differences in lifespan and mimicking the economic (and other) choices people face every day (Fernandes et al., 2019). In addition, this task also explores a participant's desire for equity and their desire for personal gain and the gap between these two aspects (Iannello et al., 2014). Using these tools in the field of DM and RT research is very important because it allows assessing decision styles and risk propensity and allows to investigate the verisimilitude behaviour of people in everyday situations.

From this premise, this study aims to investigate whether DT and creativity play a role in decision and risk performance tasks. As emerged from the literature, creative thinking is related to risk-taking and DM, but while the theoretical significance of this relationship has been recognized (i.e., Eisenman, 1987; Sternberg and Lubart, 1992; Dewett, 2007), only a few empirical studies have examined this relationship (Harada, 2021).

Therefore, this experimental study investigates the correlation between DT abilities and the different strategies implied in DM during a risky situation through two performance tasks (i.e. IGT, UG) are considered and not only styles or approaches.

4.3.2 Materials and methods

Participants

76 healthy Italian subjects (20-75; mean=37,6; SD= 16,00) [gender: F = 46 (60,5%)] participated in this research conducted online.

Experimental procedure

All participants involved in this study filled out three online self-report questionnaires by Qualtrics and Pavlovia. After signing the informed consent form, participants completed the online questionnaires on Qualtrics (Melbourne decision making questionnaire and a sociodemographic questionnaire) and three online tasks (Ultimatum game, Iowa Gambling Task, Figure Task). To the participants, the references of the experimenters were provided so that they had the opportunity to ask questions and get information about the experiment by e-mail or phone. Participants were recruited through direct sharing of the research link. All participants were asked to carry out the experiment in a quiet, distraction-free environment, preferably using a computer or tablet.

Materials

MDMQ: (Mann et al., 1997) Melbourne Decision Making Questionnaire

The questionnaire was designed to assess how individuals approach decision situations. It distinguishes between approaches to decisions.

Vigilance involves a careful, unbiased, and thorough evaluation of alternatives and rational decision-making. *Hypervigilance* involves a hurried, anxious approach. *Procrastination* involves delaying decisions. *Buck Passing* involves leaving decisions to others and avoiding responsibility. The scale includes 22 items.

Decision making: The Ultimatum Game

In this task, participants are asked to split a sum of money (in this case, €100) between themselves and their partner that appears on the screen by proposing how much money each participant gets to keep. If the partner accepts the offer, everyone keeps on the money shared, while if the partner rejects the offer, neither person receives money (Gabay et al., 2014). The presentation and choice of characters alternate between impulsive choices in which the proposer has only 30 seconds to read a description of the recipients, choose a photograph from the three presented that seems to represent him/her most and make an offer. Alternatively, rational choices in which the proposer is given more time to read a description of the subjects, match the most appropriate photograph and choose the amount of money to offer.

Risk-taking: A Modified version of Iowa Gambling Task

The Iowa Gambling Task (IGT) is commonly used to understand the processes involved in decision-making. The subject is presented with four decks of cards on the computer screen in the original computerized version of the game. The decks are labelled A, B, C and D, and each card gives the subject a chance to win and lose money. Two decks are advantageous (GOOD); low winnings and low losses characterize them; two decks are disadvantageous (BAD); in fact, they have inside cards that can give big wins and big wins losses. Starting with a predefined amount of $ 2000 (or Euros), the game aims to maximize winnings and minimize losses. Using a mouse or pressing some dedicated keys, the subject can choose a card from any four decks, changing the deck whenever he wants.

For this research, we planned a modified version of the task using Pavlovia (PsychoPy v3) to emphasize and bring out more of the metacognitive aspect of the task.

In the modified version used in this experiment, the subject is always presented with four decks of cards on the screen (A, B, C, D). Unlike the standard game, in this case, randomized plays are proposed by the computer to the subject; at each proposed play, he/she must decide whether he wants to play and reveal the card or pass. As in the classic experiment, there are two good and two bad decks. At each play, the subject is asked if he/she agrees to flip the card and find out how much money he/she wins or loses or if he decides to move on to the next play. The decision must be made quickly, within 4 seconds. Otherwise, the computer automatically switches to the next game. The experiment consists of three steps of 16 plays each, in which cards from the four decks are randomly presented for 48 plays. At each step, the decks are always the same. The required goal is always to maximize winnings and minimize losses starting from a sum of 2000 euros. At the end of each step/trial, after 16 plays, the subject is asked if he/she has understood which are the winning decks and which are the losers, asking the subject to indicate them on the screen, favouring a metacognitive investigation of the strategies implemented to move forward in the task.

Figure 16 - Examples of IGT screen

Divergent thinking: Figure Task (Agnoli et al., 2016)

The figure task is a figurative task of divergent thinking. The battery contains three figurative tasks composed of abstract drawings in black and white, like those used by Wallach and Kogan (1965). Participants have 3 minutes for each figure to list all the things they can think that each figure could represent: answers are assessed by agreement between judges for fluency/flexibility and originality (Agnoli et al., 2016).

4.3.3 Results

Statistical analyses were performed with Jamovi R-based software, version 2.0.0 (2021). Descriptives statistics regarding MDMQ, creativity, IGT and UG are reported in the following tables.

MDMQ	Mean	SD
Buck Passing	9.63	2.98
Vigilance	16.63	3.11
Procrastination	8.70	2.53
Hypervigilance	9.46	2.63

Table 19 - Descriptives MDMQ

Figure Task	Mean	SD
Originality	2.57	0.57
Flexibility	14.18	5.24
Fluency	21.53	10.39
Creativity	38.28	15.39

Table 20 - Descriptives Figure Task

IGT	Mean	SD
Sum tot	5487.50	2533.86
G/good	16.62	4.14
G/Bad	14.55	3.79
G/pass	16.83	5.66
Total correct	5.51	2.04
Total wrong	3.79	2.08
Tot I don't know	2.67	2.24

Table 21 - Descriptives IGT

UG	Mean	SD
Acceptance prop	43.75	15.1
Reject prop	39.84	11.9
Proposal tot	167.17	47.2
Accept-Reject	3.91	13.5

Table 22 - Descriptives UG

Correlation analyses were carried out between MDMQ, IGT, UG and creativity scores at Figure task. **Correlation with age:** No correlations between age and MDMQ emerged in the sample considered. However, age correlates as in the previous study with DT scores. People are less creative, notably less fluent, and less flexible in DT tasks with increasing age.

		age
Flexibility	Pearson's r	-0.30**
	p-value	0.010
Fluency	Pearson's r	-0.30**
	p-value	0.008
Creativity	Pearson's r	-0.31**
	p-value	0.007

Table 23 - Correlation between creativity and age

No correlations emerge between age and the sum proposed at the UG, either to the acceptors or the rejectors. Age is also negatively correlated with correct answers given to the IOWA task (IGT). This

score is given by the sum of all correct answers given at the end of each trial in which the subject is asked if he or she understood which decks are winning and which are losing.

		age
Total correct	Pearson's r	-0.26
	p-value	0.051

Table 24 - Correlation between IGT and age

A nonparametric ANOVA was performed to investigate age differences specifically, for exploratory purposes only, dividing the sample into three subgroups (18-30; 31-59; over 60). Significant scores are shown in the tables.

	χ^2	df	p	ε^2
Buck Passing	8.11	2	0.017	0.1081
Procrastination	14.38	2	< .001	0.1917
Flexibility	6.75	2	0.034	0.0900
Creativity	8.21	2	0.017	0.1094
Fluency	9.87	2	0.007	0.1316
G/good	5.31	2	0.070	0.0709

Table 25 - Non parametric ANOVA, Kruskal-Wallis

	class of age	Mean	SD
Buck Passing	18-30	10.63	3.26
	31-59	8.45	2.34
Procrastination	18-30	9.31	2.36
	31-59	7.31	1.81
	over 60	10.25	3.02
Flexibility	18-30	15.89	5.68
	over 60	11.25	4.03
Creativity	18-30	43.23	16.76
	over 60	28.75	10.61
Fluency	18-30	24.74	11.56
	over 60	15.08	6.35
G/good	18-30	17.83	3.54
	over 60	15.25	3.36

Table 26 - Descriptives

		Creativity	Originality	Flexibility	Fluency
Total correct	Pearson's r	**0.37*** **	0.10	**0.38*** **	**0.35** **
	p-value	**< .001**	0.382	**< .001**	**0.002**
Tot I don't know	Pearson's r	**-0.22**	-0.22	**-0.26**	-0.18
	p-value	**0.056**	0.060	**0.023**	0.115
Procrastination	Pearson's r	0.09	**-0.30** **	0.09	0.11
	p-value	0.425	**0.008**	0.436	0.351

Table 27 - Correlation between IGT, MDMQ and creativity measures

Positive correlations emerged between creativity scores at the figure task, and correct responses were given on the IGT (answer "advantageous deck" if it was advantageous/ "disadvantageous deck" if disadvantageous). The more creative people are, the less they procrastinate on decisions, and the more they recognize disadvantageous decks and disadvantageous decks. It also emerges that the more creative people are, the less they give "I don't know" answers when responding to whether decks are advantageous or disadvantageous.

		Reject proposal	Acceptance proposal	Proposal tot
G/good	Pearson's r	**0.29** **	**0.20**	**0.28**
	p-value	**0.010**	**0.076**	**0.014**
G/pass	Pearson's r	**-0.23***	-0.13	-0.20
	p-value	**0.048**	0.256	0.084

Table 28 - Correlation between IGT and Ultimatum Game

Moreover, in this study, Cluster analyses with the K-means clustering method have been conducted to identify clusters in the sample and t-tests between groups. K means cluster analysis was conducted considering MDMQ and creativity scores to construct profiles and considering performance at IGT. Unfortunately, no clusters emerged when considering performance at the UG. Considering MDMQ and creativity, two clusters were found (Cluster 1, n=30; Cluster 2, n=46).

Cluster	Buck Passing	Procrastination	Hypervigilance	Vigilance	Originality	Flexibility	Fluency
1	0.605	0.686	0.739	0.440	-0.580	-0.461	-0.407
2	-0.394	-0.448	-0.482	-0.287	0.378	0.301	0.265

Table 29 - Centroids of clusters Table

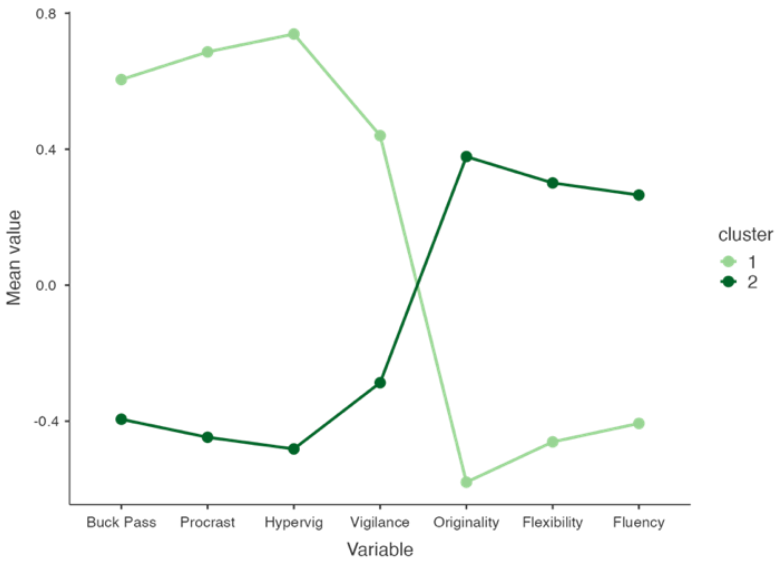


Figure 17 - Plot of means across clusters

	Clustering	Mean	SD
Buck Passing	1	11.43	3.13
	2	8.46	2.21
Procrastination	1	10.43	2.28
	2	7.57	1.99
Hypervigilance	1	11.40	2.39
	2	8.20	1.92
Vigilance	1	18.00	3.08
	2	15.74	2.82
Originality	1	2.23	0.57
	2	2.78	0.47
Flexibility	1	11.77	3.66
	2	15.76	5.54
Fluency	1	17.30	6.30
	2	24.28	11.61

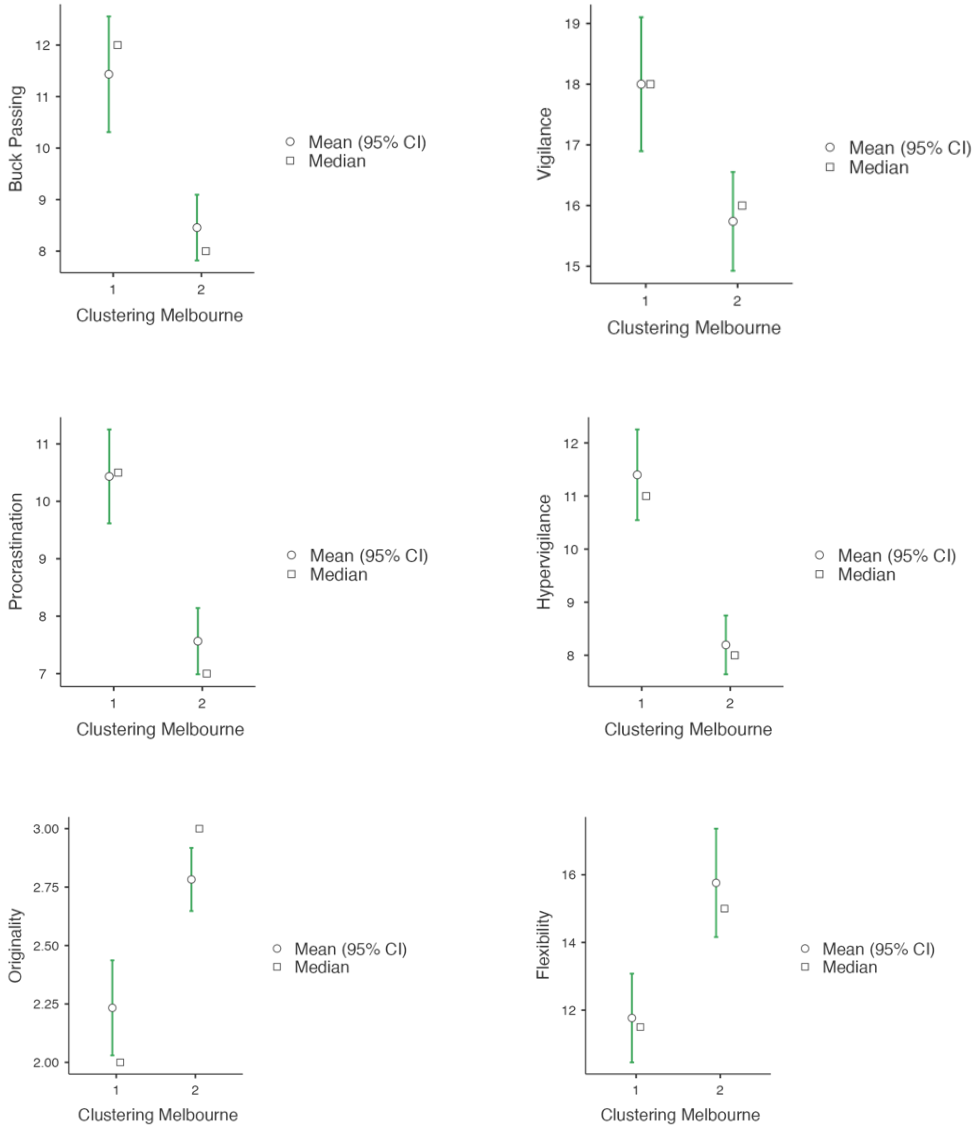
Table 30 - Descriptives of clusters

	Clustering	Statistic	p
Buck Passing	Mann-Whitney U	282	< .001
Vigilance	Mann-Whitney U	419	0.004
Procrastination	Mann-Whitney U	232	< .001
Hypervigilance	Mann-Whitney U	184	< .001
Originality	Mann-Whitney U	335	< .001
Flexibility	Mann-Whitney U	398	0.002

Creativity	Mann-Whitney U	385	0.001
Fluency	Mann-Whitney U	426	0.005

Table 31 - Independent samples T-Test between cluster 1 and 2

At nonparametric Mann-Whitney t-tests, significant differences between the two groups in buck-passing, hypervigilance, and procrastination scores are confirmed as best identifying the two groups, along with creativity scores, especially in originality. On the other hand, age does not differ significantly in the two clusters.



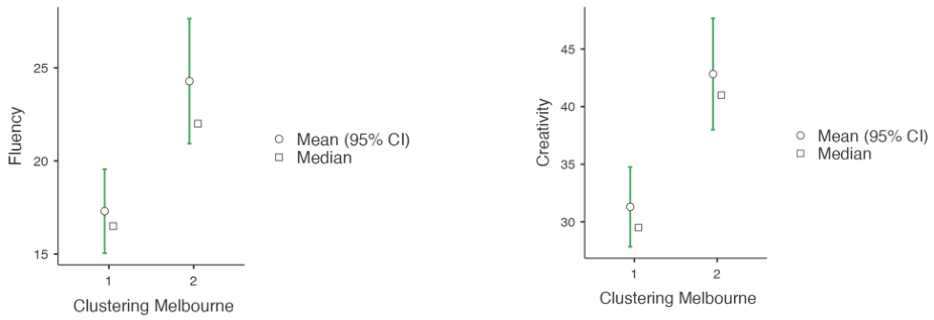


Figure 18 - Independent samples T-Test between cluster 1 and 2

Considering performance at IGT, two clusters were found (Cluster1, n= 48; Cluster 2, n=28).

Cluster	G/good	G/pass	Total wrong	Tot I don't know	Total correct
1	0.509	-0.393	-0.490	0.334	0.147
2	-0.873	0.674	0.839	-0.572	-0.251

Table 32 - Centroids of clusters Table

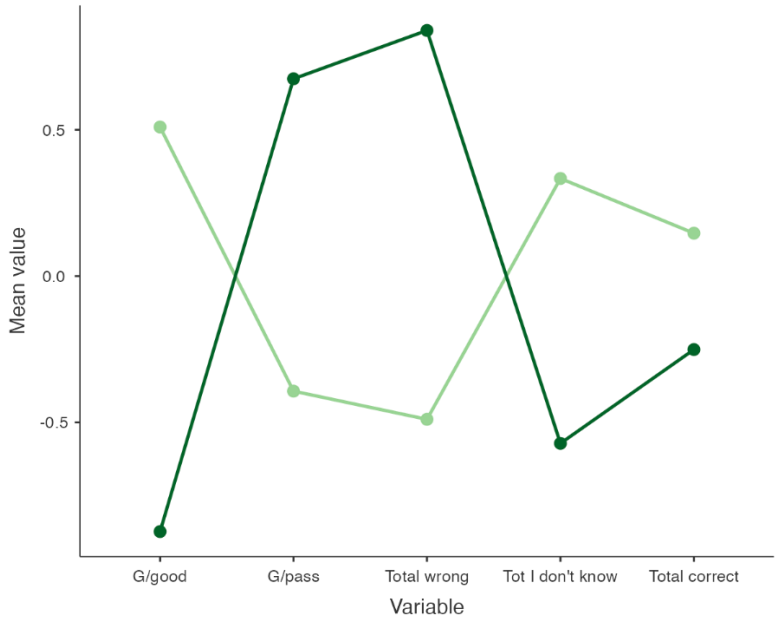


Figure 19 - Plot of means across clusters

	Clustering	Mean	SD
G/good	1	18.73	2.93
	2	13.00	3.36
G/pass	1	14.60	4.50

	2	20.64	5.45
Total wrong	1	2.77	1.68
	2	5.54	1.45
Tot I don't know	1	3.42	2.21
	2	1.39	1.64
Total correct	1	5.81	2.16
	2	5.00	1.74

Table 33 - Descriptives of clusters

At t-tests, significant differences in the two profiles are confirmed. Moreover, significant differences in vigilance scores emerge, and the sum of money proposed to the rejectors. Also, in this case, age does not differ significantly in the two clusters.

	Clustering	**Statistic**	**p**
Total wrong	Mann-Whitney U	132	< .001
Total correct	Mann-Whitney U	494	0.051
Tot I don't know	Mann-Whitney U	289	< .001
G/good	Mann-Whitney U	120	< .001
G/pass	Mann-Whitney U	273	< .001
Vigilance	Mann-Whitney U	494	0.054

Table 34 - Independent samples T-Test

4.3.4 Discussion

This study investigates whether DT and creativity play a role in decision making and risk performance tasks.

In line with previous studies, this study shows a negative correlation between age and both DT scores and “total correct” at the IGT, while no significant correlations emerge between age and UG. As the IGT is a task that measures risk taking, this result is in line with the literature suggesting a decline in risk attitudes across lifespans (Dohmen et al., 2017; Jianakoplos and Bernasek, 2006): this indicates that older subjects less correctly recognize advantageous decks from disadvantageous ones. It also emerges that older people perform less well than younger people in the IGT, scoring fewer good plays. However, again, this is in line with the literature. Furthermore, the tendency of the elderly to pass more plays and thus not take risks could be due to a major risk aversion instead of young

(Mamerow et al., 2016; Shao and Lee, 2014). Comparing the three groups in the sample divided by age with nonparametric ANOVA, the trend is in line with the literature. It emerges that young people have higher scores on the buck-passing scale than the 31-59 years group; procrastination, therefore a lower assumption of risk, is higher in the young and old compared to the adult group (U-shape). This, in line with the literature regarding risk taking, in which an inverted U-shape relationship (increasing in young adults and declining around age 60) in risk taking across domains, has been found (Rolison et al., 2014). DT scores appear to correlate with scores on the IGT and with procrastination. It thus emerges that the more creative people are, the more they tend to give correct metacognitive responses with fewer incorrect responses to the IGT. "I don't know" responses, which can be defined as avoidant, are also correlated with DT scores, but negatively. In line with these findings, the more original people are, the less they tend to procrastinate. Many studies show that risk is integral to creativity and vice versa (Dewett, 2007; Eisenman, 1987). Good plays at the IGT also correlated with implementing more functional strategies at the UG, both as proposed to refusers and acceptors; scores at "pass plays" instead correlated negatively with the UG. However, these changes in risk attitude are dependent on age and vary across individuals (Malmendier and Nagel, 2011). For this reason, it is possible to identify different profiles.

Since the profiles were obtained with the cluster analysis, we defined the groups based on MDMQ and DT and considered the IGT.

Considering the MDMQ, a profile is characterized more by low-functional strategies, with high buck-passing, procrastination, hypervigilance. This profile also shows low DT scores, both in terms of fluency, originality, and flexibility. The second profile instead has lower scores to the less functional coping patterns, while higher scores in the DT task. This result could be useful in enhancing DT skills that seem to be related to more functional coping strategies and DM than those with low DT scores.

Considering the performance at IGT, two distinct profiles emerge. One is characterized by many good plays and few passing plays, while the other is defined by many good plays and few passing plays. Considering the scores obtained from the metacognitive responses of deck recognition (disadvantageous and advantageous), the first group is defined by many good plays, few pass plays, while the second group has more pass plays and fewer good plays. This distinction can be explained by considering the differences between the two profiles at vigilance scores—the first profile results in more vigilance than the second. The vigilant style is the one that has been shown in the literature to be more effective and self-rewarding (Bailly and Ilharragorry-Devaux, 2011). The first profile is also higher in correct response scores in recognizing disadvantageous decks from advantageous ones. Thus, it can be supposed that the first profile is more functional than the second for the proposed decision context.

In conclusion, this study shows that divergent thinking skills are related to more functional DM strategies. This result could be crucial to hypothesize creative stimulation pathways to improve DT skills that seem to be related to more functional coping strategies. Likewise, considering the profiles that emerged from the clusters, it is possible to state that the more functional profile is related to higher scores in divergent thinking tasks. Moreover, this result reinforces the idea that improving DT skills (originality, flexibility, and fluency) could help people improve their behavior in DM tasks. In addition to this, in the future, it could be interesting to investigate how the profiles that emerged from the IGT are related to divergent thinking skills since the data shows that the more creative people are, the more they tend to give correct metacognitive responses, thus having a more functional attitude in decision-making tasks that involve risk.

4.4 Limitation and future research directions

Some limitations must be reported. First, the online administration of questionnaires and tasks. If the self-report questionnaires were easy to propose on the online platform, constructing and implementing the performance tasks was more complex. In particular, the Ultimatum Game, in this mode of administration, did not prove to be very effective. Additionally, considering dropouts, many people did not complete the research. Second, further analysis could be conducted, considering gender differences, especially in the sample of young people. Unfortunately, gender balancing was not possible.

As future directions, the research team analyses reaction times at performing tasks and response times to creativity tasks to investigate further links. Considering this study of healthy subjects, in addition to expanding the sample of healthy Italian elders, we set out to investigate differences between Italian and American elders, completing data collection in this direction as well.

Conclusions

The overall aim of this dissertation was to explore the relationship between the decision-making process, risk components, and creativity. As emerged in the first chapter, human DM is a complex process characterized by many interacting internal and external (contextual) factors: deciding involves encoding, combining, separating, deleting, simplifying information, and recognizing alternatives (Kahneman and Tversky, 1979). Moreover, many situations present wicked/open problems that are incomplete, contradictory, and changeable (Phillips et al., 2016; Strough and Bruine de Bruin, 2020). People face everyday decisions that have consequences for their health, wealth, economic, financial, social, and emotional well-being; living successfully means acting efficiently, making choices most properly. Therefore, a better decision-making process should help people achieve better life outcomes (Edwards 1954; Yates 1990; Keren and Bruine de Bruin 2003; Rosi et al., 2019). A better understanding of older adults' strengths and weaknesses in applying decision rules may provide relevant insights for designing interventions to promote better decision making in lifespan (Rosi et al., 2019). For this reason, investigating the variables that can help and support the DM process is crucial.

This dissertation highlights that behavioural DM research involves several approaches, including normative, descriptive, and prescriptive concepts. Besides, the first chapter described the different theories that have supported and explained DM processes over the years. Specifically, normative theories referred to people's absolute rationality; descriptive theories recognized rationality bounded by the limits of human cognition (Simon, 1956); Kahneman and Tversky's studies, with the introduction of heuristics and cognitive biases and errors, contribute to the construction of dual-process models of DM (Kahneman 2003; Kahneman and Tversky, 1979; Tversky and Kahneman, 1974). A key aspect of research in this area over the past 20 years has been the interest in older age, changes in decision-making skills and, consequently, risk perception (Strough and Bruine de Bruin, 2020). Authors have used several behavioural decision tasks in samples of different ages. However, according to Strough and Bruine de Bruin (2020), most of this research is based on cross-sectional samples that confound age and historical cohort, making it impossible to determine if age differences reflect a maturational change or cohort differences. Building profiles in the population may be useful to overcome this problem and investigate these differences. From the literature, it is known that to reduce cognitive effort older adults tend to select more specific decision-making contexts with fewer variables to consider and fewer choice options (Mikels et al. 2009; Reed et al. 2013, von Helversen

and Mata 2012; Wood et al. 2015). While this can be functional, it also precludes several opportunities that older adults do not consider because they seek less information before reducing cognitive effort (Johnson, 1990; Mata and Nunes, 2010). When alternatives are limited, people often use analytical and rational analysis; on the contrary, individuals adopt simplifying strategies, i.e., heuristics, to limit complexities (Payne et al., 1993).

In this vein, one of the most interesting aspects of decision-making behavior is the flexibility with which individuals respond to a wide variety of situations. Crucial support in this area can come from DT enhancement. Furthermore, despite the controversies that have been discussed in previous chapters and the theoretical and methodological problems encountered, especially regarding assessment tools and definitions of the various constructs, the overall conclusion is that DT is related to some components of DM and RT. Specifically, DT appears to be related to increased risk-taking across all ages but is also negatively related to dysfunctional DM strategies, such as procrastination.

Studying decision-making skills under risky conditions and functional strategies for making choices has become a very timely topic in all age groups. Therefore, considering the variables that may come into play in this process, including divergent thinking as found in this study, can be a helpful starting point for pathways of reinforcement and support. Furthermore, a crucial aspect to consider is that few empirical studies have yet been conducted to examine the relationship between these three constructs, although the theoretical relevance of this relationship has been recognized (Harada et al., 2021).

Allwood and Selart (2010), in “Decision Making: Social and Creative Dimensions”, present some studies by several authors regarding DM and the factors of creativity (in particular DT). According to these authors, originality, flexibility, and fluency (generating many ideas) are salient and fundamental points of a functional DM process. Creative people can try many formulations and interpretations until one best fits the available data and current situation. This way of proceeding provides the best opportunity to make decisions concerning the context (Allwood and Selart, 2010).

Finally, creative thinking and decision making are included in the ten critical life skills established by the WHO (Self-awareness - Empathy - Critical thinking - Creative thinking - Decision making - Problem-solving - Effective communication - Interpersonal relationships - Coping with stress - Coping with emotions). These skills are defined as behaviours that enable individuals to adapt and cope effectively with life's demands and challenges, hence the importance of pathways that can make them as effective as possible throughout life (Pandey and Tyagi, 2019)

Concerning the studies carried out in the last year, we will deepen the role of time pressure both in the DM process and in risk propensity, also in the light of the investigation carried out by our research

group with the review "The Controversial Effect of Age on Divergent Thinking Abilities: A Systematic Review" (Fusi et al., 2020). The results obtained in the reported studies may have some important practical implications that we believe researchers should consider. Creativity and in particular DT help to generate multiple ideas and consider multiple options, which can dramatically modify the decision-making process. In addition, greater creativity improves the ability to tolerate ambiguity. We intend to expand the sample of older people to investigate more systematically the differences and correlations and to consolidate the results obtained, namely a positive relationship between divergent thinking and functional decision-making styles and less procrastination and avoidance. In this regard, if the correlations are supported, it would be interesting to propose a training to stimulate DT by investigating how the strategies implemented in the decision-making process before and after the intervention might change, both in young and in elderly subjects.

A further aspect to be investigated is the cultural difference and, in this case, the hypothesis of a possible greater behaviour impulsiveness in American subjects than in Italian ones.
In conclusion, attention must be paid to the time frame in which this dissertation is written (a.a 2020/2021). A particular mention goes to the Sars-Cov-2 (Covid-19) pandemic. The pandemic has not only forced all professions to rethink their practices and approaches. However, it has undelighted the importance of managing risk, especially in the healthy/safety domain (responsibility for conduct safety behavior; reading the news; information management and whether to proceed for example, with vaccination). On the one hand, this situation has further emphasized the difficulty of making decisions in unclear, challenging, ambivalent contexts. On the other hand, because COVID-19 was an unknown disease and much is still uncertain, politicians, citizens, each of us relied on the opinions of expert committees to make daily decisions about what to do. Being aware of decision-making styles, abilities, and processes that drive the ability to choose could be critical to making good and functional decisions in lifespan.

Apparatuses

List of figures

List of tables

List of tables

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