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THE AROUSING RISK

Influences of positive and negative arousal on preferences for economic risk

by

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To my tireless parents

LIST OF PAPERS

I – Galentino, A., & Bonini, N. (in preparation). Incidental arousal elicited through contextual factors influences individual's preference for risky lotteries.

II – Galentino, A., Bonini, N., & Savadori, L. (Submitted). Positive arousal increases individual's preference for risky lotteries.

III – Galentino, A., Bonini, N., Savadori, L., Venkatraman, V., & Vo, K.(In preparation). Incidental negative arousal and individual's preferences for risky lotteries: an eye tracking study.

IV – Galentino, A., Bonini, N., Savadori, L., Venkatraman, V., & Vo, K.(In preparation). Incidental positive arousal and individual's preference for risky lotteries: an eye tracking study.

Abstract

Standard economic models explain decision making under risk as a utility maximization process. Developments in cognitive psychology and neuroeconomics showed the volatility of such conceptualization highlighting human bounded rationality and discussing the role of decision maker's *affective state* (basic reactions to any emotionally charged event) in cognitive evaluation of risk (risk as feeling). In particular, an affective-based evaluation of choice options may determine whether decision maker's behavior will be risk averse or risk seeking. Evidence indicates that affective reactions carry over significant information about the goodness of certain choice options directly influencing risk taking behavior. Affective influences on decisions may be directly associated with the evaluation of the choice options and the anticipation of future outcomes (*integral affect*) or may be associated with stimuli or event unrelated to the decision at hand, for example contextual factors or environmental cues (*incidental affect*). A classic advertisement strategy, such as a smiling face presented in association with a good, is an example of contextual affective manipulation. Research shows that experiencing a positive affective state may lead to risk aversion behavior while negative affect may lead to risk seeking. However, previous studies mostly adopted a valence-based approach to the study of affect ignoring its multidimensional nature. In particular, the role of *arousal* has been largely neglected. Recent studies showed that emotional states with the same valence may have opposite consequences on risk taking. Therefore, the main purpose of the series of studies described in this dissertation was to investigate the effect of inducing incidental affective states at high and low levels of negative arousal or positive arousal on preferences for monetary options varying in risk. Research shows that elevated arousal is associated with cognitive depletion, increased sensitivity to rewards, immediate gratification, less resistance to temptation. Therefore, we hypothesized that affective states characterized by high levels of arousal might increase preferences for the riskier option. We further predicted that including arousing stimuli as contextual factor of a decision scenario would capture individual attention interfering with information processing of risk. In order to achieve this goal, in a first series of experiments we

asked participants to make choices between couples of two-outcomes lotteries with the same expected value but different risk. Arousal was manipulated by presenting participants with visual stimuli (IAPS pictures) varying in the level of arousal (high or low) keeping the valence unvaried (negative or positive). By adopting the technique of contextual priming, participants were simultaneously exposed to stimuli (the lotteries) and the contextual factor (the arousing/unarousing image). An effect of arousal on predicting risky choice was found. Probability of selecting the riskier lottery was higher when an arousing stimuli (unpleasant or pleasant) was included as part of the decision context. In some cases, positive arousal was found to interact with gender: risk taking was higher in males than females when a pleasant arousing cue was presented. In a second series of studies, participants performed the same task and, by using an eye tracker, eye fixations and looking times were recorded. The predicted effect of arousal on attention was found. Participants spent more time looking at the arousing image (unpleasant or pleasant). This result is in line with arousal theories which correlate the level of arousal to attention allocated to the arousing stimuli. Furthermore, participants seemed to process less risky information (as indicated by decreased looking times toward the riskier option) when the arousing stimuli was contextually presented, as opposed to when the unarousing stimuli was presented.

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Part I

Introduction

When someone makes a decision,
he is really diving into a strong current
that will carry him to places he had never dreamed of
when he first made the decision.

Paul Coelho

CHAPTER 1

Affect and Decision Making

1.1 Definition of emotions and affective state

Before discussing the influences of emotional states on decision making process we need to consider an important and controversial issue concerning how to define emotions and affective reactions. Despite the fact that the scientific interest in the study of emotions has a long tradition in psychology (Zajonc, 1988), there is very little consensus among scientists on how to define emotion and what the structure of emotion should be. The reason of such turmoil is the concept of emotion itself. '*Emotion*' is mostly a convenient label used to describe certain aspects of the brain and mind (LeDoux, 1996). The term is used to include a variety of situations such as the euphoria of passing an exam, a brief startle at an unexpected scary scene while watching a movie, feeling down in the dumps for no known reason, coping with a loss for a long period, lifelong love with one's significant other, an interest in a news and so on and so forth. It is evident that there is a wild range of different situations where one can experience an 'emotion'. In the early 1884, William James published a work titled *What is an Emotion?* where he argued that the exposure to a stimulus (mental or real) is always accompanied to physical reactions (e.g. changing in the cardiovascular activity) and that the feeling of such physical changes is emotion. According to James' theory, people experience various emotions because they experience various physical reactions. Conversely, others believed that physical reactions are the same regardless the experienced emotional state (Cannon, 1929) and that what we call emotion is the result of a cognitive evaluation of the current situation (Arnold,1960; Schachter & Singer, 1962). The proliferation of numerous theories of emotions makes it difficult to establish what is an emotion and what is not and the experts are still far from achieving an agreement on this topic. As noted by the examples listed above, emotion includes a too broad class of events to be attributed to a single specific category or definition. However a clarification is necessary, at least at a theoretical and empirical level.

Russell and Feldman Barrett (1999) made a clear distinction between prototypical emotional episodes and core affects. *Prototypical emotional episodes* are often thought as discrete emotional categories (e.g. happiness, love, fear, anger, etc.) which stem from the common vision of emotion that most people has and that is also reflected in the use of verbal self-report scales by the researchers. The peculiarity of a prototypical emotional episode is that it is typically about something: i.e. a person, a condition, a thing (real or imagined) at which a mental state is directed. Following the definition provided by Russell and Feldman Barrett (1999) a prototypical emotional episode is a set of interrelated subevents concerned with a specific object (p. 806). One is in love *with*, is afraid *of*, is angry *with*, so that the emotion is always directed toward an object. Prototypical emotional episodes involve high-level processing and cognitive appraisal (Roseman et al., 1990); a specific facial expression (Ekman, 1984); a pattern of physiological reactions due to the autonomic nervous system activity (Ekman et al., 1983); behavioral response or action tendency (Frijda, 1986); neural responses that underlie the emotional episode (Panksepp, 1982). Therefore, as pointed out by Oatley and Johnson-Laird (1987), an emotion elicited by the presence of an object (real or imagined) should be considered as a complex event. Instead, there are other simpler emotional processes which could be free of objects and of that high-level processing characterizing the prototypical emotional episodes. Russell and Feldman Barrett (1999) used the term *core affect* to describe the most elementary consciously accessible affective feelings (and their neurophysiological counterparts) that need not to be directed at anything (p. 806). A core affect is the most basic reaction to any emotionally charged event. It is caused and affected by many internal and external forces like specific events, environmental cues (e.g. odors, noise, contextual cues), the weather or diurnal cycles, and so on. It represents the most primitive part of what characterize an emotion (the raw feeling). Examples of core affect, or simply affect (Watson & Tellegen, 1985), are sense of pleasure or displeasure, tension or relax, depression or elation (Russell & Feldman Barrett, 1999). A person always has a core affect: at any point in time one can infer and provide information about his/her current affective state. For example, feeling cheerful or tense for no evident reason, feeling joy or sadness from listening to music, feeling good from playing a sport, feeling mournful on a rainy day, feeling relaxed while having drinks with friends after an hardworking day, and so forth. As proposed by Russell and Feldman Barrett (1999), affect has a dimensional structure since it can be described as variations along two independent dimensions: i.e. degree of pleasantness (valence) and degree of activation (arousal). As it will be explained in more detail later, all possible combination of different levels of those two dimensions can occur so as to make distinct states that are not emotion per se, but can provide a descriptive information about core affect at any point in time (i.e. the affective state) (see section 1.5 of this dissertation). Even though affect is an object-free feeling, it could be directed toward a salient stimulus, as it becomes part of a prototypical emotional episode. For this reason, affect can also be seen as the elemental feeling included within the prototypical emotional episode (e.g. the activated pleasure within an episode of full joy). Affect and prototypical emotional episodes are related, partially overlapping, but far from identical. Affect is at the heart of an emotional episode and any prototypical emotional episode actually starts with a change in individual affective state in response to stimuli/events, but then it develops into a more complex process once high-level processing and cognitive structures are involved (Russell & Feldman Barrett 1999).

Summing up, at the heart of emotional episodes and any emotionally charged event there are affective states experienced as variation of pleasantness and activation. These states, called core affect (from now on affect), influence cognition and behavior and are influenced by many internal or external forces. Affect can be experienced as an object-free feeling or it can be related to a specific cause beginning a prototypical emotional episode which involves more complex high-level cognitive processing.

After clarifying similarities and differences between affect and prototypical emotional episode as they have been theorized by Russell and Feldman Barrett (1999), I will focus on the influences of affect on decision making. In the following section I will explain how the investigation on affect and emotion became salient in the study of the decisional processes (section 1.2) and what kind of affective reactions are involved when one is faced with a decision to be made (section 1.3). I will present evidence about the role of affect, especially positive and negative affect, on risk-taking behavior (section 1.4). Then, I will continue presenting the dimensional approach to affect as it has been proposed by Russell (1980) and Russell and Feldman Barrett (1999) (section 1.5).

1.2 Influences of affect on decision making process

Until recently researchers neglected the role of affect and emotions on decisions. For centuries the dominant economic model used for explaining decision making was the Expected Utility theory (EU) developed by Daniel Bernoulli (1738), a measure of satisfaction associated with the goodness of certain choice options. According to EU theory, decision making is an essentially consequential cognitive activity and the decision maker is assumed to be a fully rational individual able to select, dispassionately and by following a small set of axioms, the option which maximizes his/her expected utility. An important determinant of the overall utility of a given choice option is the probability that the option has to occur. For example, consider a decision maker faced with a choice between two alternatives with equivalent expected value[1]: e.g. a sure payoff of €10 versus a gamble which offers a 10% probability to win €10, otherwise €0. In such a situation, the decision maker should prefer the sure option in order to maximize the expected utility. In mathematical terms, considering a gamble which offers p_i probability of receiving the outcome x_i, the expected utility of the gamble will result in the following expression:

$$\sum_i p_i u(x_i)$$

where $u(x_i)$ is the utility of receiving the outcome x_i.

[1] The expected value *E(x)* of a random variable *x* (or a course of action) is given by the sum of all possible x_i values weighted for the p_i probability of each value to occur. In mathematical terms: $E(x) = \sum_i x_i\, p_i$

A new reexamination of EU theory was provided by Savage (1954) with the Subjective Expected Utility (SEU) theory. In this account, the decision maker will select the option which maximizes the expected utility, as predicted by the classical EU model, but instead of considering the objective probability of each choice option, he/she will consider his/her belief about its occurrence. *Beliefs* are differentiated from objective probabilities since they reflect the subjective degree of confidence that a specific outcome will be obtained and they are governed by Bayesian principles. Therefore, SEU theory (Savage, 1954) is the first normative model which explains choices (and risk taking) as guided by a purely subjective component and still remains, among economists, one of the widely-accepted normative approaches to optimal choice. Nevertheless, it follows the same conjectures of the EU theory assuming that the decision maker acts consistently with the normative rule of maximizing utility.

Empirical research showed some inconsistencies with the normative economic models in predicting choice behavior and many of these anomalies could be attributed to the unrealistic assumption that decision makers are coherent and stable while making decisions (Rick & Lowenstein, 2008). Kahneman and Tversky (1979) discussed one of the most relevant anomalies in risky choice called prospect theory. The authors showed how actual choices are often inconsistent with EU theory. When faced with a choice between a sure payoff of €3000 and an 80% chance to win €4000, people often prefer the sure win, but when faced with a choice between a sure loss of €3000 and an 80% chance to lose €4000, people often prefer the gamble over the sure loss. This is called the *reflection effect* (Kahneman & Tversky, 1979) and indicates that people are more risk seeking in the loss domain while they are more risk averse in the gain domain. Such evidence is definitely inconsistent with the normative theory of choice.

Considering that people do not have a preconceived system of preferences, and that these may change depending on the individual or the context in which the decision takes place, Simon (1987) proposed to replace the classical notion of economic rationality with the concept of *bounded rationality*. Many economists and psychologists agree with this claim which assumes that mental representation of a choice prospect are not void of bias due to the effect heuristics which can influence the more rational part of the decision making process (Langer, 1975; Johnson & Tversky, 1983; Kahneman & Tversky, 1979). More important, many of these biases can be explained taking into account affective reactions that occur while making a decision.

Decision affect theory and subjective expected pleasure

Mellers et al. (1997) developed an emotion-based theory of choice by examining how people feel about monetary outcomes of gambles. Participants were presented with some gambles one at a time and they were informed about how much they won or lost. They were also asked to report their feelings about the obtained outcome. It was found that pleasure increased with the amount of the win, and displeasure increased with the amount of the loss. In addition, pleasure increased when the unobtained outcome was worse than the obtained one. Both wins and losses were more enjoyable of a large loss was avoided. Unexpected wins were more pleasurable than expected wins and losses were more painful than expected losses. Mellers et al. (1997) formalized the *decision affect theory*. To illustrate the theory, consider a gamble with the outcomes A and B. Imagine that the gamble is played and outcome A occurs. Decision affect theory predicts the affective response to the outcome A (R_A) as follows:

$$R_A = J_R[u_A + d(u_A - u_B)(1 - s_A)], \quad (1)$$

where J_R is a linear response function; u_A and u_B are the utilities of the outcome A and B respectively; d is the so called disappointment function (Loomes & Sugden, 1986) based on the difference between the utilities of the two outcomes A and B; and s_A is the subjective probability (belief) of outcome A to occur. Mellers et al. (1997) extended the decision affect theory to the case in which an individual is faced with a choice between two gambles and a complete feedback is provided. To illustrate the case consider a choice between gamble 1, with the outcomes A and B, and gamble 2 with the outcomes C and D. Imagine that gamble 1 is chosen and outcome A occurs and that gamble 2's outcome is C. The affective response to outcome A, when gamble 2's outcome is C ($R_{A(C)}$), is

$$R_{A(C)} = J_R[u_A + d(u_A - u_B)(1 - s_A) + r(u_A - u_C)(1 - s_A s_C)]. \quad (2)$$

Equation 2 is similar to Equation 1, but it also includes *r*, that represents a regret function (Loomes & Sudgen, 1982). The regret function is based on the difference between u_A and u_C, while $s_A s_C$ is the subjective probability of the joint outcomes A and C to occur. Therefore, the impact of regret depends on the occurrence of both outcome A and outcome C.

As a further development of the decision affect theory, Mellers and colleagues (1997) also formalized an emotional theory of risky choice called Subjective Expected Pleasure (SEP) theory, according to which preferences for risky options are related to the anticipated pleasure of the consequences that will occur right after the decision is made, so that the decision maker will choose the option that maximizes the expected pleasure. For example, consider a decision maker who is choosing between two gambles with the possible outcomes A and B (gamble 1) or the outcomes C and D (gamble 2). According to SEP theory, the decision maker first assesses the overall anticipated pleasure for gamble 1as follows:

$$s_A R_A + s_B R_B \quad (3)$$

where s_A and s_B are subjective probabilities of outcomes A and B, and R_A and R_B correspond to the anticipated pleasure related to the outcomes A and B respectively. The same predictions are also made for the outcomes C and D for gamble 2, so that the subjective expected pleasure associated with gamble 2 is

$$s_C R_C + s_D R_D. \quad (4)$$

Whether the value resulting from Equation 3 is greater than those resulting from Equation 4, gamble 1 is chosen over gamble 2. In this way, risky choices are contemplated after evaluating the anticipated affect that would occur if a specific outcome will be obtained. In particular, individuals who anticipate greater pleasure with good outcomes or less pain with bad outcomes are expected to exhibit greater risky preferences. Conversely, those individuals who anticipate greater pain with bad outcomes or less pleasure with good outcomes are expected to be more risk averse (see also Mellers, 2000).

Theorizations made by Mellers and colleagues (see Mellers, 2000; Mellers et al., 1997; Mellers et al., 1999) take into account only one category of affective reactions that has impact on the decisional process, that is anticipated emotions: i.e. affective reactions arising from thinking about the future consequences of a decision. Later in this paragraph I will present all affective influences involved in shaping decisions, especially focusing on those unrelated to the decision to be made (the so called incidental affect, object of the current thesis project). However, such theorization represents one of the first tentative of incorporating affect in models of decision making.

Affective decisions

Contemporary decision research is now characterized by an increased interest in the role of affect and emotions on decision making. Slovic et al. (2007) used the expression *affect heuristic* to specify that individuals rely on their feelings while making decisions. As proposed by Zajonc (1980) and LeDoux (1996), affective reactions are the very first impressions which occur automatically to guide the following information processing and elaboration of stimuli and that subsequently will orient action planning and decision making. This statement is consistent with the definition of affect provided by Russell & Feldman Barrett (1999). As explained in the previous section of this dissertation, most of the time affective reactions (also those related to a choice option or a risky stimulus) are not mediated by any cognitive evaluation, which will occur later at a subsequent stage of the decision making process. LeDoux (1996) provided interesting neurological foundations for such effects. At a subcortical level there are direct connections from the sensory thalamus, which processes stimuli only for their elementary physical features, to the amygdala, a limbic region which plays a critical role in the processing of affective information related to stimuli. This neural pathway overrides the cerebral cortex, so that the information processing is not mediated by a deeper cognitive elaboration. This would result in an affective reaction elicited by a raw, quick and automatic representation of the stimuli (e.g. the choice options) that do not involve the upper processing systems of the brain that are implicated in thinking and analytical reasoning.

Soon, many decisional researchers started to hypothesize that both cognitive and affective components may influence decision making process as well as risk perception and risk taking behavior (e.g. Damasio, 1994; Lowenstein, 2000; Schwarz & Clore, 1983). Nevertheless, the affect heuristic is not able to depict the kind of interrelations that actually occur among the two dimensions (cognitive and affective). Loewenstein and colleagues (2001) provided a thorough explanation for this blank developing the *risk as feeling* hypothesis. In this view, affective states (not cortically mediated) exert a reciprocal influence on cognitive evaluation of risk (based on subjective probability estimation and desirability of consequences). In addition, affective reactions are elicited by a variety of factors, such as anticipated feelings about the occurrence of an outcome, but also decision maker's current mood that is not part of the cognitive evaluation and which respond to probabilities and choice options (e.g. monetary values) differently from the way in which the same elements are evaluated by the cognitive system. Therefore, the behavioral response (the decision) to a risky situation is determined by an interplay of both cognitive and affective responses but the evaluation of the same risk (or decisional prospect) may diverge among the two systems.

Lo and Repin (2002), in a behavioral finance study, measured real-time affective responses of professional financial securities traders in a naturalistic setting. Psychophysiological reactions (i.e. skin conductance, blood volume pulse, heart rate and other autonomic parameters) were recorded during live treading sessions while simultaneously capturing changes in market stocks. Findings from this study suggest that affective response is a determinant factor in processing real-time financial risk. In particular, Lo and Repin (2002) found statistically significant differences in mean electrodermal activity and in cardiovascular variables during periods of heightened market events volatility compared with no-event control baselines. Authors explain these results suggesting that a cognitive-emotional interaction is involved in the genesis of intuitive judgments characterized by low cognitive control, low consciousness awareness and rapid processing of information guided by emotional mechanisms, as suggested by both risk as feeling hypothesis (Loewenstein et al., 2001) and affect heuristic (Slovic et al., 2007).

In summary, evidence show strong influences of affective state on decision making process which may guide also individual risk preferences. In particular, when considering a decisional scenario, preferences for choice options are thought to be driven by two kinds of information: a cognitive-type information linked to the value of the outcomes and beliefs about their occurrence, and several affective-type information linked to the anticipation of the outcomes, to the act of making a decision itself and to other internal or external elements, such as feelings or contextual cues, which may trigger further affective reactions (e.g. Kahneman, 2011; Loomes & Sugden, 1982; Mellers et al., 1999). The combination of such influences will determine how the decision maker places the utility of a specific choice option, as well as his/her risk perception, so that affect results to be a powerful mediator between cognitive evaluation of risk and decision maker's behavioral response.

Neuroeconomics evidence

The influence of affective states on decision making and risk taking behavior is also informed by neuroeconomics studies (e.g. Schonberg et al., 2011). Many researchers agree with the assumption that two important brain systems account for motivations which underlie diverse affective states: the reward approach (or appetitive) system and the loss avoidance (or defensive) system (e.g. Lang et al., 1990). These neural systems are evolutionary old and have evolved to mediate behaviors that protects and sustain life and even risk preferences are thought to be related to their activity. Specifically, risk taking behavior could be linked to the activation of the reward approach system whereas risk avoidance would be ascribable to the activation of the loss avoidance system (e.g. Peterson, 2007). Both systems are implemented by neural circuits in the brain which have projections to the centers for autonomic regulation and systems which control attention and motor planning (e.g. Davis, 2000; Davis & Lang, 2003).

The *reward system* is active when a potential reward or a stimulus present in the environment is evaluated as potentially appetitive or pleasing, so that it motivates the tendency to approach towards it. The neurotransmitter that regulates the activity of the brain areas of the reward system is dopamine which is associated to reward evaluation and well-being. Indeed, this neural network lies along the dopamine mesolimbic pathways which involves the ventral tegmental area (Vta), nucleus accumbens (Nacc) and ends at cortical level in the medial prefrontal cortex (Mpfc) (Bozarth, 1994; Knutson et al., 2001a). Knutson et al. (2005) found that Nacc activation is proportional to the anticipated gain magnitude while Mpfc responds better to anticipated gain probability, so that mesolimbic pathway is organized as to provide an accurate evaluation of expected value which includes also the affective components computes. Additionally, the activity of the reward system has been found to correlate with participants' self-reported levels of positive affect (Knutson et al., 2001b).

On the other hand, the *loss avoidance system* is mostly related to the subjective experience of anxiety and the neurotransmitter which modulates its activity is serotonin. It involves mostly regions of the limbic system including the amygdala and anterior insula. Paulus and colleagues (2003), in an fMRI study, hypothesized that the degree of risk taking correlates with the degree of activation in the insular region founding that right insula was significantly more activated when a risky option was selected and that the degree of insula activation was related to the probability of selecting a safe option after a negative outcome was obtained. In addition, insula activation was related to the participants' degree of harm avoidance and neuroticism as measured through personality questionnaires.

Taken together, these findings suggest that both the reward system and the loss avoidance system are remarkably implicated in the genesis of the emotional response which guides risk taking and risk aversive behavior respectively. In particular, among the reward approach system, Nacc seems to precede a risk response (Kuhnen & Knutson, 2005).

After briefly presented evidence from neuroscience studies, in the following section I will describe different kinds of affective reactions that are commonly thought to influence decision making process as well as risk taking behavior.

1.3 Affective influences on decision making process

So far, I presented studies showing that affective state is an important variable that should be taken into account while making predictions about one's choice behavior, especially under conditions of risk or uncertainty. When considering a typical decision making scenario we can recognize different kinds of affective reactions and each of them could have specific influences on choice.

The first distinction is kind of temporal: we distinguish between pre-decisional affect and post-decisional affect (Loewenstein et al., 2001). Pre-decisional affect includes affective reactions that influence the decision before it is actually made. Anticipatory influences, anticipated influences and current mood (or background mood) are part of this group. Post-decisional affect, on the other hand, includes experienced affect: i.e. affective states experienced when the outcome of the decision is finally known. A second major distinction is the one between integral affect and incidental affect (Loewenstein et al., 2001; Loewenstein & Lerner, 2003). Integral affect consists of affective influences that are strictly related to the decision at hand. They are elicited by the act itself of making a choice (e.g. imagining future consequences about a choice; thinking about future feelings that might be triggered out when the choice outcome will be known, and so forth). Anticipatory, anticipated and experienced influences are typical examples of integral affective states. Conversely, incidental affect concerns affective responses totally unrelated to the decision to be made. Incidental affect is an affective reaction elicited due to a specific cause or stimulus which could be, or not be, part of the decisional context (e.g. feeling teased if the decision takes place in a noisy environment, or feeling calm and serene because it is a sunny day). Therefore, incidental affect determines decision maker's affective state at the moment of choice (his/her background mood). Here, after briefly presenting some evidence relative to the interplay between integral affect and decision making process, I will focus, in more detail, on evidence about the role of incidental affect on risk perception and risk taking behavior (main theme of this dissertation).

1.3.1 Integral affect

Integral affective states encompasses influences normatively relevant to the decision at hand (Lerner & Keltner, 2000). They are elicited by the act itself of making a decision and they are strictly related to choice options as well as their probability of occurrence (Västfjäll & Slovic, 2013). As an example, consider an investor who is evaluating the chance of buying an high risk stock. While the investor is making the decision, he/she may experience feelings of fear or anxiety because he/she could anticipate the regret that would be experienced if the investment would fail. In such a case, fear or anxiety presently experienced by the investor is the anticipatory emotion. The main antecedent of the anticipatory fear or anxiety is the concern for the likely feeling of regret that could be experienced if the outcome would be negative (i.e. the anticipated affect). Whether the bought stock will increase in its price, it will be more likely that the investor's final experienced emotion and affect will be negative (e.g. regret or disappointment); whereas whether it will increase in its price the investor's final experienced emotion and affect will be positive (e.g. joy or elation). Therefore, *anticipated* influences are pre-decisional cognitive expectations about future consequences. They are not experienced at the moment of choice, but they are relevant as they prepare the decision maker for the feelings he/she might experience in the next future after the decision has been made (Loomes & Sugden, 1982; Mellers, 2000; Mellers et al., 1999).

On the other hand, anticipatory influences are pre-decisional affective reactions triggered out by anticipating future consequences of a decision. Contrary to anticipated affect, which has influence only at a cognitive level, anticipatory affect is an immediate feeling experienced in the present. As noted by Damasio (1994), the association between the presentation of an affective eliciting stimulus (e.g. a risky option) with bodily sensations (somatic markers), allows the development of an internal representation of the possible future consequences related to that stimulus. Somatic markers are visceral reactions (e.g. changes in heartbeat, skin conductance, or other homeostatic reactions) produced by secondary feelings (e.g. the anticipated affect) which may favor the approach toward an appetitive stimulus or the avoidance of a dangerous one and guiding the decision (Bechara et al., 2000; Damasio, 1994). The association affective eliciting stimulus – affective reactions is the result of the activity of a neural network involving limbic areas, ventromedial prefrontal cortex (Vmpfc), somatosensory cortex (Smc), insula and basal ganglia (Damasio, 1998). This network has direct projections to the brain stem (in particular to the hypothalamus) that produce the physiological changes that underlie the anticipatory affective reaction (Loewenstein et al., 2001). Bechara et al. (1997) argued that Vmpfc plays a critical role in the translation of cognitive inputs from external environment into affective reactions. A damage to Vmpfc leads individuals to ignore signals from the body and to make more disadvantageous choices.

Finally, *experienced* affect refers to post-decisional affective states elicited once the outcome of the decision is known (e.g. elation or happiness if the outcome is positive, regret or disappointment if the outcome is negative).

Interesting evidence about the role of integral affect on decision making under risk comes from a study of Johnson et al. (1993) on consumer willingness to pay for flight insurance. Authors asked participants how much they would willing to pay for a flight insurance that covered against death due to “any act of terrorism” or another that covered against “any reason”. Johnson et al. (1993) found that participants were willing to pay more for insurance protecting against terrorism although an insurance covering all types of crashes would be more convenient. Authors explain these findings suggesting that events related to terrorism may be imagined more vividly so that consumers consider more important to insure against them.

1.3.2 Incidental affect

Incidental influences are short-lived affective states with clear triggers or causes of which individuals may be aware or unware. They could represent a specific individual disposition to react to a given event in a particular affective way, otherwise they can be affective states elicited by situational factors (e.g. stressor events), or by particular contextual cues or environmental conditions (e.g. images, music, odors). Affective reactions produced by such external events/stimuli are normatively irrelevant to the decision task, nevertheless they have been found to influence judgment and decision making (e.g. Bagneux et al., 2013; Lerner et al., 2004), risk perception (Lerner & Keltner, 2001) and risk taking behavior (Hsee & Rottenstreich, 2003). Influences of incidental affect can be experimentally investigated through the direct manipulation of participant's affective state before or while making a decision. It is known that the effect of incidental affect can be strong enough to direct cognition not only to affective eliciting stimuli per se but also to other unrelated events, including judgments and decision making (the so called *incidental carryover effect*) (Johnson-Laird & Oatley, 1992; Lazarus, 1991). For example, Schwarz and Clore (1983) asked participants to make judgments of happiness and satisfaction with one's life after experimentally induced positive or negative moods. Moods were manipulated by requiring participants to describe recent happy or sad events or they were naturally induced by interviewing participants on sunny or rainy days. In both cases, participants reported more happiness and satisfaction with their lives when in a good mood than when in a bad mood. Authors concluded that affective states provide relevant information (*affect as information*) about the current situation and people tend to rely on these feelings while making judgments (or choices).

Hirsch (1995) investigated the role of incidental odors on gambling behavior. The study was conducted in a Las Vegas casino where one area was odorized with a pleasant odor, while another one was unodorized. The author measured and compared the amount of money gambled in each area before, during and after the incidental odor manipulation. Data suggested that the amount of money gambled in the slot machines located in the odorized area was significantly greater than the amount of money gambled in the same area before and after the experimental manipulation. Hence, the study by Hirsch (1995) suggests that a pleasant odor may elicit incidental affective states able to influence consumer's gambling behavior.

Further evidence from the consumer behavior field have shown that incidental affective states influence the way people price different products (Lerner et al., 2004), eating behavior (Grunberg & Straub, 1992), preferences for the status quo option (Yen & Chuang, 2008). Moreover, Andrade and Ariely (2009) demonstrated that incidental affective states can influence economic decisions not only in the short term, but that they can also live longer than the emotional experience itself. It should be also noted that even minimal sensorial stimulation can establish an affective state able to influence decision making process (Lowenstein & Lerner, 2002).

Taken together, this evidence show that affective reactions unrelated to the decision may influence preference for different choice options. In the following section I will focus attention on the effect of different kind of incidental affective state on risk taking behavior.

1.4 Incidental affect and risk taking

The influence of incidental affect on risk perception and risk taking behavior is one of the most studied interplays between affect and cognition in the field of decision making. It is widely documented that different affective states carries over different information about the goodness of certain risky options (e.g. Lerner & Keltner, 2001). In particular it has been found that affective states have different impact on risk taking according to the degree of pleasantness: i.e. the dimension of valence (Russell & Feldman Barrett 1999).

1.4.1 Mood maintenance and mood repair

Many decisional researchers showed that positive (pleasant) affect leads to risk aversion whereas negative affect leads to risk seeking behavior (Isen & Patrick, 1983; Morris & Reilly, 1987). In particular, it was found that people in whom a positive affect is induced make more optimistic assessments than people in negative mood and controls (Johnson & Tversky, 1983;

Williams et al., 2003). However, as noted by Isen and colleagues, they are characterized by a cautious optimism since they report high probability estimates of obtaining gains (which is an index of optimistic behavior) but they are more risk averse than controls when they are offered the chance to bet on an high risk gamble (Isen, 2000; Isen & Patrick, 1983; Isen et al., 1988). As an explanation for these findings, authors proposed the *mood maintenance hypothesis* which suggests that people in positive affect have tendency to be protective of their positive feelings. When in a positive state, individual maybe reluctant to take more risks because of the repulsion from the chance of getting the negative outcome which might reduce their global well-being. Therefore, it seems that participants in a positive affective state increase the value associated with a potential gain. At the same time, they could consider a potential loss as more unpleasant than participants in a neutral or negative affective state, so that the risky option is evaluated with greater disutility (Isen, 2000).

Conversely, negative (unpleasant) affective states are associated with increased perceived uncertainty and lower probability estimates of obtaining gains (Johnson & Tversky, 1983). Furthermore, participants in a negative mood may be more prone to take risk than participants in positive or neutral mood (e.g. Desteno et al., 2000; Hockey et al., 2000; Mano, 1992; Raghunathan & Pham, 1999). It has been argued that, when in a negative emotional state, people are motivated by the desire of changing their current uncomfortable mood, so that the risky option is evaluated as more pleasant since the potential gain is conceived as a chance of turning the negative state into a positive one (Larsen, 2000; Morris & Reilly, 1987). This is called *mood repair hypothesis*.

Taken together, these evidence suggest that decision makers' incidental affective state influence the way choice options are evaluated in a valence-dependent manner. In particular, the valence dimension (pleasant – unpleasant) of current mood seems to provide strong information about current well-being, so that it may influence information processing, priming mood-congruent anticipated and anticipatory emotions and determining the psychological burden attributed to the risky option.

1.4.2 Same valence, different affect

According to explanations provided from both mood maintenance and mood repair hypothesis, affective states which share the same valence should have equivalent influences on decision making and risk taking behavior. A serious limitation of these theorization is that affective state is conceived as a one-dimensional and bipolar construct (positive – negative or pleasant – unpleasant).

Recently, researchers have begun exploring differences in the influence of different affective states with the same degree of pleasantness (e.g. DeSteno et al., 2000; Han et al., 2007; Lerner et al., 2004; Raghunathan & Corfman, 2004; Raghunathan & Pham, 1999). For example, Raghunathan and Pham (1999) hypothesized that sadness and anxiety, two distinct negative emotions, may have different influences on risky behavior. Emotions were manipulated by presenting participants with three scenarios, each thought to induce a distinct emotion (i.e. anxiety, sadness, neutral). Participants were asked to experience the event described in the scenario as vividly as possible and imagine what they would feel in that specific situation. Later, participants were asked to assess the attraction of two gambles: a low risk – low reward gamble and a high risk – high reward one. Results from the study suggest that preference for the risky option was higher in the sadness condition than in the anxiety condition, with the neutral condition in between. Authors concluded that two emotions with same valence (negative) can have distinct influences on decision making under risk. Specifically, anxiety is associated with a low-risk preference, whereas sadness is associated with a high-risk preference. In a subsequent study, Raghunathan and Corfman (2004) proposed the *Different Affect – Different Effect* (*DADE*) model, according to which different negative affective states, such as sadness and anxiety, may target different motivational goals so that they could have opposite influences on behavior. Built on cognitive theories and psycho evolutionary perspectives of affect, DADE model proposes that sadness motivates individual to seek more pleasant stimuli in order to eliminate or mitigate it, as predicted by the mood repair hypothesis (Larsen, 2000; Morris & Reilly, 1987). Conversely, anxiety leads to more attentiveness, since being attentive promotes the best deal in order to reduce uncertainty, typical of states of anxiety (Raghunathan & Corfman, 2004). This point of view is also supported by Han, et al. (2007) which provided the theoretical basis for the Appraisal-Tendency Framework (ATF) suggesting that specific emotions carry over specific cognitive and motivational processes able to account for the differences found for diverse influences of emotions and affective states of the same valence on decision making and assessment of risk.

Taken together, these findings suggest that theorizations provided by mood maintenance and mood repair hypothesis (e.g. Isen et al., 1988; Morris & Reilly, 1987) does not account for the influences of incidental affective states on individual preferences for risk. As mentioned in section 1.1, Russell and Feldman Barrett (1999) adopted a bi-dimensional model of affective state which explain affect as differences in the degree of valence and arousal. As I will suggest and argue in the following section, reducing affective states at a one-dimensional type conception (i.e. the reliance on affective valence) could represent a serious limitation, while the study of incidental affect in terms of valence (pleasant or unpleasant) and arousal (high or low) would result in a suitable understanding of the influences of affect on risk taking behavior.

1.5 Dimensionality of affect

As noted earlier, a valence-based approach to the investigation of influences of incidental affect on decision making and risk taking often fails in the tentative of identifying the variance which characterizes different affective states (e.g. Raghunathan & Corfman, 2004). Affect should be considered as a far more complex construct which is multidimensional in its nature.

Factor analyses of self-reported affective states, scaling of words for emotion, vocal and facial expression for emotion has led most psychologists to describe affect as variation along two main dimensions interpretable as pleasure (valence) and activation (arousal) (e.g. Russell, 1980). Therefore, in addition to affective valence, there is one more dimension that should be taken into account when the influences of affective states on cognition are discussed: i.e. the dimension of affective arousal. Russell and Feldman Barrett (1999) suggest that at any point in time, affect is a the result of the combination of different levels of valence and arousal pleasure. The two components combine in an integral fashion, so that, subjectively, a person has one feeling rather than, for example, unpleasant and separately, deactivated (Russell & Feldman Barrett, 1999, pp. 809).

1.5.1 The circumplex model of affect

A widely-accepted two-dimensional model is the circumplex model of affect proposed by Russell (1980) and it is still one of the most important reference models in describing affective states (e.g. Lang et al., 1993; Russell & Feldman Barrett, 1999; Russell, 2003). In this model affective dimensions (valence and arousal) are depicted as two orthogonal axis whose intersection defines four quadrants which include affective states that result from all possible combinations of different levels of valence and arousal. Therefore, at any given moment, affect is a single integral blend of the two dimensions. In this model all affective states lie neatly around the two main dimensions forming a circumplex (see figure 1).

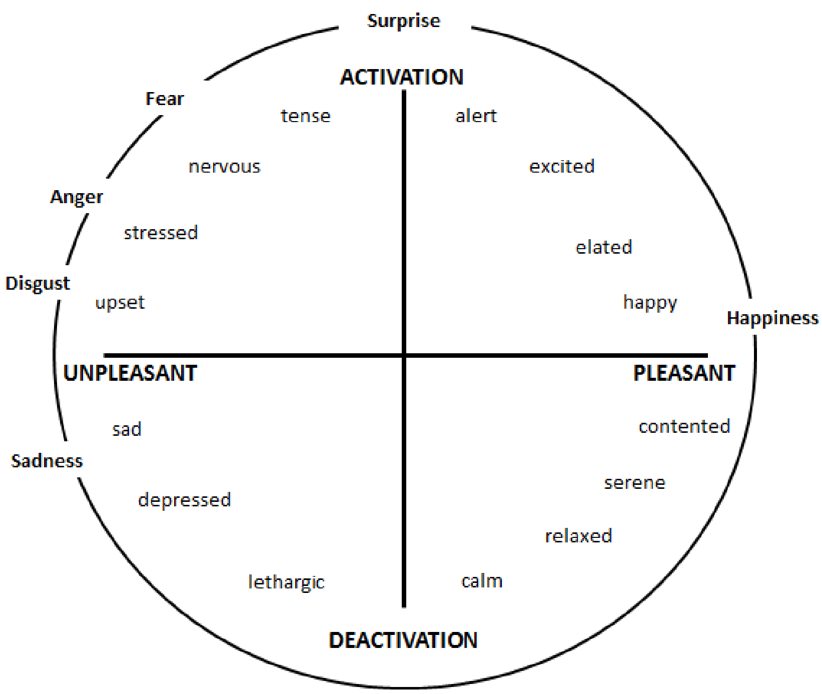

Figure 1. The affective circumplex. The inner circle shows a map of core affect. The outer circle shows where several prototypical emotional episodes typically fall. Edited from Russell & Feldman Barrett, 1999.

Valence dimensions ranges from unpleasant to pleasant, while arousal dimension ranges from activation to deactivation so that, for instance, boredom results from the combination of low level of valence (unpleasant) and low level of arousal (deactivation), whereas excitement is a combination of high level of valence (pleasant) and high level of arousal (activation). Likewise, relaxation is the product of high level of valence (pleasant) and low level of arousal (deactivation), while tension has low valence (unpleasant) and high arousal (activation). By rotating the two main axis of 45°, two intermediate dimensions will be obtained (see figure 2): *pleasant activation – unpleasant deactivation* including affective states characterized by positive valence and high arousal or negative valence and low arousal; *unpleasant activation – pleasant deactivation* including affect characterized by negative valence and high arousal or positive valence and low arousal.

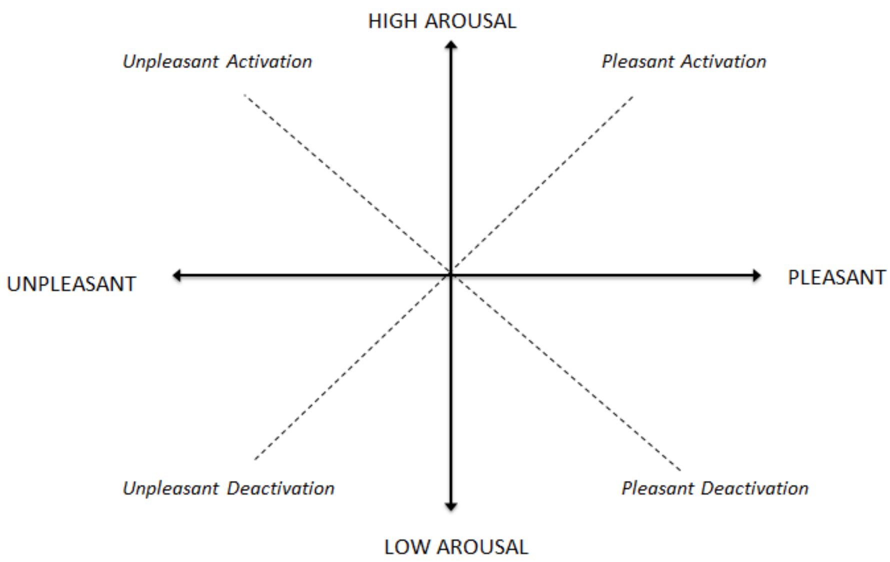

Figure 2. Intermediate dimensions in the circumplex of affect.

Russell and Mehrabian (1977, 1978) formalized the Pleasure – Arousal Hypothesis which explains individual's preference for current mood according to both dimensions of valence and arousal. In particular, preference is linearly related to valence dimension while arousal assumes the form of an inverted U-shaped function (see figure 3) (regarding the effects of arousal on preference and cognition see sections 2.3 and 2.4 of this dissertation; see also Hebb, 1955; Yerkes & Dodson, 1908).

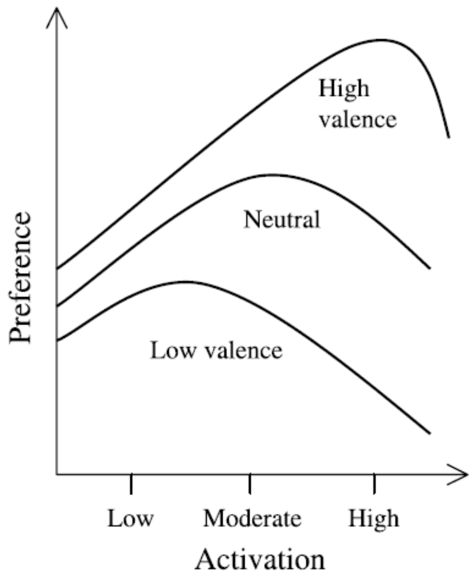

Figure 3. Predictions form the Pleasure – Arousal hypothesis (Russell & Mehrabian, 1978).

A statement of the Pleasure – Arousal Hypothesis is represented by the following regression equation:

$$Approach = b_1P - b_2A^2 + b_3PA, \quad (5)$$

where b_1, b_2 and b_3 are positive constants expressing the weights of the terms, P is pleasantness (valence) and A is arousal. In Equation 5, approach is expressed as the result of the sum of the independent variables of valence and arousal: b_1P represents the positive linear relationship between pleasantness (valence) and approach; $-b_2A^2$ expresses the inverted-U relationship between arousal and preference for current mood and b_3PA expresses the hypothesis of an interaction of valence with arousal, such that approach increases with arousal as valence increases (pleasant), but decreases with arousal as valence decreases (unpleasant) (Russell & Mehrabian, 1978).

Some authors proposed that affect could be better explained considering more than two dimensions. Indeed, some additional features can be recognized including potency (Osgood, 1969), dominance (Russell & Mehrabian, 1977), aggressiveness (Bush, 1973), locus of causation (Russell, 1978). Actually, each of these elements may characterize emotions but, as argued by Russell and Feldman Barrett (1999) they should be interpreted in relation to the event that elicits the emotional reaction and therefore they could not be considered as elementary elements that constitute affective states. Rather, such features are better justified if considered as part of prototypical emotional episodes, but should not be attributed to affect per se, since by definition, affect doesn't need to related to a specific object (Russell & Feldman Barrett, 1999; see also section 1.1 of this dissertation). Hence, more dimensions can be relegated as main aspects of the emotional experience but beyond the domain of core affect. Affective states remains a simpler two-dimensional conceptualization defined as variations in degree of valence and arousal.

Valence

Valence dimension, at the level of the subjective experience, refers to the individual well-being, so it describes the dimension of feeling happy, pleased, contented at one extreme or feeling unhappy, annoyed, unsatisfied at the other extreme. At any point in time, valence dimension should be considered as varying along a continuum, so that one could infer his/her personal state of pleasure – displeasure. Valence dimension has been also named differently: e.g. hedonic tone, good-bad mood, approach-avoidance, positive-negative, appetitive-aversive, but all of them refer to the same concept of pleasure – displeasure, therefore the similarity is clear.

Arousal

Arousal dimension, at the level of the subjective and physiological experience, refers to sense of energy, tension, alertness of stress. It is related to the intensity by which a state of pleasantness or unpleasantness is actually experienced, so it describes the dimension of feeling hyperactive, alerted, wide-awake at one extreme, or feeling relaxed, sluggish, sleepy at the other extreme. At any point in time, arousal dimension should be as considered as varying along a continuum, so that one could infer his/her personal state of activation – deactivation. Arousal dimension has been also named differently: e.g. energy, tension, activity, but all of them refer to the same concept of activation – deactivation, therefore, again, the similarity is clear.

In the present research the role of arousal on risk taking behavior is examined. In a series of experiments I induce incidental positive or negative arousal and individual's preferences for risky monetary options are detected. In the following chapter I will provide a clearer description of arousal and its psychological and physiological features, then I will present evidence about the influences of high/low arousal on cognition as well as on decision making and risk taking behavior and I will present the experimental research questions that I will try to address in a series studies presented throughout the rest of this dissertation.

CHAPTER 2

Arousal and Decision Making

2.1 Definition of Arousal

In chapter 1 of this dissertation, I introduced the concept of arousal as it has been proposed by Russell & Feldman Barrett (1999). Differently from valence, which informs about how well one is doing, arousal refers to the experience of energy, mobilization, activity, alertness, tension, and so forth. Arousal is ranged from a state of full activation (e.g. feeling excited) to a state of complete inactivity (e.g. deep sleep). Arousal is also associated to a body experience since it is characterized by changes in many physiological parameters, through the activity of the autonomic nervous system (e.g. Hagemann et al., 2003). In the following section I will illustrate characteristics of arousal from a psychological and physiological perspective. Then, I will explain the impact that arousal has on cognitive system and, in more detail, on decision making.

2.2 Psychological and physiological correlates of arousal

At a psychological and subjective level, arousal is related to the intensity with which pleasure or displeasure is experienced (Russell, 2003). Therefore, people may experience a positive form arousal or, conversely, a negative form of arousal. *Positive arousal* covers the first and the second quadrant of the circumplex of affect (see figure 2 in chapter 1). Affective states with high positive arousal (*pleasant activation*) include feelings of happiness, joy, or elation. These affective states are characterized by very intense positive mood: i.e. sensations of pleasantness combined with an high level of activation. At the maximum level of positive arousal there are feelings of excitement such as being in a very pleasant adrenaline situation (e.g. playing extreme sports); or experiencing a very intense joy (e.g. getting married or graduating); or being attracted by someone else (i.e. being sexually aroused). Affective states with low positive arousal (*pleasant deactivation*) include feelings of calmness, relaxation, or peacefulness. These affective states are still characterized by sensations of pleasantness but they are associated with very low levels of activation. People may experience low positive arousal during leisure situations (e.g. spending a lazy summer day at the shore); or in the absence of a task to perform (e.g. being on vacation in a relaxing spa); or during a period of rest (going to sleep after an intense workday). Conversely, negative arousal ranks in the third and fourth quadrant of the circumplex. Affective states with high negative arousal (*unpleasant activation*) include feelings of tension, distress, or fear. These are affective states marked by sensations of unpleasantness and elevated levels of activation. At the maximum level of negative arousal there are feelings of elevated tension such as being scared of something (e.g. be on the verge of an accident); or feeling anxious due to an imminent event (e.g. before presenting a public speech); or feeling upset (e.g. be angry with someone). Among affective states with low negative arousal (*unpleasant activation*) we found negative feelings associated with low energy or activity. For instance, being sick at home, or feeling very sad or depressed are typical situations in which people may experience such feelings.

Even tough positive arousal and negative arousal are qualitatively distinct, they are similar in several aspects. First of all, they are physiologically overlapping. It has been found that presenting participants with pleasant and unpleasant stimuli equated for the level of arousal elicits the same physiological reactions (Bradley et al., 2001; Codispoti et al., 2008). Negative arousal is typically characterized by changes in skin conductance and heart rate deceleration. This is the case also for positive arousal (see Codispoti et al., 2008). Skin conductance is expected to increase as an automatic reaction to any increase in emotional arousal. Conversely, cardiac deceleration has been interpreted as reflecting orienting and attention (Bradley et al., 2001; Lang et al., 1993). Second, several brain areas involved in the processing of unpleasant arousing stimuli are similarly activated when people are presented with pleasant arousing stimuli (Stark et al., 2005). Third, when presented with affective-eliciting pictures combined with increased arousal the differentiation between self-reported levels of positive affect and negative affect is highly reduced (Reich & Zautra, 2002). Therefore, to the extent to which physiological reactions, neural activations and self-report indices are the same for both positive and negative arousal, it is reasonable to believe that arousal may have a unique and specific influence on decision making and cognition, regardless of valence. As I will explain in more detail in section 2.3 and 2.4, it seems that the specific role of arousal is to provide information about urgency and importance (Storbeck & Clore, 2008).

As mentioned above, psychological states of arousal are always associated to a physiological changes, elicited through the activity of the autonomic nervous system (e.g. Hangemann et al., 2003). Physiological correlates of arousal are primarily related to electrodermal response (skin conductance) (Lang et al., 1993). However, the relation between the subjective experience of arousal and its physiological counterpart is still poorly understood (on this topic see Russell & Feldman Barrett, 1999). Moreover, arousal is a key component of the stress response and in many cases the two words are used interchangeably. Neural components that modulate arousal play also an important role in modulating the response to stress (see Winsky-Sommerer et al., 2005). An interesting distinction has been provided by Selye (1978) who differentiated between a negative form of stress (*distress*) and a positive form of stress (*eustress*). According to Selye's definition, *stress* is the nonspecific response of the body to any demand. Such demand may be positive or negative so that it could produce pleasure or pain. Distress (negative arousal) arises when something is perceived or evaluated as a threat to one's well-being (e.g. the loss of a job). Eustress (positive arousal) arises when something is perceived or evaluated as appetitive and motivating (e.g. a job promotion). Selye (1978) argues that both eustress and distress elicit a similar physiological response (i.e. the arousal reaction). Whether this response is perceived as a form of eustress or distress depends primarily on how the stressful situation is perceived and interpreted by the individual (appraisal).

In summary, at a psychological level we can distinguish between a pleasant form of arousal (stress) and a negative form of activation. At any point in time, people can experience high/low positive arousal or high/low negative arousal. Both kind of activation elicit a similar physiological reaction due to the activity of the autonomic nervous system. Such evidence permits to postulate that both forms of arousal may have similar consequences on the functioning of the cognitive system.

2.3 Effects of arousal on cognition

In this section, I will present some evidence about influences of arousal on cognitive processes (i.e. perception, attention, memory). Then, I will continue introducing the Yerkes-Dodson law, that is the most common pattern of description about the influence of arousal on cognitive performance.

Perception

For centuries, researchers of visual perception retained that the perception of physical basic stimuli was not influenced by emotional factors. It was assumed that affective response occurred only after object perception and only as a reaction to it (e.g. Arnold, 1960). This means that we first see a red, round, hard object perceived as an apple and right after recognizing the object we can add other affective features like its sweetness or remembering of enjoying very good apples in a specific time and place and so forth. Nevertheless, this standard view has been revised and redefined by studies finding that affective response to objects may occur at an early-stage of the perception process (e.g. Barrett & Bar, 2009). There is accumulating evidence that, during object perception, the brain quickly responds to a first rough vision of the scene (e.g. Bar et al., 2001; 2006). In generating such initial prediction of the scene, the brain integrates information from the orbitofrontal cortex (OFC), a region highly involved in producing affective response to stimuli. This supports the idea that affect is an essential part in constructing object perception.

Evidence show that also arousal plays a role in perception. For example, Proffitt et al. (2006) found that when individuals are physically exhausted (e.g. while wearing an heavy backpack) they perceive hills as steeper as well as when their resources are limited (e.g. when people are elderly in declining health condition). Furthermore, when people are asked to assess perceptions of distance from a balcony to the ground below, distance estimation is increased by mild fear (Stefanucci & Proffitt, 2008). In order to test the influence of arousal in this process, Stefanucci and Storbeck (2009) asked participants to view either arousing or unarousing pictures before estimating the height of the balcony and the size of a target on the ground below the balcony. Judgments of height were higher for people who viewed arousing pictures compared to those who viewed unarousing pictures. In another experiment of the same study, both valence and arousal were manipulated and it was found that arousal moderated height perception, while valence did not. Furthermore, when viewing the arousing pictures, some individuals were asked to try to up-regulate or down-regulate their affective reaction in order to make it more or less arousing. A control group simply viewed the arousing pictures. It was found that the up-regulation group provided significantly higher estimates of the balcony height than down-regulation group and controls. Authors concluded that the experimental manipulation of arousal influenced height perception, and that this influence may be moderated by emotion regulation strategies.

Arousal has been found to influence also time perception. In one experiment, participants were presented with pictures varying along valence and arousal dimension and they were asked to estimate for how long the pictures were shown. Results show a significantly valence by arousal interaction in time estimation. Among low arousal stimuli, negative pictures were judged to be presented relatively shorter than positive pictures. among high arousal stimuli, negative pictures were judged to be presented relatively longer than positive pictures. Authors explain results through a model of action tendency, where arousal controls two different motivational mechanisms, one emotional and the other attentional.

Attention

In addition to influence perception, arousal modulates attention allocation. It is well-known that high arousal narrows attentional focus. A typical example is the ‘weapon effect’, a phenomenon in which witnesses of an homicide failed to remember the serial killer, but did remember the gun (e.g. Loftus, 1979). This effect occurs because the most arousing cue in a specific scenario is also capable to capture attention since it is evaluated as the most important object in the scene while few attentional resources remain available for other peripheral information (Heuer & Reisberg, 1990).

Some theories of arousal correlate directly arousal with attention. For example, Anderson (2005) reports that increased arousal is also associated with decreased attentional resources, enabling emotional significance to shape perceptual experience. This assumption has been empirically investigated showing that arousal produces an interference effect which has consequences on attention allocation and cognitive performance (Fernandes, et al., 2011; Gronau et al., 2003; Lang et al., 1993; Schimmack, 2005). In particular, it has been shown that it is arousal that influences the amount of attention that is voluntarily or involuntarily directed to those stimuli. Lang et al. (1993) demonstrated that participants look at arousing stimuli for longer than unarousing stimuli, regardless of valence. It was also found that skin conductance, which is a direct feature of arousal, is correlated with the interference effect on emotional Stroop task (Gronau et al., 2003). The same interference effect emerged when people were asked to ignore emotional stimuli (pictures) while performing a cognitive task (solving math problems) and an attentional task (detecting the location of a line) (Schimmack, 2005). On both tasks, the arousal level of stimuli predicted the interference effect with the most arousing stimuli (both positive and negative) producing the strongest interference effect.

Taken together, this evidence suggests that arousing stimuli are capable to capture attention, since they are perceived as the most important and relevant stimuli present in a given scenario, leaving few attentional resources available. This can also cause an interference effect which may have consequences when an additional cognitive task is performed.

Memory

As a consequence of the effects of arousal on attention allocation, it is reasonable to believe that arousal may also influence information consolidation, thus signaling which information is important for memory. As illustrated by Storbeck and Clore (2008), arousal signals importance of a stimuli in a duplex way: implicitly, through the release of adrenergic hormones, and explicitly, through subjective experience. The release of adrenergic hormones represent a typical response to stressing (arousing) situations. This process also results in enhanced long term memory for specific events. For example, most people can easily remember where they were and what they were doing on September 11, 2001. The most important hormone involved in this process of long memory consolidation is epinephrine released into the peripheral nervous system by the adrenal gland (Packard et al., 1995). Epinephrine has effects on amygdala and this would be a critical process for the consolidation of information in the long-term memory storage. Therefore, the effect of arousal on memory is not due to the heightened attention allocation during stimuli presentation but rather to hormonal phenomena that take place afterward (Storbeck & Clore, 2008).

Summing up, a state of elevated arousal has multiple consequences on cognitive functions. In particular, it influences visual perception as well as attention allocation and selects relevant stimuli that will be retrieved in the long-term memory. More important, it seems that emotional arousal may interfere with cognitive performance when the arousing reaction takes place in close concomitance with the execution of a cognitive task. In the next section I will illustrate this effect describing the Yerkes-Dodson law and the cognitive depletion hypothesis.

2.3.1 Arousal and cognitive performance

So far, I underlined the importance of differentiating affect and emotion in terms of arousal, in addition to valence, when affect is used as explanatory variable of a behavioral response. As explained earlier, arousal does have impact on cognition since it signals importance and urgency, therefore it constitutes a central part of the psychological process of motivation which guides human behavior toward a particular goal.

What kind of relationship exists between arousal and cognitive performance? The current view is that optimal human performance requires an intermediate level of affective arousal (emotional intensity), while too little or too much arousal results in an impaired performance. Intermediate levels of arousal are necessary for executive functions since, as explained above, arousal is capable of orienting attention toward important or relevant environmental stimuli. As a consequence, when an individual experiences very low level of activation cognitive system is not able to perform complex tasks. For instance, an individual in condition of sleep deprivation or illness, which represents typical situations of low arousal, would not be able to have a satisfying performance on a cognitive task. Similarly, too much emotional activation lead the person to be so aroused that reasoning and self-control become disorganized (e.g. Yates, 1990) creating an instance of cognitive depletion (e.g. Fedorikhin & Patrick, 2010). Such relationship is well described by the Yerkes-Dodson law. According to this law, cognitive performance is related to arousal through an inverted U-shaped function.

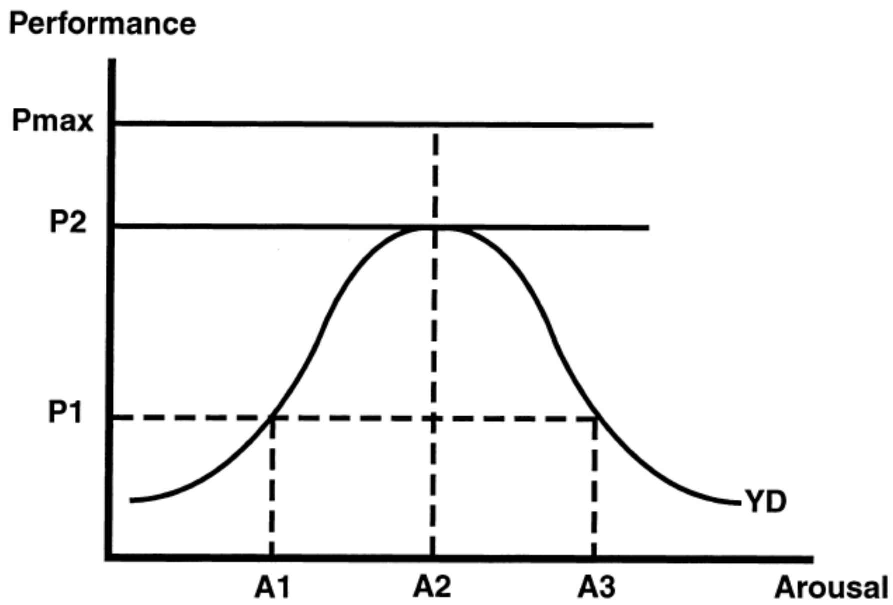

Figure 4. The relationship between cognitive performance and arousal in the Yerkes-Dodson law (Kaufman, 1999).

In figure 4 the vertical axis represents any kind of mental or physical task where P_1 represents a very low performance, P_2 an intermediate performance and P_{MAX} is the best performance, while the horizontal axis is referred to arousal (both mental and physiological) or the intensity of a specific emotion (e.g. fear or anxiety). On the horizontal axis, A_1 is low arousal, A_2 is intermediate arousal and A_3 is high arousal. Therefore, the curve well represents the statement according to which the best performance (P_{MAX}) is reached at the intermediate level of arousal (A_2), while at low arousal (A_1) and high arousal (A_3), performance is below the minimum level P_1. Empirical studies investigated the effect of emotional intensity on examination performance (test scores) by manipulating participants' level of arousal before the examination (Field et al., 1985; Ashcraft & Faust, 1994). Consistently with Yerkes-Dodson law it has been shown that with low level of arousal (e.g. boredom) test scores were relatively low. As level of arousal increased, participants' test scores increased as well until an optimum point. However, with additional arousal increase (e.g. under anxiety conditions) participants' performance decreased again.

Yerkes-Dodson law (1908) and the cognitive depletion hypothesis (e.g. Fedorikhin & Patrick, 2010) is also valid in the domain of decision making. Kaufman (1999) suggests that affective arousal can become a source of bounded rationality, since conditions of elevated arousal (negative and positive) may have detrimental effects on cognitive system, including decision making. According to Kaufman's theory, bounded rationality can be decomposed in two parts: one is related to the cognitive limitations, typical of human mind (cognitive BR), while the second form of bounded rationality is related to extremes in emotional arousal (emotional BR). In figure 4 the horizontal line at P_{MAX} represents the decision making outcome if the human agent possesses 'full' rationality. At A_2 emotional BR is zero by definition, therefore the gap between the horizontal line at P_{MAX} and P_2 measures the inefficiency in decision making related to cognitive BR only. For any given individual, the gap $P_{MAX} - P_2$ is larger the more restricted is the agent's cognitive capacity or the more complex the decision making problem. The amount of emotional BR is then the distance between the horizontal line at P_2 and the U-shaped curve at any given level of arousal. At arousal level A_1, for example, emotional BR is $P_2 - P_1$ amount. People who are better able to exercise self-control over their emotions will have a curve which lies closer to the P_2 line and will thus suffer less impairment to their decision making at low or high emotional arousal (Kaufman, 1999 pp. 139).

Why too little or too much arousal should impair decision making? Under low arousal conditions little energy is devoted to information processing and problem solving, attention is not focused on the main task and often memory is blocked by ruminant thoughts (e.g. in states of depression) and physiological activity is at very low levels (see Baker & Channon, 1995). An increase in emotional activation creates good conditions for optimal decision making, at least up to a point. An excessive activation (high levels of arousal) lead the individual to make extra effort in information processing and problem solving (Kahneman, 1973). The autonomic activity is very high and this creates the conditions for cognitive depletion so that decision making quality becomes very poor, losing much of its logical component so that behavior is guided by impulse, obsessions, and instinct (Kaufman, 1999). Such detrimental effects on cognition caused by elevated arousal (cognitive depletion) have been experimentally documented in several areas of decision making including consumer choice (Fedorikhin & Patrick, 2010); decision making under uncertainty (Laier et al., 2013); decision making under risk (Ariely & Loewenstein, 2006). In the following section I will present and discuss the effect of arousal on judgment, decision making and risk taking behavior.

2.4 Influences of arousal on decision making

In chapter 1 I illustrated how the role of emotions and affective states have been largely ignored by decisional researchers. Even less attention has been payed to the impact of affective arousal on decisional process. Schwarz and Clore (1988) explained that often people rely on their feeling while making judgments and decisions. In this way, affective reactions provide useful information which will be used as a basis for guiding decisions. This is well-known as *affect-as-information* approach. In particular, when faced with a decision, people would first assess the goodness of a choice option by asking themselves ‘How do I feel about it?’ (Schwarz & Clore, 1988). Authors report that, generally, people in positive affect express more positive judgments while a negative affective state seems to be associated with more negative judgments. Affect-as-information approach is still considered one of the most important descriptions for the influences of affect on judgments and decisions. However, it is mainly conceived as a valence-based approach since it accounts for differences between positive and negative affect, but it ignores the role of arousal. More recently, Storbeck and Clore (2008) extended the affect-as-information approach to arousal dimension. In particular, when faced with judgments and decisions people would also ask themselves ‘How *strongly* do I feel about it?’. Therefore, authors argue that whether valence provide a basic information about the pleasantness (or unpleasantness) of a thing, arousal should further intensify that information. Thus, arousal may make an object seem more important or may intensify its apparent affective value so that positive objects seem more positive and negative objects more negative (Storbeck & Clore, 2008, pp. 1827). Zillman (1971) showed that arousing cues can be easily (incidentally) misattributed or transferred to other unrelated objects or events (e.g. choice options) when arousing and target stimuli occur in close temporal proximity. Moreover, Schwarz & Clore (1983) posit that affect may influence decision making, but only when the source of affect is attributed to the object of the decision at hand and is experienced as a reaction to that. In a classical study conducted by Dutton and Aron (1974), male participants were asked to cross an high suspended bridge over a deep ravine, a situation capable of inducing an high level of arousal. On the other side of the bridge an attractive female experimenter debriefed them about the experiment and this included also giving them her telephone number. It was found that few days later, aroused males were more likely to telephone her compared to the control group who crossed a low unarousing bridge. Authors explained this result as a tendency to misattribute the arousing feelings arising from crossing the high suspended bridge to the presence of the attractive woman, thus amplifying feelings of attraction to her. Such misattribution effect of arousal on decision making has been often exploited by marketing companies in order to make products more desirable at consumers’ eyes. Indeed, in advertisements it is common to see products associated to arousing contexts: for example, spots of car often include attractive women or high speed driving scenarios.

The idea is that a consumer should experience the arousing stimulation as a reaction to the product itself.

Evidence from neuroimaging studies showed that when participants are asked to evaluate emotionally arousing words an increased brain activation is registered, especially in the amygdala (55). Moreover, amygdala activation is associated with processing the importance of specific stimuli (Cunningham et al., 2008). Therefore, it has been suggested that arousal may signal relevance and importance of stimuli (Storbeck & Clore, 2008). Studies on the effect of arousal on judgment found that high arousal negative emotions, such as anxiety and anger, increase stereotypical judgments toward out-group members, compared to judgments made in a low arousal state (e.g. Bodenhausen, 1993). Further studies investigating the effects of arousal on decision making found that it has impact on advertisements evaluation (Gorn et al., 2001); consumer preferences (Di Muro & Murray, 2012); ultimatum game (Van den Bergh & Dewitte, 2006); intertemporal choice (Van den Bergh et al., 2008); moral judgment (Carmona-Perera et al., 2014). Some researchers also started to investigate the role of affective states on decision making under risk focusing on the influences that the decision maker's current state of arousal may have on the evaluation of the choice scenario and preferences for risky options and most of evidence converge on the fact that experiencing high levels of arousal increases risk taking (e.g. Ariely & Loewenstein, 2006; Fedorikhin & Patrick, 2010; Knutson, Wimmer, Kuhnen, & Winkielman, 2008; Mano, 1992; Porcelli & Delgado, 2009; Starcke et al., 2008). In part II of this dissertation I will review the more relevant studies from this field of research before presenting empirical evidence for this research.

In the next section I will present the most used methods researchers use to manipulate individual's level of arousal in experimental setting. Then. I will focus especially on a wide used system of affective eliciting pictures, which have been used in all empirical studies presented in part II of this dissertation.

2.5 Methods for arousal manipulation

Manipulation of emotion in an experimental setting has always represented a big challenge for psychological research. Emotion manipulation is indeed a controversial topic which involve ethical, methodological and practical problems. Several methods have been suggested for the experimental manipulation of specific emotions, such as joy, fear, happiness, sadness and so forth (for a review on this topic, see Gerrards-Hesse et al., 1994).

Whether inducing an emotion or a positive/negative affect may be an hard achievement, the experimental manipulation of arousal dimension might represent an even harder accomplishment, since the goal is to induce a positive/negative affective state at high/low level of intensity. One of the most common methods to induce negative arousal in studies that have tested influences of arousal on risk, is the public speech (Lejuez et al., 2002; Mano, 1992; Pabst, et al., 2013; Starcke et al., 2008). The technique requires that participants are asked to prepare a public talk or presentation prior to perform a risk taking task. Giving a public speech is considered a typical situation in which people experience high distress, this make it a good and ecological method for inducing negative arousal (Levenson, 1988). Another wide-used method for inducing distress is the cold press task (Ferracuti et al., 1994), where participants are asked to immerse a hand into an ice water container for at least one minute. This is experienced as a very stressful situation capable to enhance the level of negative arousal. The cold press task has been used in studies on decision making under risk as well (e.g. Porcelli & Delgado, 2009). Other methods are thought to induce a physical stress: e.g. requiring participants to spend some time in an oxygen depleted environment (Pighin et al., 2012), or doing physical exercise (Schmidt et al., 2013). Conversely, few studies have examined the role of positive arousal or eustress, therefore there are few methods documented in literature able to induce positive affective state with high intensity. Sexual arousal, a specific form of positive arousal, has been examined more often and it has been manipulated mainly by presenting participants with erotic stimuli (e.g. erotic pictures) while or before performing a decision making task (e.g. Knutson et al., 2008; Laier et al., 2013; Van den Bergh & Dewitte, 2006). Ariely and Loewenstein (2006) manipulated participants' level of sexual arousal through self-stimulation (masturbation). Generic positive arousal has been also experimentally manipulated through exposition to highly pleasant incidental odors (Fedorikhin & Patrick, 2010).

A wide-adopted method for affective manipulation is presenting participants with affective eliciting pictures: i.e. images with emotional content able to induce changes in individual's affective state while viewing them. Most of the studies interested in examining the effect of both dimensions of valence and arousal dimensions at the same time use the International Affective Picture System (IAPS; Lang et al., 2005), a wide collection of affective pictures rated along dimensions of valence and arousal. In all studies presented in this dissertation IAPS pictures have been selected as method for manipulating participants' affective state. Therefore, here I will briefly introduce and describe such methodology.

2.5.1 The International Affective Picture System (IAPS)

In this section I will discuss on the use of the International Affective Picture System (IAPS; Lang et al., 2005). IAPS are currently used in several studies interested in the investigation of emotion and attention since they are able to induce transitory short-lived affective states; they guarantee good experimental control and facilitate replication as well as comparison with other studies. IAPS pictures contain a large set of color photographs that include ratings along dimensions of valence and arousal provided by men and women[2]. A large amount of studies across psychology and neuroscience have explored the subjective, physiological, neurophysiological and behavioral reactions of individuals while viewing IAPS stimuli (Cuthbert et al., 2000; Lang et al., 1993; Libkuman et al., 2007).

IAPS pictures include about 1000 images depicting mostly scenes from human experience: joyful pictures, sad pictures, terrifying pictures, attractive pictures, erotic pictures, and so forth; but

[2] In addition to valence and arousal, IAPS pictures are rated also along a third dimension, called dominance. *Dominance* dimension refers to the sense of potency – impotency that a person live while experiencing an affective state. However, the investigation of dominance dimension has been widely neglected by previous studies and it is also beyond the goal of this research.

also pictures depicting animals, objects, landscapes, geometric shapes, cemeteries, pollution, sport events, etc. To each picture is assigned a four-digit number that permits to recognize it. Presenting participants with IAPS pictures is useful for studies which aim to induce affective states following the circumplex model of affect (Russell, 1980) since the experimenter, following the affective norms, is able to select the best pictures in order to induce a specific affective state or, as the case of this research, affective states lying in a specific quadrant of the circumplex of affect (see figure 5).

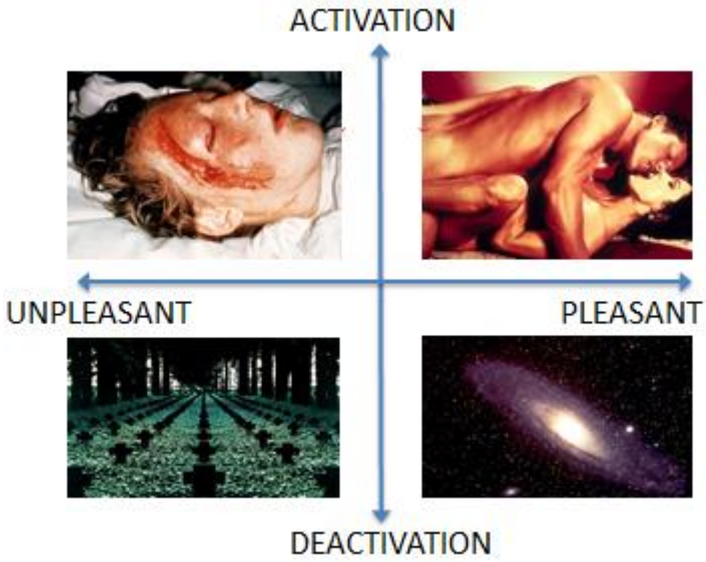

Figure 5. Samples of IAPS pictures.

In particular, pictures with negative valence and high arousal include scenes of mutilation, death, surgery operations. Such images are judged as terrifying and elicit emotions such as fear, disgust, emotional tension. Pictures with negative valence and low arousal include pictures eliciting mostly a sense of sadness, boredom or depression: e.g. children or adults crying, scenes of poverty, environmental pollution, photographs of cemeteries, and so forth. Pictures eliciting affective states characterized by positive valence and high arousal include two main categories of stimuli: erotic stimuli, depicting opposite-sex couples intercourses, and pictures depicting people playing extreme sports or having fun. An additional category of stimuli is for neutral stimuli: i.e. pictures expected to not provide a substantial change in participants' affective state. In this category we found pictures depicting objects as well as geometric shapes.

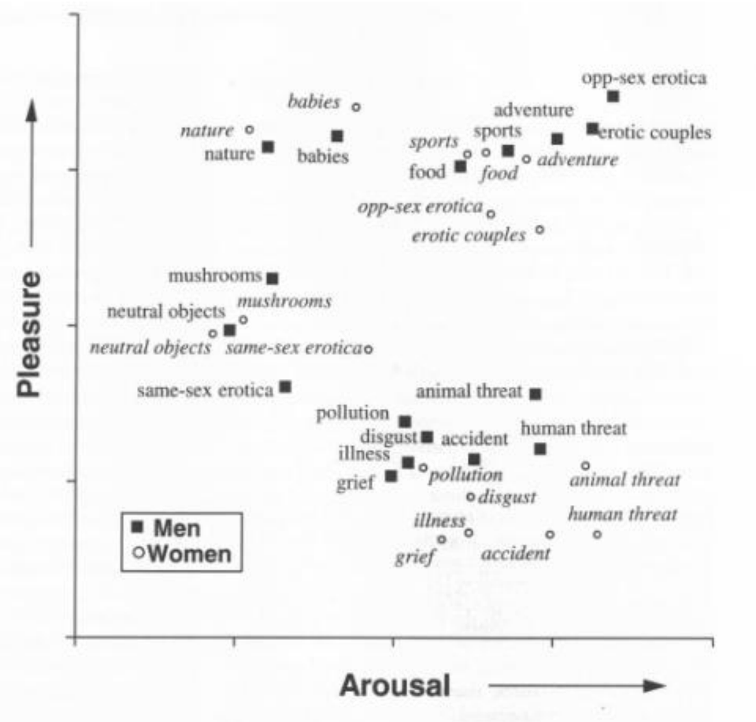

Figure 6. IAPS stimuli in the affective space.

In figure 6 is provided a graphical representation of different types of IAPS stimuli in the affective space determined by the two dimensions of valence and arousal. A large amount of psychophysiological and neuroimaging studies provide evidence that IAPS pictures are actually able to induce affective states, by recording of different physiological parameters (i.e. skin conductance; heart rate variability; startle reflex; EEG; EMG; and so on) (e.g. Anders et al., 2004; Bradley et al., 2001; Codispoti et al., 2001; Nielen et al., 2009).

Rating system: the Self-Assessment Manikin (SAM)

As explained earlier, IAPS is built on the normative ratings provided by men and women for each picture that characterize the whole collection. Normative ratings have been gathered by using the Self-Assessment Manikin (SAM) and it is frequently adopted in studies that use IAPS pictures (Bradley & Lang, 1994). As depicted in figure 7, SAM includes two 9-pointed scales depicting a manikin. One is a valence scale, the scale depicted above in figure 7, the other one is the arousal scale, the scale below in figure 7. Valence scale ranges from a smiling manikin to a thrown manikin. At one extreme of the scale, individual felt happy, pleased, satisfied, contented, hopeful.

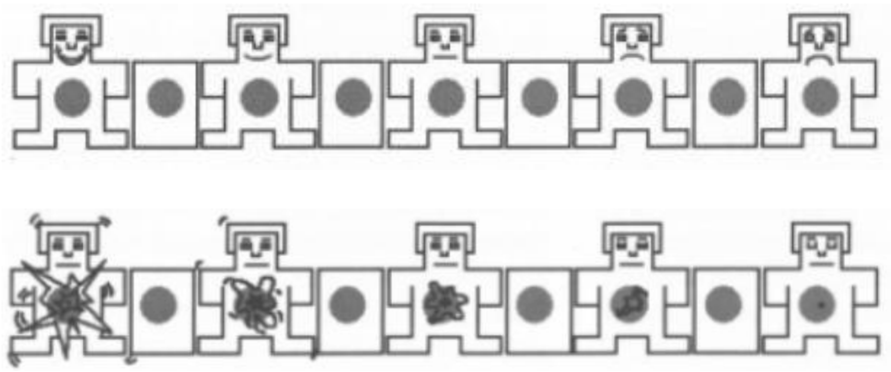

Figure 7. Valence scale and Arousal scale from the Self-Assessment Manikin (SAM).

At the other hand of the scale, individual felt completely unhappy, annoyed, unsatisfied, melancholic, despaired, bored. The scale also allow to describe intermediate feelings of pleasure – displeasure by selecting any of the other manikins. If one felt completely neutral, neither happy or unhappy, should select the figure in the middle, while if the feeling of pleasure – displeasure falls between two of the pictures, one should select the space between the two figures. This permits people to provide a more-fine grain rating of their personal reaction while viewing pictures. Arousal scale ranges from an excited manikin to a sleepy manikin. At one extreme of the scale, individual felt stimulated, excited, frenzied, jittery, wide-awake, aroused. At other hand of the scale, individual felt completely relaxed, calm, sluggish, dull, sleepy, unaroused. The scale also allow to describe intermediate feelings of activation – deactivation by selecting any of the other manikins. If one feel not at all excited or not at all calm, should select the figure in the middle of the raw, while in order to make a more accurate rating could select the space between two manikins. Participants are instructed to select on each scale and for each picture, the manikin that better correspond to their actual experience of valence and arousal while viewing the picture.

In sum, IAPS pictures are visual stimuli thought to induce specific affective states varying in the level of valence and arousal dimension. Such experimental tool has been created in order to reach such aim in a safe and noninvasive way, in a controlled experimental setting. IAPS pictures vary in the intensity of their emotional provocation. However, such provocation never exceed those that may be generated by other pictures available in the most common media, such as TV, cinema, newspapers, the net. They have been found to be very efficient for those studies that currently seek to understand the role of emotions, affect and attention on several cognitive functions. For this reason, IAPS stimuli have been selected as the most efficient experimental method for this research, in order to manipulate participants' affective state along valence and arousal dimension.

CHAPTER 3

Aim of the Thesis

As aforementioned, there is accumulating evidence showing that emotions and affective states have an influence on a wide range of cognitive functions (Barrett & Bar, 2009). Most important, they play a prominent role in shaping judgments and decisions. As reviewed in the previous chapters of this dissertation, affective reactions are able to provide information about the goodness of certain choice options, thus influencing risk perception and risk taking behavior (Schwarz & Clore, 1983).

However, previous studies on this topic mostly adopted a valence-based approach. That is, they have considered affective states as a unidimensional bipolar construct (negative or positive), ignoring its multidimensional nature (Russell & Feldman Barrett, 1999). In particular, the role of *arousal* (i.e. the intensity by which pleasure or displeasure is actually experienced) has been largely undervalued from prior studies. It has been shown that emotional states with the same valence (e.g. sadness and anxiety) may have different consequences on risk taking (Raghunathan & Pham, 1999). Therefore, it is crucial to examine the influence of affect taking into account differences along the arousal dimension since focusing on valence dimension only fails in capturing all the variability among different affective sates. Few research investigated the effects of affective states on risk preference at different levels of arousal (e.g. Mano, 1992). In particular, the way in which arousal (negative and positive) impact risk taking and the processing of risky information remains still unclear.

Hence, the fundamental aim of this thesis was to explore whether inducing negative or positive affective states at high or low levels of arousal differently influences individual's preference for monetary options varying in risk.

To address this question I first tested whether a high arousal state, either negative or positive, increases individual tendency to take risks. In particular, I sought to understand whether including an unpleasant (pleasant) arousing cue as part of the decision scenario (contextual priming; Yi, 1990) influence the probability of selecting a risky option, as compared to a control condition in which an unpleasant (pleasant) unarousing cue is presented (chapters 4 and 5). Secondly, I inquired into possible explanations for this effect. In two eye-tracking studies I tested an hypothesis of cognitive depletion according to which an affective state characterized by elevated arousal would be associated to decreased attentional resources to be allocated to the processing of risky information (chapters 6 and 7).

3.1 Summary of empirical studies

The aforementioned aims will be analyzed throughout the second part of this dissertation in four different papers, summarized as follows.

Paper 1 – Galentino, A., Bonini, N., Savadori, L. (in preparation). *Incidental arousal elicited through contextual factors influences individual's preference for risk*. (Chapter 4)

In this study, the effect of inducing incidental negative and positive arousal on preferences for risky monetary options has been investigated. Starting from evidence showing that inducing high levels of distress (negative arousal) increases risk taking behavior (e.g. Mano, 1992), I replicate and extend the effect of experimentally inducing incidental arousal (negative and positive) on incentivized risky choice. In two experiments, participants' affective state has been experimentally manipulated in order to induce high or low levels of negative arousal (experiment 1) and positive arousal (experiment 2). Affect was manipulated by presenting participants with affective eliciting pictures (IAPS pictures), selected for each experimental condition with refer to the affective norms. In experiment 1 the effect of negative arousal has been examined. Therefore, in order to induce incidental affective states, unpleasant pictures with high or low level of arousal have been selected and inserted as contextual factor of the decision scenario. Preferences for monetary lotteries with same expected value, constant probability but different risk were recorded.

Seventy-two participants took part in the study for monetary remuneration. Participants were randomly assigned to one of two experimental conditions: Unpleasant Activation (UA, high arousal group; n = 31; 19 females); Unpleasant Deactivation (UD, low arousal group; n = 41; 17 females). Participants played a computerized risk taking task where in each trial they had to choose one among a pair of two-outcome lotteries. Each pair of lotteries was equal in expected value and probability of occurrence (50%). Riskiness was determined by manipulating the variance between the two monetary payoffs: The higher the variance, the higher the risk. IAPS pictures were presented in combination with each pair of lotteries. Therefore, on a single trial participants were presented with a pair of lotteries and a picture (high or low in negative arousal) displayed on the background of the screen. No feedback was provided. Once completed the risk taking task participants performed an affective experienced task where they were presented with all the previously seen pictures and they were asked to report the current level of valence and arousal experienced while viewing the pictures, using the two SAM scales. At the end of the experiment one trial was randomly extracted and the lottery chosen for that trial was played for participants' remuneration. As expected, participants in the UA group (high arousal) reported higher levels of arousal than participants in UD group (low arousal). More important, it was found that the probability of selecting the risky lottery was higher for participants assigned to the UA group (high arousal) compared to those assigned to the UD group (low arousal). The result however, was one-tailed significant. No gender effect emerged.

In experiment 2, the effect of positive arousal has been examined. Sixty-eight participants took part in the study for monetary remuneration. Participants were randomly assigned to one of two experimental conditions: Pleasant Activation (PA, high arousal group; n = 30; 15 females); Pleasant Deactivation (PD, low arousal group; n = 38; 15 females). Procedure was identical to that adopted for experiment 1, except that pictures were selected among those with high level of valence (pleasant stimuli) and high or low levels of arousal (according to the experimental condition). Participants assigned to the PA group (high arousal) reported higher levels of arousal than participants in the PD group (low arousal). Contrary to experiment 1, no main effect of arousal on risky choice was found. However, a gender effect and an interaction effect arousal by gender emerged: Probability of selecting a risky option was higher for males than females and this difference was increased by the arousal manipulation. More specifically, high positive arousal increased risk taking in males, but decreased risk taking in females.

Taken together, findings from this study suggest that arousal does impact risky choice. In particular, an unpleasant arousing contextual cue enhances probability of making a risky choice. Moreover, positive arousal also influences risk taking but a gender-dependent effect has been found. It may increase risk taking in males and decreasing it in females. Since there are few evidence in the literature documenting the effect of positive arousal (eustress) on risk-taking behavior, I conducted an additional study focusing on the role of positive arousal only, in order to deeply understand its impact on individuals' preferences for risk.

Paper 2 – Galentino, A., Bonini, N., & Savadori, L. (Submitted). *Positive arousal increases individual's preference for risk.* (Chapter 5)

In this study I investigated whether preferences for monetary options varying in risk are influenced by inducing incidental affective states with high or low level of positive arousal. Research on arousal and risk suggests that negative arousal (i.e. distress) leads to increased risk taking (Porcelli & Delgado, 2009; Starcke et al., 2008) while very little is known about the role of positive arousal. Recent research suggests that positive arousal is accompanied to cognitive depletion, heuristic processing, less resistance to temptation and more willingness to engage in risky activities (Ariely & Loewenstein, 2006; Fedorikhin & Patrick, 2010). This is generally accounted in terms of increased sensitivity to rewards and immediate gratification. Therefore, I predicted that also positive arousal would influence preferences for risky monetary choices. Specifically, I expect that a pleasant arousing contextual cue would increase probability of making a risky choice.

One-hundred twenty-five participants were randomly assigned to one of two experimental conditions (High arousal, n = 65; 32 females, Low arousal, n = 60; 31 females). Risk taking was assessed by asking participants to choose between couple of lotteries with same EV but differed in terms of risk. Arousal was manipulated by presenting participants with visual stimuli (IAPS pictures) varying in the level of arousal keeping the valence constant (positive). Contrary to studies presented in paper 1, new lotteries have been included and also neutral images were presented. By adopting the technique of contextual priming each subject was simultaneously exposed to the stimuli (the gambles) and the contextual factor (the arousing/unarousing image). Time spent for making each decision was also recorded.

A main effect of arousal on predicting risky choice was found: Participants in the high arousal condition selected the risky option more often than participants in the low arousal condition. Furthermore, participants in the high arousal condition took on average more time than participants in low arousal condition for making each choice. This result is in line with arousal theories which correlate the level of arousal of a stimuli to attention showing that high arousal is associated with decreased attentional resources (Anderson, 2005). Additional studies including some process tracing measures (e.g. eye tracking) are described in the rest of the thesis that may help to disentangle the cognitive mechanisms that determine the impact of arousal on choice.

Contrary to experiment 2, no effect of gender was found in this study. This is puzzling, however it is not the first time in the literature that the effect of gender shows to be inconsistent (in some studies it is elicited and in other studies it is not). The boundaries of this effect have not been further explored because they are out of the main aim of the present dissertation.

In summary, with this study I provide evidence that incidental affective states characterized by high levels of positive arousal increase preferences for risky monetary options. Since, both positive and negative arousal are characterized by changes in physiological activity, it may be reasonable to posit that the same effects of negative arousal on cognition may occur even when the antecedent of the arousing reaction is a pleasant event or stimuli.

Despite, at present, it has not been provided any exhaustive description for why arousal should increase risk taking, some psychological explanation suggests that an optimal cognitive performance requires a low/moderate level of arousal, while too little or too much arousal may have detrimental effects on cognition, including decision making (Kaufman, 1999; Yerkes & Dodson, 1908).

Paper 3 – Galentino, A., Bonini, N., Savadori, L., Venkatraman, V., & Vo, K.(In preparation). *Incidental negative arousal and individual's preferences for risky lotteries: an eye tracking study*. (Chapter 6)

In this study I seek to understand the mechanism underlying the influence of negative arousal on preferences for monetary offers varying in risk. Research show that subjects experiencing high levels of distress (e.g. a public speech) were more risk taking in playing hypothetical gambles (e.g. Mano, 1992). In the present work I replicate and extend the effect of experimentally inducing incidental negative arousal on risky choice. I further tested the influence of arousal on visual attention. Evidence shows that high arousal narrows attentional focus (e.g. Loftus, 1979). Therefore, I predicted that introducing an unpleasant arousing cue as part of the decisional scenario would have influence on participants' attention allocation

Twenty-two participants (10 females) were asked to choose between couples of two-outcomes lotteries with same expected value but different risk (variance between payoffs). Arousal was manipulated within subjects by presenting participants with IAPS pictures varying in the level of negative arousal (i.e. unpleasant stimuli with high or low levels of arousal). By adopting the technique of contextual priming (Yi, 1990), participants were simultaneously exposed to stimuli (lotteries) and a contextual factor (the arousing/unarousing image). In addition, eye fixations were recorded.

An effect of arousal on predicting risky choice was found. Probability of selecting a risky lottery was higher when an arousing contextual cue was presented, as found in experiment 1 (paper 1). Moreover, the predicted effect of arousal on attention allocation was found. Participants spent more time looking at the arousing image, compared to trials when an unarousing image was included. This result is in line with arousal theories which correlate the arousal level of a stimuli to attention (e.g. Fernandes et al., 2011).

In summary, with this study I provided evidence that incidental affective states characterized by high levels of negative arousal increases individuals' preferences for risky monetary options compared to safe monetary options and influence attention allocation. The robustness of this result is also given due to the within subjects manipulation of arousal adopted for this experiment. Consistently with previous research, it was found that arousing stimuli are capable of capturing attention. A growing literature on the effect of arousal on cognition shows that elevated arousal is often accompanied with cognitive depletion and decreased attentional resources (Anderson, 2005; Yerkes & Dodson, 1908). This experiment shows that less attentional resources may be devoted to the processing of information, and this might be an explanation for the increase in risk-taking (or better, decrease in risk aversion) tendency of individuals under high arousal states. However, the link between less information processing and risk taking is still ambiguous, and further exploration of this topic is needed.

Paper 5 – Galentino, A., Bonini, N., Savadori, L., Venkatraman, V., & Vo, K.(In preparation). *Incidental positive arousal and individual's preference for risky lotteries: an eye tracking study*. (Chapter 7)

In this study I seek to understand how incidental affective states with high or low levels of positive arousal differently influences preferences for monetary offers varying in risk. Previous studies show that subjects positively aroused through exposure to IAPS pictures were more risk seeking while playing real gambles (Knutson et al., 2008; Galentino et al., submitted). However, the instances for this effect are scant and, more importantly, the mechanisms underlying the effect of arousal on risk preferences are not clear. In a within-subjects eye-tracking experiment I experimentally induced positive arousal (high and low) and recorded individuals' preferences for monetary lotteries varying in risk. I further predicted that arousing stimuli would capture visual attention and, as a consequence, would induce an high level of interference with the processing of risk information (measured as time spent looking at the riskier option).

24 participants (11 females) were asked to choose between couples of two-outcomes lotteries with same expected value but different risk (variance between payoffs). Arousal was manipulated within subjects by presenting participants with IAPS pictures varying in the level of positive arousal (i.e. pleasant stimuli with high or low levels of arousal). By adopting the technique of contextual priming (Yi, 1990), participants were simultaneously exposed to stimuli (lotteries) and contextual factor (the arousing/unarousing image). In addition, eye fixations were recorded.

No behavioral effect of arousal on risky choice was found for this experiment. Nevertheless, eye-tracking data showed that participants spent more time fixating the arousing image, compared to trials when a pleasant unarousing image was included. Furthermore, participants seemed to process risky information longer when the pleasant unarousing cue was presented, as opposed to when a pleasant arousing cue was presented: fixation times towards the risky monetary offer was longer when the pleasant unarousing stimuli was contextually present, compared to when the pleasant arousing stimuli was present.

In conclusion, this study provides evidence of the effect of arousal on attention allocation and information processing of risk. It was found that when a pleasant stimuli with low levels of arousal is included as part of the decisional context, participants process risky information for longer than when a pleasant arousing cue is presented. Even though no behavioral effect was found for this experiment, results may explain evidence from previous studies which found that presenting pleasant arousing stimuli included as part of the decision context makes participants less risk averse.

This result is in line with arousal theories which correlate the arousal level of a stimuli to attention (e.g. Fernandes et al., 2011) and with studies showing that elevated state of arousal are often associated to cognitive depletion (Fedorikhin & Patrick, 2010).

In summary, based on the evidence of this experimental work, it is possible to say that incidental affective states characterized by high levels of arousal may increase risk-taking behavior. This effect is consistently found for negative arousal (paper 1 and paper 3). It is partially found for positive arousal (paper 1, paper 2 and paper 4). Such effect may be due to an instance of cognitive depletion that characterizes elevated states of arousal. In such condition, arousal may influence attention allocation, leaving few cognitive resources available for a deeply information processing of risk. This may reduce people's risk aversion normally observed in studies involving choices between gambles with same expected value. As suggested by Kaufman (1999), arousal may represent an additional source of bounded rationality, so that when people experience affective states (pleasant or unpleasant) characterized by high levels of arousal, choices may be guided by more impulsive mechanisms. This might lead people to make more hazardous choices.

In the second part of this dissertation, there will be presented the four papers summarized in this chapter.

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Part II

Empirical studies

Everything in your life is a reflection of a choice you have made.
If you want a different result make a different choice.

Unknown

CHAPTER 4

Paper I – Incidental Arousal and Individual's Preference for Risky Lotteries

4.1 Abstract

Incidental affect arise independent of a decision (e.g. due to contextual factors). Research show that negative affect may lead to risk propensity while positive affect may lead to risk avoidance, but very little is known on the effect of arousal on risk taking. Research shows that elevated arousal is associated to less resistance to temptations and increased willingness to engage in risky activities. In this study we investigated whether preferences for monetary offers varying in risk are influenced by inducing incidental affective states at high or low levels of arousal. Arousal was induced by presenting pictures varying in the level of negative (experiment 1; n = 72) or positive arousal (experiment 2; n = 68). Participants were randomly assigned to a low-arousal or high-arousal condition and asked to choose between pairs of two-outcome lotteries with same expected value, same probability, but different risk. Negative high-arousal increased preference for risk, while positive high-arousal influenced risk taking in a gender-dependent manner, increasing it in males and decreasing it in females. Implications for future research are discussed.

4.2 Introduction

Standard economic models explain decision making under risk as a methodical utility maximization process (e.g. Von Neumman & Morgestern, 1947). Developments in cognitive psychology and neuroeconomics show the volatility of such conceptualizations highlighting human bounded rationality (Simon, 1987) and discussing the role of decision maker's affective state in cognitive evaluation of choice options, especially under risky conditions (Loewenstein, Weber, Hsee, & Welch, 2001). In particular, an affective-based cognitive evaluation of choice options may determine whether the decision maker's response will be more or less risk averse.(Isen, 2000; Isen & Patrick, 1983; Lerner & Keltner, 2001). Affective state is distinguished from the wide-ranging of emotions for two reasons. First, they are steadily experienced as feeling states (in the presence or in the absence of awareness) (Russell, 2003). Most of the time, affective reactions remain at a subcortical level so that people are not always aware of them. Nonetheless, they always exert influences on several cognitive functions (e.g. memory, attention, judgment; for a review see Pessoa, 2008) and modify the way information is processed (e.g. Le Doux, 1996; Zajonc, 1980). Second, they can be explained according to some features including variations along valence and arousal dimensions (Russell & Feldman Barrett, 1999). For this reason, affective state is an overarching construct which incorporates not only emotions per se, but also feeling states that could have or could not have a clear triggering source, such as environmental cues and bodily reactions (e.g. Russell & Carroll, 1999; Schwarz, 2000).

When considering affective influences on decision making process, two kinds of affective reactions are usually considered: integral affect and incidental affect (Loewenstein, Rick, & Cohen, 2008). Integral affect consists of affective influences that are elicited by the decision process itself (i.e. by the act itself of making a decision), for instance by anticipating future consequences linked to the decision; thinking about future emotions that could be triggered out by knowing the decision outcome and so forth. In this study we focus on incidental affect which are, conversely, affective reactions unrelated to the decision to be made. Incidental affect are short-lived affective state with a clear trigger or cause. Specifically, they are elicited by situational factors (e.g. stressor events), or due to contextual cues and environmental conditions (e.g. images, music, odors). Affective reactions produced by such external events have been shown to influence judgment and decision making (incidental carryover effect; Johnson-Laird & Oatley, 1992). For example, in a famous study, Hirsch (1995) investigated the role of incidental odors on gambling behavior. The study was conducted in a Las Vegas casino and one area was odorized with a pleasant odor, while another one was unodorized. The amount of money gambled in each area was measured and compared before, during and after the experimental manipulation. It was found that money gambled in the slot machines located in the odorized area was significantly higher than the amount of money gambled in the same area before and after the experimental manipulation. Conversely, the amount of money gambled in the unodorized area did not change significantly. Hence, Hirsch (1995) suggests that a pleasant odor may elicit incidental affective states able to influence consumer's gambling behavior.

Many decisional researchers investigating the role of incidental affect on risk propensity show that positive affect may lead to risk aversion while negative affect may lead to risk seeking behavior (Isen & Patrick, 1983; Morris & Reilly, 1987). In particular, it has been shown that people in whom a positive affective state is induced report higher probability estimates of obtaining gains (i.e. an index of optimistic behavior) but, compared to controls, they are more risk averse when they are offered the chance to bet on an high risk gamble (Isen, Nygren, & Ashby, 1988; Isen & Patrick, 1983). As an explanation for this findings, the authors suggest that when in positive affect people may have the tendency to be protective of their feelings so that they would be reluctant to take more risk because of the repulsion from the negative outcome which might reduce their global well-being (*mood maintenance*). Conversely, when in negative affect, people would tend to take more risk since they find in the positive outcome the chance to enhance their low mood (*mood repair*, Morris & Reilly, 1987).

A serious limitation of these theorizations is that affective state is conceived as a unidimensional bipolar construct (positive or negative) assuming that affective state with same valence have equivalent influences on decision making and risk behavior. Recently, researchers started to explore differences among diverse affective states which share the same level of valence (DeSteno, Petty, Wegener, & Rucker, 2000; Han, Lerner, & Keltner, 2007; Raghunathan & Pham, 1999) pointing out that adopting a valence-based approach may represent a big weakness since it fails in capturing all the variance which characterizes affective states. Rather, affect should be considered as a far more complex construct that is multidimensional in its nature (Russell, 2003). In addition to valence, at least one more dimension should be taken into account when influences of affective states on cognitive processes are discussed: i.e. the arousal dimension (Russell & Feldman Barrett, 1999). While valence dimension refers to the experience of affective well-being and the hedonic tone of an affective state, arousal dimension refers to the subjective experience of energy or mobilization, alertness or tension. Affective arousal provides information about bodily experience since it is characterized by specific physiological reactions, elicited through the activity of the autonomic nervous system (e.g. Hagemann, Waldstein, & Thayer, 2003).

In this study we focus on the role of incidental affective arousal on decision making under risk. By adopting the affect circumplex model, a widely-accepted bi-dimensional model of affect proposed by Russell (1980), we test the effect of inducing high or low levels of incidental negative arousal (experiment 1) and incidental positive arousal (experiment 2) on individuals' preferences for risky monetary options.

Evidence on influences of arousal on risk taking seem to converge on the idea that experiencing high levels of arousal increases risk taking behavior. It has been observed that people experiencing negative arousal (e.g. due to a pending presentation) were more risk seeking in playing hypothetical gambles (e.g. Mano, 1992). By using the same stressor, Starcke et al. (2008), required participants to play the Game of Dice Task (GDT, Brand et al., 2005), a computerized game where the goal is to maximize a capital of fictitious money by choosing between alternatives that consist of different combinations of dice. Compared to controls, stressed participants selected the risky combination more often and had a worse performance. In another study using the cold press task, a wide-used methodology for induce distress where participants have to immerse a hand into a container filled up with ice water (Ferracuti, Seri, Mattia, & Cruccu, 1994), a stronger reflection effect (Kahneman & Frederick, 2007; Kahneman & Tversky, 1979) was observed: i.e. stressed participants showed an increased risk taking behavior in the loss frame (i.e. a gamble was preferred over a sure loss of equal expected value) and decreased risk taking in the gain frame (Porcelli & Delgado, 2009). In other studies, negative arousal (distress) has been found to interact with gender. For example, male participants exposed to the cold press task pumped more times on the BART (demonstrating greater risk taking) than non-stressed male participants; while female stressed participants were less risk taking than female non-stressed participants on the BART (Lighthall, Mather, & Gorlick, 2009).

Positive arousal has been examined less often than negative arousal. However, evidence shows that in some circumstances experiencing high-intensity positive affect increases risk taking behavior as well. For example, excitement, a pleasant emotion characterized by high levels of arousal has been found to be related to impulsive buying (Rook & Gardner, 1993). Similarly, Macht, Roth, and Ellgring (2002) found that joy, which is often accompanied by arousing reactions, increases chocolate consumption. Fedorikhin & Patrick (2010) studied the role of positive arousal on consumer choice finding that it is associated with cognitive depletion and results in decreased resistance to temptations. Ariely and Loewenstein (2006) studied the role of sexual arousal (i.e. a specific form of positive arousal) on sexual decision making. After inducing sexual arousal (through self-stimulation), authors required participants to make judgments and hypothetical decisions on the attractiveness of different sexual stimuli and activities; on the willingness to take various morally dubious measure to procure sex; and on the willingness to engage in risky sexual activities. Authors reported that, compared to the condition in which the same participants answered the questions in a neutral unaroused state, sexual arousal acted as a strong amplifier of sorts. More relevant to our study, it was found that the exposure to incidental pleasant stimuli (erotic pictures) increased financial risk-taking by altering anticipatory affect (Knutson, Wimmer, Kuhnen, & Winkielman, 2008).

The fact that negative arousal and positive arousal have a similar influence on risk taking behavior is not surprising. Although qualitatively different, negative and positive arousal are similar in several aspects. First, they elicit the same physiological reactions. It has been proved that pleasant and unpleasant stimuli equated for the level of arousal produce a similar physiological response (Bradley, Codispoti, Sabatinelli, & Lang, 2001). For instance, negative arousal is typically characterized by changes in skin conductance and heart rate deceleration. This is the case also for positive arousal (Codispoti, Surcinelli, & Baldaro, 2008). Skin conductance is expected to increase as automatic reaction to any increase in affective arousal. Conversely, cardiac deceleration has been interpreted as reflecting orienting and sustained attention (Bradley et al., 2001; Lang, Greenwald, Bradley, & Hamm, 1993). Second, the processing of unpleasant arousing stimuli and pleasant arousing stimuli activates similar areas in the brain (Stark et al., 2005). Third, when presented with affective-eliciting pictures high in level of arousal, the differentiation between self-reported levels of positive affect and negative affect is highly reduced (Reich & Zautra, 2002).

The way in which arousal impacts risk taking, instead, is still unclear. According to a dominant view, the increase in arousal is accompanied by a decrease in mental resources (Kaufman, 1999). How, then, a decrease in mental resources translates in more risk taking is another problematic aspect of this explanation. According to several evidences, limited cognitive resources impacts human sensitivity to rewards, making them more desirable than what they are (Fedorikhin & Patrick, 2010). Following this view, increasing physiological arousal would increase human sensitivity to rewards and hence, make individuals more prone to accept risky options, which, by definition offer higher rewards, disregarding the fact that they also offer higher losses or, anyway, a less convenient outcome.

Therefore, we predicted that introducing an arousing contextual cue as part of the decision scenario, would increase the probability of making a risky choice.

Our study tries to encompass several limitations of previous studies. For example, the evidence suggesting that high levels of incidental arousal are associated to increased risk taking is fragmented as regards of the type of arousal manipulation, the extent to which valence was kept constant and differed in the type of task used to measure risk taking. In our study we kept all these constant. Furthermore, most studies on positive arousal and risk referred only to male population (e.g. Ariely & Loewenstein, 2006), leaving the field of positive arousal unexplored for what concerns women subjects. In our study we used both male and female participants. We induced high or low levels of arousal keeping the valence controlled (negative and positive) and used the same risk taking task across conditions, thus we were able to measure separately the influence of both incidental negative arousal (experiment 1) and incidental positive arousal (experiment 2) on risky choice. Furthermore, our arousal manipulation was minimally contaminated by uncontrolled emotions, such as fear, joy, or anger, that could have polluted previous studies. For example, requiring participants to give a public speech has been used as a manipulation of (negative) stress (e.g. Mano, 1992). However, one could complain that giving a public speech produces a cohort of emotions ranging from fear to excitement, which are both positive and negative in valence dimension. In this study we manipulated arousal and valence by using IAPS pictures (Lang et al., 2005). This allowed us to control for the level of arousal as well as the level of valence induced by each stimuli in two ways. First, by using records collected in previous studies with a similar population. Second, by asking our participants to report perceived arousal and perceived valence for each stimuli at the end of the experiment.

In experiment 1, participants were induced into a high-negative (Unpleasant Activation) or a low-negative (Unpleasant Deactivation) arousal condition and then their preferences for choices between couples of safer and a riskier two-outcomes lotteries, equal in expected value and probability but different risk (as determined by the variance between payoffs) were recorded. In experiment 2, participants were induced into an high-positive (Pleasant Activation) or a low-positive (Pleasant Deactivation) arousal condition. We used the same risk taking task to measure individuals' risk preference. Given that physiological reactions, neural activations and self-report indices are the same for both negative and positive arousal (Codispoti et al., 2008; Reich & Zautra, 2002; Stark et al., 2005), we expect to observe the same pattern of results for both incidental negative arousal and incidental positive arousal. We also expect that a high arousal state will reduce risk aversion, as documented by previous literature on the effects of arousal on decision making under risk (e.g. Ariely & Loewenstein, 2006; Mano, 1992; Starcke et al., 2008).

As mentioned above, in the current research incidental affect was manipulated by presenting participants with affective-eliciting images (IAPS pictures) varying in the level of negative or positive arousal. Adopting the technique of contextual priming (Yi, 1990), participants were simultaneously exposed to stimuli (i.e. the lotteries) and a contextual factor (i.e. the affective picture). In contextual priming, the simultaneous presentation of a stimulus and a contextual cue is able to create an association which can prime specific attributes of the stimulus influencing decision making. This is a very efficient way in order to specifically test the effect of contextual (incidental) affect on risky choice (distinguishing it from the effect of integral affect; see Mandel & Johnson, 2002).

4.3 Experiment 1

In experiment 1 we tested the influence of incidental high-negative vs. incidental low-negative arousal on preference for monetary lotteries varying in risk.

4.3.1 Method

Participants

Seventy-two undergraduate students participated in the study (M_{age} = 21.97 years; 36 females). Students were recruited by a campus email announcement promising monetary reward for participation in a decision-making task. Eligibility criteria were defined as follows: (i) being in good health; (ii) having excellent knowledge of Italian language; (iii) not having actual or previous episodes of psychopathology and not being under psychopharmacological treatment. Before confirming their participation in the study all participants were asked to carefully read an information sheet containing few information about the aim of the study, eligibility criteria, experimental procedure, and remuneration procedure.

Ethicality

Approval for this study was obtained by the University Ethics Committee for Experimentation on the Human Being. This experiment was conducted in accordance with the principles of the Declaration of Helsinki.

Design

Negative arousal (high vs. low) was manipulated in a between-subjects design. Participants were randomly assigned to one of two experimental conditions: Unpleasant Activation (UA, high arousal group, n = 31; M_{age} = 21.06 ; 19 females) and Unpleasant Deactivation (UD, low arousal group, n = 41; M_{age} = 22.66 ; 17 females). A statistical analysis revealed that the two groups differed significantly in terms of age, t = 2.64 p = .01. Therefore, all the subsequent analysis have been run controlling for participants' age.

Materials

Risk taking task. Risk taking was assessed by asking participants to choose between pairs of 18 two-outcome lotteries, A and B, which shared the same expected value (EV) but differed in terms of risk (see Table 1). The degree of riskiness was determined by the variance between the two monetary outcomes, so that the higher the variance the higher the risk. All lotteries offered the participant the opportunity to win or lose a monetary reward with a 50% probability. For example, lottery A offered a 50% probability to win €7 or a 50% probability to win €5 and lottery B offered a 50% probability to win €12 or a 50% probability to win €0. Among the set of risky lotteries, six included a zero gain as outcome (e.g. €12, 0.5; €0, 0.5), six included a sure gain as outcome (e.g. €12, 0.5; €1, 0.5) and six included a loss as outcome (e.g. €10, 0.5; €-1, 0.5). Table 1 reports the list of all stimuli used in this study. The two lotteries were displayed in two four-cell grids each with the two monetary outcomes displayed in the two upper cells and the 50% probability in the lower cells (see figure 1). In order to avoid changing participants' affective state, no feedback was provided after a choice was made.

	Riskier lottery		Safer lottery		
Decision #	Outcome A	Outcome B	Outcome A	Outcome B	Expected value (EV)
1	Winning €11	Winning €0	Winning €6	Winning €5	5.5
2	Winning €12	Winning €0	Winning €7	Winning €5	6
3	Winning €13	Winning €0	Winning €6	Winning €7	6.5
4	Winning €15	Winning €0	Winning €8	Winning €7	7.5
5	Winning €16	Winning €0	Winning €7	Winning €6	8
6	Winning €20	Winning €0	Winning €11	Winning €9	10
7	Winning €12	Winning €1	Winning €7	Winning €6	6.5
8	Winning €14	Winning €1	Winning €6	Winning €9	7.5
9	Winning €13	Winning €2	Winning €7	Winning €8	7.5
10	Winning €14	Winning €3	Winning €9	Winning €8	8.5
11	Winning €15	Winning €2	Winning €7	Winning €10	8.5
12	Winning €17	Winning €1	Winning €9	Winning €10	9
13	Winning €6	Losing €3	Winning €1	Winning €2	1.5
14	Winning €7	Losing €2	Winning €3	Winning €2	2.5
15	Winning €11	Losing €3	Winning €3	Winning €5	4
16	Winning €11	Losing €1	Winning €4	Winning €5	5
17	Winning €16	Losing €2	Winning €6	Winning €8	7
18	Winning €18	Losing €3	Winning €7	Winning €8	7.5

Table 1. Pairs of two-outcome lotteries used in the risk taking task.

The order of presentation of the 18 trials was randomized between participants.

Affective induction. We induced affect using images chosen from the International Affective Picture System (IAPS; Lang et al., 2005) and selected according to the affective norms[3]. Ratings in valence and arousal were obtained from a normative study conducted on a large sample of six-hundred fifty-nine Italian students (Balconi, Arangio, & Venutelli, in prep.) that followed the same procedure used in the original study by Lang et al. (2005). A total of 36 images were used for this experiment: among these, 18 were unpleasant emotional-eliciting stimuli high in arousal and 18 were unpleasant emotional-eliciting stimuli low in arousal. Images chosen for the UA condition included unpleasant high arousal stimuli. This category included images depicting scenes of

[3] List of IAPS pictures used in experiment 1. *Unpleasant Activation*: 3000; 3010; 3015; 3016; 3030; 3051; 3053; 3060; 3063; 3064; 3068; 3069; 3080; 3101; 3170; 3261; 3266; 6550. *Unpleasant Deactivation*: 2205; 2276; 2399; 2590; 2752; 2840; 3300; 7031; 7060; 9000; 9001; 9008; 9041; 9110; 9210; 9280; 9290; 9330.

mutilation, death, bloody pictures or surgeries. These are stimuli able to induce states of negative tension such as fear, disgust or terror, i.e. unpleasant affective reactions characterized by a high level of arousal. Images chosen for the UD condition included unpleasant low arousal stimuli. This category included images depicting scenes of poverty, environmental pollution, cemeteries, children or adults crying. These stimuli can induce states of sadness, boredom or depression, i.e. unpleasant affective reactions characterized by a low level of arousal. Criteria for stimuli selection were set such that their range for valence dimension was 4.5 or less. High arousal stimuli had a range for arousal dimension of 5.5 or greater whereas low arousal stimuli had a range of 2.5 or less. Overall, high arousal stimuli had a mean of 1.33 in valence dimension and a mean of 7.5 in arousal dimension; for the law arousal stimuli the valence mean was 3.44 and the arousal mean was 2.61. Notably, a statistical analysis conducted across rating data from Balconi et al. (in prep.) indicated a significant difference in arousal ratings, $t = 12.24$ $p < .001$. However, also a difference in valence ratings has been registered, , $t = -8.6$ $p < .001$. Even though all the selected stimuli have a valence rating far below the neutral point (5) so that they must be considered unpleasant, it is reasonable to observe that arousing stimuli have been rated as more unpleasant than unarousing stimuli. Since stimuli selected for the affective manipulation differed significantly also along valence dimension, we tested the effect of arousal on risky choice controlling for differences in participants' levels of experienced valence.

Affective experience task. Following Lang et al. (2005), we used a computerized version of the two nine-point Self-Assessment Manikin (SAM) scales asking participants to rate their level of experienced valence and arousal while viewing each image selected for their specific experimental condition.

Post-task questionnaire. In a post-task questionnaire participants were asked to provide information about their age, gender and educational level.

Procedure

The experiment was conducted at the University Experimental Economic Laboratory, in a large room with 24 carrels divided by partitions that prevent visual contact and discourage conversation with neighbors. On arrival at the lab participants drew a number randomly to learn their assigned carrel and were asked to observe silence. Participants were told that they would complete two tasks: the risk taking task and the affective experience task. All the tasks were run on PCs (operating system: *Windows 7*, *Intel* processor) and presented on monitors with 1920 × 1080 resolution. Experimental protocol was developed using *Borland Delphi*® software package. Participants first read instructions on the screen under the guide of the experimenter, and then the lights of the laboratory were turned off to encourage individual focus and the experiment started with a practice trial.

At the beginning of each trial a fixation cross was displayed for a random interval between 100-300 ms. Next, the pair of two-outcome lotteries and the associated image were displayed (see figure 1).

Figure 2. Example of trial in the risk taking task. *Note*: The example is taken from Experiment 2, Pleasant Activation condition.

To induce an affective state during choice we revealed the affective manipulation (i.e. the image) and the stimuli (i.e. the lotteries) in the exact time. The left/right presentation of the riskier and safer lottery was randomized, so that in some trials lottery A was the safer option and in the other trials lottery B was the safer option. Also lotteries position was randomized, so that in some trials each grid containing the lottery was placed above the image, in the upper part of the screen, and in the other trials grids were placed below the image, in the lower part of the screen. A button reporting the label "Alternative A" or "Alternative B" was placed below each grid. After revealing the two lotteries (alternative A and alternative B) with the associated image, participants could select the lottery they preferred by clicking on the respective button. After completing the risk taking task, participants were presented with the affective experience task: they saw all the previously seen pictures and asked to report their current affective state using the two SAM scales.

Participants were told initially they already gained a €3 participation fee for taking part in the study. Furthermore, they were told and reminded throughout that one pair of gambles would be selected at random at the end of the experiment and the lottery they had chosen from that pair would be played for real money. After they completed the task, the computer determined which of their choices would be played for real, and then played the lottery to determine the outcome of the gamble they had chosen. In case of loss, the corresponding amount was deducted from the €3 participation fee. For this reason negative payoffs did not exceed €3 (see Table 1). At the end of the experiment, after completing the affective experience task, participants were presented with a screen reporting the trial extracted for the remuneration, the chosen option and the obtained outcome. Then they completed the post-task questionnaire. Finally they were paid in cash, debriefed and released.

4.3.2 Results

Choice made by participants across trials was used as dichotomous dependent variable. The safer lottery was coded as "0" and the riskier lottery as "1".

Affective experience task. Ratings of valence and arousal provided for emotional stimuli at the affective experiencing task were averaged in order to obtain an overall index of valence and arousal for each participant. The affective induction worked as expected. Self-reported levels of arousal in response to emotional stimuli were higher for participants in UA group than for participants in UD group $t(70) = -4.32$ $p < .001$ (UA, M = 5.66 SD = 1.75; UD, M = 4.19 SD = 1.11). In addition, participants in UA condition reported lower levels of valence in response to emotional stimuli than did participants in UD condition $t(70) = 5.58$ $p < .001$ (UA, M = 2.75 SD = 1.07; UD, M = 3.89 SD = .65). This result is aligned to literature which shows that negative arousing stimuli are also evaluated as more unpleasant. Both groups reported a mean score of valence collocated below the neutral midpoint of the scale (5) indicating that in either group participants experienced negative affect. Female participants reported lower levels of valence in response to emotional stimuli than did male participants $t(70) = -3.72$ $p < .001$ (Males, M = 3.81 SD = .68; Females, M = 2.98 SD = 1.14) and reported higher levels of arousal than did males participants $t(70) = 3.14$ $p < .01$ (Males, M = 4.27 SD = 1.14; Females, M = 5.38 SD = 1.78).

Arousal induction and risk taking. In order to test the influence of arousal on probability of making a risky choice, we developed the following generalized linear mixed model of logistic regression

$$\ln\left(\frac{p}{1-p}\right) = \bar{a} + a_j + \overline{b_1} + \overline{b_2} + \overline{b_3} + \overline{b_4} + \overline{b_5}$$

including arousal (b_1), gender (b_2) and the interaction between the two (b_3) as fixed effects, including age (b_4) and valence (b_5) ratings as covariates, and the intercept estimated for each participant (a_j) as random effect, specifying the participants identification variable as a cluster, as required by the mixed models procedure. Choices made across trials were used as dependent variable specifying the safe choice as reference category.

Analysis revealed a one-tailed significant main effect of arousal on predicting risky choices $F(1, 1285) = 2.72$ $p = .09$. In particular, participants assigned to the UA group (high arousal) selected the riskier option more often than did participants assigned to the UD group (low arousal) (UA, M = 4.3 SD = .77; UD, M = 2.43 SD = .66; see figure 3). Neither gender effect nor interaction between arousal and gender was found. The two covariates, age and valence, were not significant in predicting risky choice, all $p > .05$. Additional analyses introducing self-reported levels of valence as a covariate showed that valence did not predicted risky choice, $p = .37$, while the effect of arousal was still one-tailed significant, $p = .08$.

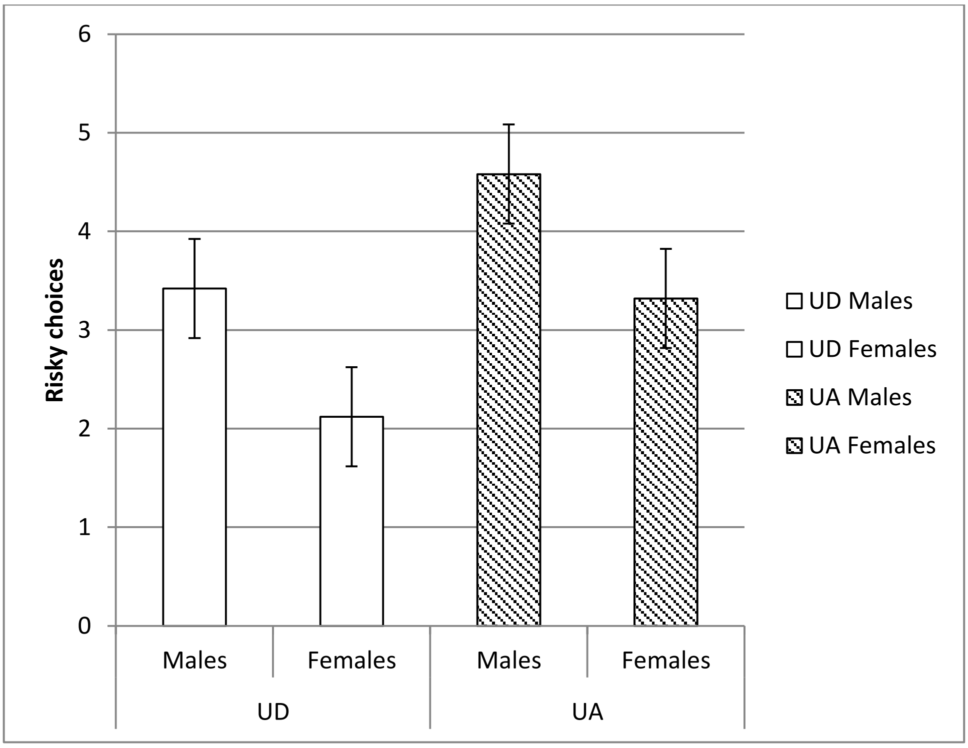

Figure 3. Number of risky choices across conditions, Unpleasant Deactivation (UD) and Unpleasant Activation (UA) differentiated by gender.

We run additional analysis distinguishing between the three domains of stimuli used in this study (i.e. zero gain stimuli, sure gain stimuli and loss stimuli). A unique one-tailed significant effect of arousal on risky choice was found among stimuli including a zero gain as outcome $F(1, 421) = 3.26$ $p = .07$.

Summarizing, participants induced into a high-arousal negative state made more risky choices than those induced into a low-arousal negative state.

4.4 Experiment 2

Experiment 2 was identical to experiment 1 except that we focused on the influence of incidental high-positive vs. incidental low-positive arousal on preference for monetary lotteries varying in risk.

4.4.1 Method

Participants

Sixty-eight undergraduate students participated in the study (M_{age} = 23 years; 35 females). Students were recruited by a campus email announcement promising monetary reward for participation in a decision-making task. Eligibility criteria were defined as experiment 1.

Design

Positive arousal (high vs. low) was manipulated in a between-subjects design. Participants were randomly assigned to one of two experimental conditions: Pleasant Activation (PA, high arousal group, n = 30; M_{age} = 22.37 ; 15 females) and Pleasant Deactivation (PD, low arousal group, n = 38; M_{age} = 23.5 ; 20 females). A statistical analysis revealed that the two groups did not differ significantly in age.

Materials

Risk taking task. Risk taking task was identical to experiment 1.

Affective induction. A total of 36 IAPS pictures were used for this experiment[4]: among these, 18 were pleasant emotional-eliciting stimuli high in arousal and 18 were pleasant emotional-eliciting stimuli low in arousal. Images chosen for the PA condition included pleasant high arousal stimuli. Since images involving people tend to be rated as more arousing, especially pictures with

[4] List of IAPS pictures used in experiment 2. *Pleasant Activation*: 2344; 4652; 4656; 4658; 4659; 4670; 4681; 4683; 4800; 4810; 5629; 8030; 8191; 8210; 8300; 8370; 8400; 8490. *Pleasant Deactivation*: 2514; 2580; 2850; 5000; 5020; 5220; 5250; 5300; 5631; 5635; 5720; 5731; 5764; 5779; 5780; 5891; 7490; 7900.

erotic content, pleasant high arousal images included pictures depicting situations with people having fun or playing extreme sports as well as erotic stimuli. The latter were selected among those involving double-sex couples. These are stimuli able to elicit states of excitement and euphoria, i.e. pleasant affective reactions characterized by a high level of arousal. Images chosen for the PD condition included pleasant low arousal stimuli. This category included pictures depicting landscapes, flowers, scenes from the outer space, cute animals, and serene faces. These stimuli are generally expected to elicit a sense of calm and peacefulness, i.e. positive affective states usually associated with a low level of arousal. Criteria for stimuli selection were set such that their range for valence dimension was 5.5 or greater. High arousal stimuli had a range for arousal dimension of 5.5 or greater whereas low arousal stimuli had a range of 2.5 or less. Overall, high arousal stimuli had a mean of 6.33 in valence dimension and a mean of 6.06 in arousal dimension; for the law arousal stimuli the valence mean was 6.17 and the arousal mean was 1.72. Notably, a statistical analysis conducted across rating data from Balconi et al. (in prep.) indicated a significant difference in arousal ratings, $t(34) = 21.4$ $p < .001$ and no difference in valence ratings, $t(34) = .61$, *ns.* between selected high arousal and low arousal stimuli.

Affective experience task. As in experiment 1.

Post-task questionnaire. As in experiment 1.

Procedure

In experiment 2 we followed the same procedure adopted for experiment 1.

4.4.2 Results

Choice made by participants across trials was used as dichotomous dependent variable. The safer lottery was coded as “0” and the riskier lottery as “1”.

Affective experience task. Ratings of valence and arousal provided for emotional stimuli at the affective experiencing task were averaged in order to obtain an overall index of valence and arousal for each participant. The affective induction worked as expected. Self-reported levels of arousal in response to emotional stimuli were higher for participants assigned to the PA group (high arousal) than participants assigned to the PD group (low arousal) $t = -5.47$ $p < .001$ (PA, M = 4.92 SD = 1.31; PD, M = 3.36 SD = 1.03). Valence ratings did not differ significantly between the two groups $t = -1.38$ *ns*. No gender difference between males and females emerged in response to both valence and arousal scales, all $p > .05$.

Arousal induction and risk taking. In order to test the influence of arousal on probability of making a risky choice, we developed the following generalized linear mixed model of logistic regression

$$\ln\left(\frac{p}{1-p}\right) = \bar{a} + a_j + \overline{b_1} + \overline{b_2} + \overline{b_3}$$

including arousal (b_1), gender (b_2) and the interaction between the two (b_3) as fixed effects, and the intercept estimated for each participant (a_j) as random effect, specifying the participants identification variable as a cluster, as required by the mixed models procedure. Choices made across trials were used as dependent variable specifying the safe choice as reference category. No main effect of arousal in predicting risky choice emerged $F(1, 1221) = .82$ *ns*. A main effect of gender on was found $F(1, 1221) = 5.18$ $p < .05$ (Males, M = 3.45 SD = .52; Females, M = 1.95 SD = .51). A significant interaction effect emerged between arousal and gender in predicting risky choice $F(1, 1221) = 4.8$ $p < .05$. Probability of making a risky choice was higher for males participants assigned to the PA group (high arousal) compared to males participants assigned to the PD group (low arousal) (PA Males, M = 4.06 SD = .77; PD Males, M = 2.83 SD = .71). Conversely, probability of selecting a risky option was lower for females assigned to the PA group (high arousal) compared to females participants assigned to the PD group (low arousal) (PA Females, M = 1.06 SD = .78; PD Females, M = 2.85 SD = .67, see figure 4).

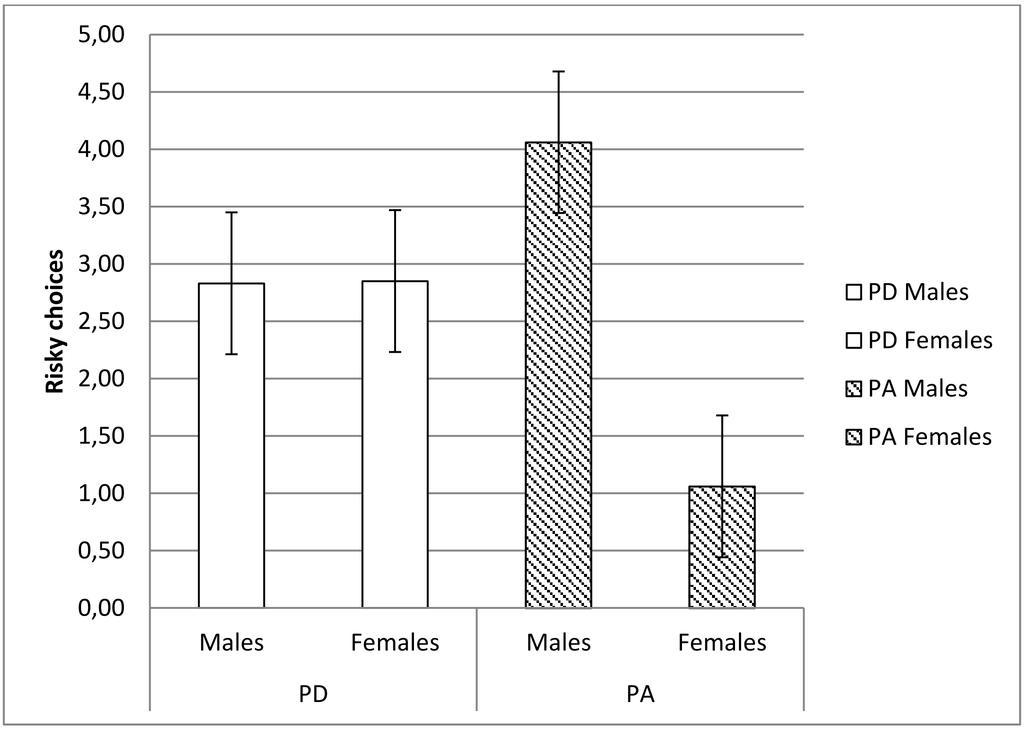

Figure 4. Number of risky choices across conditions, Pleasant Deactivation (PD) and Pleasant Activation (PA) differentiated by gender.

We run additional analysis distinguishing between the three domains of stimuli used in this study (i.e. zero gain stimuli, sure gain stimuli and loss stimuli). A unique significant gender effect was found among stimuli including a loss as outcome $F(1, 404) = 7.42$ $p < .01$, while a marginally significant interaction effect between arousal and gender was found among stimuli including a zero gain as outcome $F(1, 404) = 3.46$ $p < .06$.

Summarizing, positive arousal influenced risky choice in a gender-dependent manner increasing it in males and decreasing it in females.

4.5 Discussion

In this study we examined the impact of inducing incidental unpleasant (pleasant) affective states with high or low levels of arousal on preferences for monetary options varying in risk. By adopting the technique of contextual priming (Yi, 1990), we repeatedly induced incidental affective states with high or low arousal, keeping the valence constant (negative or positive). Arousal was manipulated by presenting participants with arousing or unarousing images (IAPS pictures) inserted as contextual factor of the decisional scenario. In a risk taking task we asked participants to make choices between safer and riskier lotteries with the same expected value and constant probability.

In both experiment 1 and experiment 2, we found that introducing an arousing cue as part of the decision context influences preferences for risk. In particular, we found that inducing an high-intensity unpleasant affective state increases preference for the risky option, as compared to the condition in which participants were induced into a low-intensity unpleasant affective state. Even though this result was one-tailed significant it is consistent with a growing literature which finds that experiencing negative arousal (e.g. distress) does indeed increase risk taking behavior (e.g Mano, 1992; Porcelli & Delgado, 2009; Starcke et al., 2008). Previous research mainly ignored the role of positive stress on decision making. Nevertheless, evidence show that positive arousal and risk taking are positively correlated as well. For example, it has been shown that positive arousal decreases resistance to temptations (Fedorikhin & Patrick, 2010), increases willingness to be engaged in risky sexual activities (Ariely & Loewenstein, 2006), and increases financial risk taking (Knutson et al., 2008). In the current study we found that positive arousal influenced risk taking behavior in a gender-dependent manner. Specifically, we found that inducing high-intensity positive affective states increased risk taking behavior in males participants and decreased it in females participants. However, the interplay between stress (arousal) and gender should be further examined. In previous studies on negative stress, often this interaction effect has been evident under specific conditions (e.g. Lejuez et al., 2002; Lighthall et al., 2009; Pighin, Bonini, Savadori, Hadjichristidis, & Schena, 2014). Therefore, future research should deeply investigate gender differences in response to positive stress as well as their impact on behavior and cognition. Overall, the role of positive stress on influencing preferences for economic risk remains mostly unclear, therefore in the next paper of this dissertation we focused on positive arousal only. Furthermore, this study does not permit to validate any psychological explanation about the effect of arousal in risk taking behavior, therefore in the following papers we will seek to understand the mechanisms that underlie such relationship.

In summary, this study represents a preliminary attempt to extend the scientific investigation regarding the role of arousal on risk preferences. We showed that both, negative and positive arousal may have impact on shaping individual preferences for risk. This research highlights the need of assessing both dimensions of valence and arousal when affective state is used as explanatory variable of differences in risk taking between individuals, considering that incidental affective states (elicited through situational or contextual factors) may influence risk preferences in a gender-dependent manner.

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CHAPTER 5

Paper II – Positive Arousal and Individual's Preferences for Risky Lotteries

5.1 Abstract

It is recognized that high positive arousal impacts decision-making but little is known on its effect on preferences for risk. We manipulated positive arousal in an experimental setting and measured individual choices under risk in an incentivized task. 125 participants were randomly assigned to either a low-arousal or a high-arousal condition and asked to choose between pairs of two-outcome monetary lotteries with same expected value but different risk, in terms of outcome variance. The probability was fixed at 50%. Participants in the high-arousal group selected the risky lottery more often and took more time to make choices than participants in the low-arousal group. These results show that high positive arousal alters economic behavior. The mechanisms responsible for this effect and practical implications are discussed.

5.2 Introduction

In many occasions people experience positive high-arousal. For example, getting married, passing an exam, being sexually attracted to someone else, feeling excited by partaking in a particular activity (e.g. extreme sports, or clubbing in an overcrowded party), are all instances of situations characterized by a highly intense positive emotion. Despite this, the majority of studies investigating the effect of high-intensity emotions on decision making have examined negative emotions, such as, stress, anxiety, anger (for a review, see Starcke & Brand, 2012). Few studies have examined the effect of high-intensity positive emotions (i.e. joy, excitement, elation) on decision making.

High-intensity emotions, either positive or negative, are characterized by high levels of arousal. Arousal is the intensity with which pleasure (displeasure) is experienced and ranges from deactivation (or calm) to activation (or stress) (see Russell, 2003). Arousing reactions, along with pleasantness, constitutes affective state (i.e. the immediate reaction to any emotionally charged event). Affect provides basic information about the state of the environment and the organism and, most of the time, this information is used as a basis for guiding judgments and decisions (e.g. Schwarz & Clore, 1983). It is therefore crucial to examine the influence of affect on cognition at different levels of arousal.

A variety of studies from psychology, economics, and marketing tend to converge on the fact that inducing positive arousal does indeed increase individual preference for risk. In a famous field study, players of a Las Vegas Casino gambled more money when the slot machines area was odorized with a pleasant odor, compared to when the area was unodorized (Hirsch, 1995). Even if there are no proofs that the effect of odor on behavior was mediated by an increase in positive arousal, the authors suggest this as a very likely explanation. Individuals in a positive high-arousal state also show more impulsive buying (Rook & Gardner, 1993), consume more chocolate (Macht, Roth, & Ellgring, 2002) and resist less to temptations (Fedorikhin & Patrick, 2010). For example, participants exposed to pleasant arousing stimuli were more impatient toward obtaining a smaller but sooner reward in an intertemporal choice task and this effect was more evident in individuals with higher reward sensitivity (Van den Bergh, Dewitte, & Warlop, 2008). Likewise, sexually aroused subjects (i.e. a specific form of positive arousal) have been found to be more willing to take various morally dubious measures to procure sex and engage in risky sexual activities (Ariely & Loewenstein, 2006) and male participants exhibited increased preference for disadvantageous decks in the Iowa Gambling Task (IGT) when these were associated with sexual pictures (Laier, Pawlikowski, & Brand, 2013). More relevant to our study, male participants presented with pleasant incidental cues (erotic pictures) increased their preference for risk and this effect was partially mediated by nucleus accumbens activation which is usually stimulated by an anticipatory affect

(Knutson, Wimmer, Kuhnen, & Winkielman, 2008). On a similar vein, it has been found that individuals exhibit an increased preference for risk on hypothetical gambles after viewing opposite sex faces (McAlvanah, 2009).

The effect of positive arousal on risk attitude has been explained in various ways. It has been suggested that positive high-arousal may increase anticipatory affect, thus increasing the desire for rewards (Knutson et al., 2008) and the preference for immediate, compared to future, rewards (Van den Bergh et al., 2008). The effect of opposite-sex faces on gambling has also been attributed to the activation of either a mating mindset or to an increase in competitiveness (McAlvanah, 2009). According to several views, positive high-arousal causes a state of cognitive depletion in which the individual attention is focused on a very specific aspect of the situation (presumably the rewards) thus altering choice behaviour (Ariely & Loewenstein, 2006; Fedorikhin & Patrick, 2010; Laier et al., 2013; Rook & Gardner, 1993). According to this view, positive high-arousal should impact individual's choice under risk, increasing preferences for risk which is associated to greater rewards. To test this prediction we measured the effect of positive high-arousal on individual preference for risk in an incentivized task. Previous studies focused on erotic stimuli which is only a subset of positive arousal activators. Furthermore, in most of these studies only male participants were used. In the present study, both male and female participants were either induced into a high-positive or a low-positive arousal condition and their preferences for a series of choices varying between safer and riskier lotteries, equal in Expected Value and with 50% probability, were measured. Risk was manipulated by varying the degree of variance between monetary outcomes of two options. To illustrate this, imagine that alternative A is a lottery which offers you a 50% chance of winning $15 and a 50% chance of winning $0 while alternative B is another lottery which offers you a 50% chance of winning $8 and a 50% chance of winning $7. The expected value for both alternatives is the same (i.e. $7.5) but A is riskier than B. We expect that participants in the high positive arousal condition will choose the riskier option more often than those in the low positive arousal condition.

It must be said, however, that in some studies stress has been found to affect risk taking differently depending on gender. Male participants exhibited greater risk taking under stress while female were less risk-taking under stress (e.g. Lighthall, Mather, & Gorlick, 2009). Thus, we controlled also for the interaction between gender and arousal in search for a replication of the effect.

Differently from most of the previous studies that have manipulated arousal through classical priming techniques (e.g. Fedorikhin & Patrick, 2010; Knutson et al., 2008), we adopted the technique of contextual priming (Yi, 1990). This technique requires that a subject is simultaneously exposed to a stimulus (in our case, the gamble) and a contextual factor (in our case, the arousing or unarousing images). The simultaneous presentation of the stimulus and the contextual factor creates an association such that the contextual factor can prime certain attributes of the stimulus influencing preferences for choice options.

5.3 Method

Participants

One-hundred twenty six undergraduate students participated in the study (M_{age} = 22.74 years; 64 females). Students were recruited by a campus email announcement promising monetary reward for participation in a decision-making task. Eligibility criteria were defined as follows: (i) being in good health; (ii) having excellent knowledge of the experimental language; (iii) not having actual or previous episodes of psychopathology and not being under psychopharmacological treatment. Before confirming their participation in the study all participants were asked to carefully read an information sheet containing few information about the aim of the study, eligibility criteria, experimental procedure, and remuneration procedure.

Ethicality

Approval for this study was obtained by the *University Ethics Committee for Experimentation on the Human Being*. This experiment was conducted in accordance with the principles of Declaration of Helsinki.

Design

Arousal (high vs. low) was manipulated in a between-subjects design. Participants were randomly assigned to one of two experimental conditions (High arousal, n = 65; M_{age} = 22.94; 32 females; Low arousal, n = 61; M_{age} = 22.53; 32 females).

Materials

Risk taking task. Risk taking was assessed by asking participants to choose between pairs of 18 two-outcome lotteries, A and B, which shared the same EV but differed in terms of risk (see Table 1). The degree of riskiness was determined by the variance between the two monetary outcomes, so that the higher the variance the higher the risk. All lotteries offered the participant the opportunity to win or lose a monetary reward with a 50% probability. For example, lottery A offered a 50% probability to win €7 or a 50% probability to win €5 and lottery B offered a 50% probability to win €12 or a 50% probability to win €0 Among the set of risky lotteries, six included a zero gain as outcome (e.g. €12, 0.5; €0, 0.5) and twelve included a loss as outcome (e.g. €10, 0.5; €-1, 0.5). Table 1 reports the list of all stimuli used in this study. The two lotteries were displayed in two four-cell grids each with the two monetary outcomes displayed in the two upper cells and the 50% probability in the two lower cells (see figure 1). In order to avoid changing participants' affective states, no feedback was provided after a choice was made. In addition to participants' preference for lottery A or lottery B, decision time for each choice was also measured.

To ensure that participants paid attention to the task (i.e., did not choose randomly) we included 6 filler trials. The filler trials consisted of 6 choices between pairs of two-outcome lotteries that differed in probability of occurrence and expected value (see Table 1). Participants who did not prefer the dominant option in at least five out of six filler trials were excluded from the analyses.

	Riskier lottery		Safer lottery		
Decision #	Outcome A	Outcome B	Outcome A	Outcome B	Expected value (EV)
1	Winning €11	Winning €0	Winning €6	Winning €5	5.5
2	Winning €12	Winning €0	Winning €7	Winning €5	6
3	Winning €13	Winning €0	Winning €6	Winning €7	6.5
4	Winning €15	Winning €0	Winning €8	Winning €7	7.5
5	Winning €16	Winning €0	Winning €7	Winning €6	8
6	Winning €20	Winning €0	Winning €11	Winning €9	10
7	Winning €6	Losing €1	Winning €2	Winning €3	2.5
8	Winning €7	Losing €2	Winning €3	Winning €2	2.5
9	Winning €11	Losing €3	Winning €5	Winning €3	4
10	Winning €10	Losing €1	Winning €5	Winning €4	4.5
11	Winning €11	Losing €1	Winning €6	Winning €4	5
12	Winning €14	Losing €1	Winning €7	Winning €6	6.5
13	Winning €16	Losing €2	Winning €8	Winning €6	7
14	Winning €16	Losing €1	Winning €8	Winning €7	7.5
15	Winning €18	Losing €3	Winning €8	Winning €7	7.5
16	Winning €18	Losing €2	Winning €9	Winning €7	8
17	Winning €19	Losing €3	Winning €9	Winning €7	8
18	Winning €33	Losing €3	Winning €14	Winning €16	15

Table 2. Pairs of two-outcome lotteries used in the risk-taking task.

The order of presentation of the 24 trials was randomized between participants.

Affective induction. We induced affect using images chosen from the International Affective Picture System (IAPS; Lang et al., 2005) and selected according to the affective norms[1]. Ratings in valence and arousal were obtained from a normative study conducted on a large sample of six-hundred fifty-nine fellow countryman students (Balconi, Arangio, & Vanutelli, in prep.) that followed the same procedure used in the original study by Lang et al. (2005). A total of 72 images were used: among these, 48 were positive emotional-eliciting stimuli (24 high in arousal, 24 low in arousal) and 24 were neutral emotional-eliciting stimuli. Since images involving people tend to be rated as more arousing, especially pictures with erotic content, pleasant high arousal images included pictures depicting situations with people having fun or playing extreme sports as well as erotic stimuli. The latter were selected among those involving double-sex couples. These are stimuli able to elicit states of excitement and euphoria, i.e. pleasant affective reactions characterized by a high level of arousal. Pleasant low arousal images included pictures depicting landscapes, flowers, scenes from outer space, cute animals, and serene faces. These stimuli are generally expected to elicit a sense of calm and peacefulness, i.e. positive affective states usually associated with a low level of arousal. Neutral stimuli mainly included pictures depicting objects as well as geometric shapes. These stimuli are not expected to elicit a substantial change in participant's affective state. Criteria for stimuli selection were set such that their range for valence dimension was 5.5 or greater. High arousal stimuli had a range for arousal dimension of 5.5 or greater whereas low arousal stimuli had a range of 2.5 or less. Neutral images were selected among stimuli with a valence range between 4 and 5 and an arousal range between 1 and 3. Overall, high arousal stimuli had a mean of 6.42 in valence dimension and a mean of 6.17 in arousal dimension; for the low arousal stimuli the valence mean was 6.13 and the arousal mean was 1.63, while neutral stimuli had a mean valence of 5.08 and a mean arousal of 1.58. Notably, a statistical analysis conducted across rating data from Balconi et al. (in prep.) indicated a significant difference in arousal ratings, $t(46) = 27.5$, $p < .001$ and no difference in valence ratings, $t(46) = 1.2$, *ns*. between selected high arousal and low arousal stimuli.

Affective experience task. Following Lang et al. (2005), we used a computerized version of the two nine-point Self-Assessment Manikin (SAM) scales asking participants to rate their level of experienced valence and arousal while viewing each image selected for their specific experimental condition.

Post-task questionnaire. In a post-task questionnaire participants were asked to provide information about their age, gender and education level.

Procedure

The experiment was conducted at the University Experimental Economic Laboratory, in a large room with 24 carrels divided by partitions that prevent visual contact and discourage conversation with neighbors. On arrival at the lab participants drew numbers randomly to learn their assigned carrel and were asked to observe silence. All participants provided written informed consent before starting the experiment. Participants were told that they would complete two tasks: the risk-taking task and the affective experience task. All the tasks were run on PCs (operating system: *Windows 7*, Intel processor) and presented on monitors with 1920 × 1080 resolution. Experimental protocol was developed using *Borland Delphi* software package. Participants first read the instructions on the screen under the guide of the experimenter, and then the lights of the laboratory were turned off to encourage individual focus and the experiment started with a practice trial.

At the beginning of each trial a fixation cross was displayed for a random interval between 100-300 ms (see Figure 1). Next, two vertical rectangles with the label "click to show" were displayed. Participants had to click with the mouse on each rectangle for revealing the pair of two-outcome lotteries and the associated images. Each lottery of the pair was associated to an image. To induce an affective state during choice we revealed the affective manipulation (i.e. the image) and the stimuli (i.e., the lottery) in the exact same time. One image was neutral and the other was high (or low) in arousal. The association between the lottery and the arousing (unarousing) image was counterbalanced across participants, so that for each individual who saw the arousing (unarousing) image associated to the riskier lottery, another saw the arousing (unarousing) image associated to the safer lottery. The other lottery was always associated to a neutral image. The left/right presentation of the riskier and safer lottery was also randomized, so that in some trials lottery A was the safer option and in the other trials lottery B was the safer option. Each grid containing the lottery was placed inside the image, in the lower part, with a button reporting the label "Alternative A" or "Alternative B" below it. Only after revealing both lottery A (with its associated image) and lottery B (with its associated image) participants could select the lottery they preferred by clicking on the respective button.

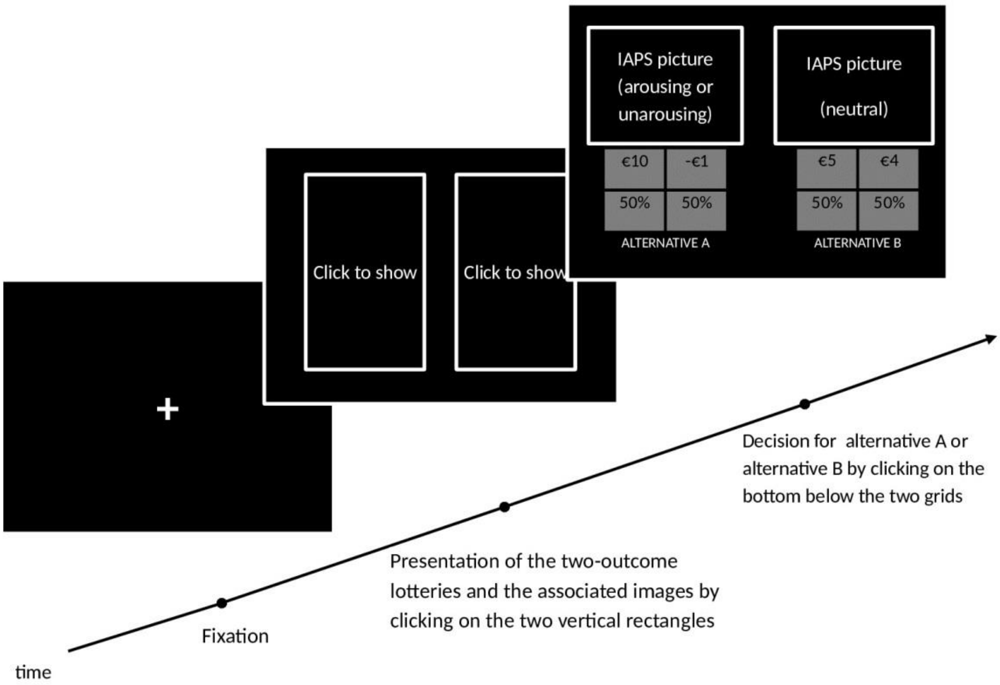

Figure 8. Time course of one trial in the risk taking task.

After completing the risk-taking task, participants were presented with the affective experience task: they saw all the previously seen pictures and asked to report their current affective state using the two SAM scales.

Participants were told initially that they already gained a €3 participation fee for taking part in the study. Furthermore, they were told and reminded throughout that one pair of gambles would be selected at random at the end of the experiment and the lottery they had chosen from that pair would be played for real money. After they had completed the task, the computer determined which of their choices would be played for real, and then played the lottery to determine the outcome of the gamble they had chosen. In case of loss, the corresponding amount was deducted from the €3 participation fee. For this reason negative payoffs did not exceeded €3 (see Table 1). At the end of the experiment, after completing the affective experience task, participants were presented with a screen reporting the trial extracted for the remuneration, the chosen option and the obtained outcome. Then they completed the post-task questionnaire. Finally they were paid in cash, debriefed and released.

5.4 Results

Choice made by participants across trials was used as dichotomous dependent variable. The safer lottery was coded as “0” and the riskier lottery as “1”. One participant was excluded for not having chosen the dominant option in at least five filler trials in the behavioral task, so that the final sample resulted in one-hundred twenty-five participants (high arousal, n = 65; 32 females; low arousal, n = 60; 31 females).

Affective experience task. Ratings of valence and arousal provided for emotional stimuli at the affective experiencing task were averaged in order to obtain an overall index of valence and arousal for each participant. The affective induction worked as expected. Self-reported levels of arousal in response to emotional stimuli were higher for participants in high arousal condition than for participants in low arousal condition $t(123) = 5.62$ $p < .0001$ $d = 1.01$ (High Arousal, M = 5.76 *SD* = 1.56; Low Arousal, M = 4.32 *SD* = 1.25). In addition, participants in high-arousal condition reported higher levels of valence in response to emotional stimuli than did participants in low-arousal condition $t(123) = 2.43$ $p = .01$ $d = 0.43$ (High Arousal, M = 6.98 *SD* = .97; low arousal, M = 6.6 *SD* = .73). Nevertheless, both groups reported a mean level of valence collocated over the neutral midpoint of the scale (5) indicating that in either group participants experienced positive affect. Female participants reported higher levels on both valence and arousal scales in response to emotional stimuli than did male participants (Valence: $t(123) = -2.61$ $p = .01$ $d = 0.47$ Males, M = 6.59 *SD* = .9; Females, M = 7 *SD* = .82; Arousal: $t(123) = -1.98$ $p < .05$ $d = 0.35$ Males, M = 4.79 *SD* = 1.42; Females, M = 5.34 *SD* = 1.7).

Arousal induction and risk taking. In order to test the influence of arousal on the probability of making a risky choice, we developed a generalized linear mixed model of logistic regression including arousal, gender, and the interaction between the two as fixed effects, and the intercept estimated for each participant as random effect, indicating the participant identification variable as a cluster, as required by the mixed models procedure. Choices made across trials were used as dependent variable specifying the safe choice as reference category. Filler trials were excluded from the analysis and only the choices made through the 18 experimental trials were analyzed.

Analyses revealed a significant main effect of arousal on predicting risky choices $F(1, 2245) = 4.47$ $p = .03$. Participants in the high-arousal condition selected the riskier option more often than did participants in the low-arousal condition (High Arousal, $M = 4.14$; $SD = 3.9$; Low Arousal, $M = 2.8$; $SD = 3.38$; see figure 2).

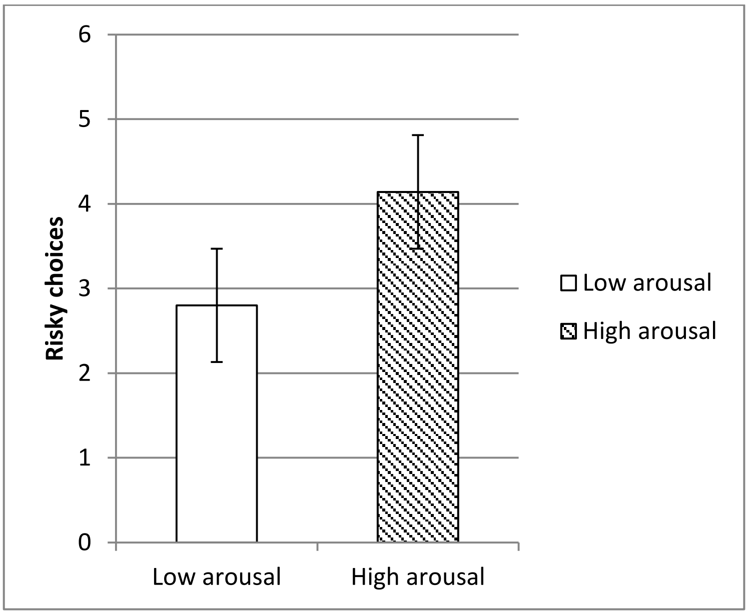

Figure 2. Number of risky choices across conditions, Low arousal and High arousal.

A main effect of gender, $F(1, 2245) = 3.7$ was also found and this result was significant at the $p = .05$ level. Males made more risky choices than females (Males, M = 4.15 $SD = 3.91$; Females, M = 2.86 $SD = 3.39$). Finally, the interaction effect between arousal and gender was not significant in predicting risky choice, $p = .38$.

Ratings provided during the affective experience task revealed that the high and the low arousal groups differed in the experienced arousal, confirming that the arousal manipulation worked. However, they also differed in valence. For this reason, we performed the regression model again introducing valence ratings as covariate. Valence ratings did not influence directly risky choice, p = 1 and the effect of arousal on risk preference was still significant $F(1, 2194) = 4.51$ p = .03.

We run additional analyses distinguishing between the only-gain lotteries (the first 6 rows of Table 1) and the mixed lotteries (from row 7 to the end of Table 1). A unique effect of arousal on risky choice was found only among those lotteries including a loss as outcome $F(1, 1121) = 5.17$ $p = .02$ (e.g. 16;-1 vs. 7;8).

An independent samples t-test also revealed that participants in the high-arousal condition took on average more time than participants in the low-arousal condition to make each choice, $t(123) = 2.46$; $p = 0.01$ $d = 0.44$, (High Arousal, $M = 10269.16$; $SD = 4071.01$; Low Arousal, $M = 8517.33$; $SD = 3841.86$). Including the decision time measure into the regression model as a covariate showed that it significantly predicted risky choice $F(1, 2242) = 19.82$ $p < .001$, and reduced the effect of the arousal factor to a marginally significant one $F(1, 2242) = 3.48$ $p = .06$ suggesting a possible mediational effect of time on the relationship between arousal and risky choice.

Summarizing, participants induced into a high-arousal positive state made more risky choices and took more time to decide than those induced into a low-arousal state.

5.5 Discussion

In this study we examined the impact of positive high-arousal on risk preferences. By adopting the technique of contextual priming (Yi, 1990), we repeatedly induced incidental affective states with high or low levels of positive arousal. We found that introducing a pleasant arousing cue as part of the decision context increases individual’s preferences for the risky option. Our results are consistent with a growing literature on arousing effects on risk propensity which finds that positive arousal and risk taking behavior are positively related (e.g. Laier et al., 2013; McAlvanah, 2009).

In this study, the two experimental groups differed in the level of experienced arousal as indicated by the self-reported indices of arousal provided in the affective experience task. However, they also differed in terms of valence: the high-arousal group reported higher positive valence than the low-arousal group. This is not an unexpected result since stimuli rated as more pleasant are rated as more arousing as well (Bradley & Lang, 2007). This is not even a troublesome result, since after controlling for valence, the effect of arousal on risky choice was still significant. Therefore, we can conclude that differences in risky choices found between the two experimental groups are not better explained by differences in valence ratings.

The effect of positive high-arousal that we have reported is somewhat similar to the effect of negative high-arousal. Previous research indeed showed that stress leads to increased risk taking behavior (e.g. Mano, 1992). Given that physiological reactions, neural activations and self-report indices are the same for both positive and negative arousal (Codispoti, Surcinelli, & Baldaro, 2008; Reich & Zautra, 2002; Stark et al., 2005), it is not surprising to find that the two have similar effects on behavior. However, it is noteworthy, since it could mean that high positive arousal might have the same negative effects on health as negative high arousal.

Why greater physiological activation does increase risk-taking? According to several views elevated arousal decreases cognitive capacity (Ariely & Loewenstein, 2006; Fedorikhin & Patrick, 2010; Laier et al., 2013; Rook & Gardner, 1993). Arousal theories correlate the arousal level of emotional stimuli to attention (Fernandes, Koji, Dixon, & Aquino, 2011); in particular, high arousing stimuli are capable of capturing attention. More importantly, it is arousal that influences the amount of attention that is voluntarily or involuntarily directed to those stimuli. Lang, Greenwald, Bradley, & Hamm (1993) demonstrated that participants look at arousing images for longer than unarousing images regardless of valence. Gronau, Cohen, and Ben-Shakhar (2003) showed that skin conductance, a feature of arousal, is correlated with the interference effect on an emotional Stroop task. Schimmack and Derryberry (2005) examined the interference effect of arousal on cognition and attention by asking participants to ignore emotional stimuli (IAPS pictures) while performing a cognitive task (study 1, solving math problems) and an attentional task (study 2, detecting the location of a line). It was found that arousal level of pictures predicted interference effect on both tasks with the most arousing pictures (with positive and negative valence) producing the strongest interference effect.

According to the cognitive depletion hypothesis, a reduced cognitive capacity is accompanied by an altered sensitivity to rewards which triggers increased risk-taking (e.g. (Ferrara et al., 2015; Killgore, Kamimori, & Balkin, 2011) (Venkatraman, Huettel, Chuah, Payne, & Chee, 2011). Positive high-arousal indeed has been linked to an increase in anticipatory affect which increases the desire for rewards (Knutson et al., 2008). Since greater risk is always associated to greater rewards, an altered sensitivity to rewards can explain why high-arousal induces people to be more risk takers.

In our study we found evidence that decision times were longer for the high-arousal group. However, when controlling for decision times the effect of arousal was reduced but still marginally significant. Therefore, we cannot conclude that the difference in the time spent for making decisions between the high arousal and low arousal groups directly mediates the relation between arousal and increased risk taking but stronger methodologies for attention allocation detection, such as some process-tracing measures (e.g. eye-tracking), might help to disentangle the attentional mechanisms that determine the impact of arousal on choice.

Furthermore, we found that the effect of positive arousal on risk-taking was specific for mixed lotteries involving a gain and a loss. A unique effect in such specific lotteries might indicate that arousal alters in particular individual indexes of loss aversion (increased sensitivity to rewards would reduce individual index of loss aversion). However, this may also be due to the difference in the number of stimuli involving a loss and those involving no loss used for this study. Future works using an identical number of stimuli may help to clarify this point. Moreover, in this experiment probability was kept constant at the 50% level. Additional studies may investigate whether the effect of positive arousal on risk-taking is sensitive to variations in probability of the outcomes.

In sum, this research represents a further evidence on the role of positive high-arousal on risk preferences for monetary options in an incentivized task We showed that both male and female participants induced in a high arousal state were more attracted by the risky option than by the safer option compared to those induced into a low-arousal state; furthermore valence was not the explanation, since reported levels of valence made no difference to the main result.

We also showed that incidental affect was able to influence decision making under risk. In particular, a pleasant and arousing cue inserted as a contextual factor of a decisional scenario was able to shift individual preferences. This evidence has practical relevance for psychological, marketing and consumer research since a lot of studies in these fields currently seek to understand the role of emotional states and mood on choices. Several real-world decisions like healthcare and retirement investments involve significant emotional tradeoffs. Yet very little is known about the mechanisms underlying the interplay between affect and cognition. We contend that further understanding of such mechanisms would provide valuable insights into the comprehension of decision making processes.

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CHAPTER 6

Paper III – Negative Arousal and Individual's Preferences for Risky Lotteries: an Eye-tracking Study

6.1 Abstract

In this study we seek to understand how incidental affective states with high or low levels of negative arousal differently influence preferences for monetary offers varying in risk. Previous evidence indicates that experiencing high-intensity negative affect increases risk taking, however little is known about the mechanisms which govern the relationship between arousal and risk. Arousal is often associated with cognitive depletion and narrowed attention. Therefore, we predicted that introducing an unpleasant arousing cue as part of the decision context will subtract attentional resources and interfere with normal decision making processes thus alter risk taking. In an eye-tracking experiment we manipulated arousal within subjects by presenting participants with pictures varying in the level of negative arousal. 22 participants were asked to choose between pairs of two-outcome monetary lotteries with same expected value but different risk. In line with attentional theory of arousal participants spent more time looking at arousing images. Behavioral results indicated that participants presented with an arousing contextual image selected more often the lottery higher in risk. Implications for future studies are discussed.

6.2 Introduction

Consider Laura, a 30-year-old advertiser that is going to present her proposal for a new spot for a very famous company. Laura worked really hard on her project and today she will show her idea in front of a large commission who will judge her work and will decide whether or not to assume her for developing her idea. Laura is restless, tense, and also frightened. She is experiencing negative emotions with an high level of activation.

Laura had her presentation very late, she is very tired and annoyed, and she is looking forward to meet her friends for hanging out with them at a party tonight. Unfortunately she got a very bad cold and she must stay at home for the night. She is completely bored, frustrated and sad. Now, she is experiencing a multitude of negative emotions with a low level of activation.

Now imagine that Laura was asked to choose between:

A: a sure win of 500.000 dollars

B: a 50% chance to win 1 million dollars and a 50% chance to win nothing.

Option A is safer while option B is riskier. What would she choose? Would her choice be the same in the two moments presented above? Before her presentation, Laura was experiencing high-intensity negative emotions. Then, when she became sick, Laura experienced low-intensity negative emotions. In both situations Laura experienced negative feelings but at different level of arousal. Experiencing a high-intensity negative affect (e.g. distress) or experiencing a low-intensity negative affect (e.g. boredom) would impact her choice differently?

High intensity affects are characterized by high levels of arousal (stress). Indeed, there is accumulating evidence documenting a positive relationship between arousal and risk taking behavior (e.g. Mano, 1994, see also Galentino et al., chapter 4 and 5 in this dissertation). A variety of studies from psychology and economics have demonstrated that experiencing high level of stress would increase preference for risk (e.g. Starcke, Wolf, Markowitsch, & Brand, 2008). However, the mechanisms which govern the effect of arousal on risk preferences remain unclear. Therefore, returning to the example above, Laura will be more tempted to choose the riskier alternative before presenting her project while she is tense, than when she is bored and sick.

In the present work we replicate and extend the effect of experimentally inducing incidental negative arousal on risky choice. Furthermore, we tested an attentional explanation for the effect. We show that introducing an arousing stimuli contextually presented in the decision scenario (contextual priming) captures individual attention thus subtracting attentional resources from the main task.

With the term incidental affect we refer to short-lived affective states with a clear trigger or cause. Differently from integral affect, which are affective reactions elicited by the act itself of making a decision, incidental affect arises independent of a decision. Therefore, it could represent an individual disposition to react to an event but it could also be elicited through situational factors (e.g. stressor events) or contextual and environmental cues (e.g. images, sounds, odors). Affective reactions elicited by such external events are normatively irrelevant to the decision at hand but nonetheless have influence on decision making process (e.g. Bonini et al., 2011).

By definition, an affective state is conceived as the immediate reaction to a stimulus or event. It represents the most primitive part of what characterize an emotion. affective state is typically described according to two main dimensions: valence and arousal (e.g. Russell, 2003). Differently form valence, which provides information about the current well-being of the organism, arousal refers to the psychological and physiological experience of energy, mobilization, activity, tension, alertness or quietness (Russell & Feldman Barrett, 1999). Arousal dimension ranges from deactivation (or calm) to activation (or stress). Furthermore, it is associated with a bodily experience since it is characterized by changes in many physiological parameters through the autonomic nervous system activity (e.g Hagemann, Waldstein, & Thayer, 2003).

Arousing reactions, along with pleasantness, provide basic information about the state of the environment and the organism and, most of the time, this information is used as a basis for guiding judgments and decisions (Loewenstein, Weber, Hsee, & Welch, 2001; Schwarz & Clore, 1983). As summarized by Storbeck & Clore (2008), arousal can be easily misattributed to other unrelated events leading people to make more polarized judgments: i.e. positive outcomes or events are evaluated more favorably while negative outcomes or events are evaluated less favorably. Given the data, it is crucial to examine the influence of affect on cognition at different levels of arousal. For example Lerner & Keltner (2001) showed that fear and anger, two negative emotions which differ in the level of arousal, have opposite effect on risk taking. In particular, fear leads to pessimistic risk-estimates and risk averse choices while anger leads to optimistic risk estimates and risk seeking choices.

A large amount of studies show that inducing negative distress increases risk-taking behavior (Johnson, Dariotis, & Wang, 2013; Mano, 1992; Pabst, Brand, & Wolf, 2013; Pighin, Bonini, Savadori, Hadjichristidis, & Schena, 2014; Pighin & Schena, 2012; Porcelli & Delgado, 2009; Reynolds et al., 2013; Starcke et al., 2008).

Starcke et al. (2008) for example, required participants to prepare a public speech (a common method for inducing distress and consequently negative arousal (Levenson et al., 1988) prior to paying the Game of Dice Task (GDT, Brand et al., 2005), a computerized game where the goal is to maximize a capital of fictitious money by choosing between alternatives that consists of different combinations of dice. Stressed participants selected the risky combination significantly more often and had a significantly lower net score than non-stressed participants. Using the same social stressor and the same task, a more recent study replicated this findings but a time dependent result was found: the risk-taking increase was observed after 18 minutes from the stressing task but not before (Pabst et al., 2013). The same stressor also increased adolescent risk-taking on the BART (Lejuez et al., 2002), a task in which participants have to pump a virtual balloon wherein more pumps are associated with increased earnings but also increased risk of balloon explosion and consequent loss of the earning s for that trial (Johnson et al., 2012; Reynolds et al., 2013). In a study using the cold press task (Ferracuti, Seri, Mattia, & Cruccu, 1994) wherein participants are asked to immerse a hand into an ice water container for one minute, a stronger reflection effect (Kahneman & Frederick, 2007; Kahneman & Tversky, 1979) was observed: increased risk-taking in the loss frame (i.e. a gamble was preferred over a sure loss of equal expected value and decreased risk-taking in the gain frame (Porcelli & Delgado, 2009). Similarly, when participants were examined in the same task in an oxygen depleted environment (physical stress), they exacerbated the reflection effect: they choose the gamble over the sure thing more often than when they were examined in a normal environment, especially in the loss frame (i.e. when the sure thing was compared with a loss of equal expected value (EV) (Pighin et al., 2012).

Taken together, this evidence suggests that experiencing an unpleasant affective state characterized by an high level of arousal may increase individual risk taking. Therefore, in line with previous studies, we expect to observe an increase in individual's preference for a riskier option when an incidental unpleasant arousing cue is inserted in the decision context.

In some studies, but not all, stress has been found to affect risk taking differently depending on gender. Male participants under the cold press task pumped more times on the BART (demonstrating greater risk taking) than non-stressed male participants; while female stressed participants were less risk-taking than female non-stressed participants on the BART (Lighthall, Mather, & Gorlick, 2009). Similarly, when male athletes were under stress (intense physical exercise) they made more pumps on the BART, than when they were not; on the contrary, female athletes made less pumps on the BART under stress (Pighin, Savadori, Bonini, Andreozzi, Savoldelli, & Schena, in press). For this reason, in our study we controlled for the interaction between arousal and gender.

Why an increase in the tone of arousal does increase risk taking? At present, no definite unique explanation has been provided. Some authors, following the dual-process approach, found that high-intensity affect leads people to adopt more automatized risk biases (Porcelli & Delgado, 2009). However, most of the studies converge toward a cognitive depletion explanation. According to this assumption, the increased risk-taking observed under stressful conditions may be the result of a decrease in cognitive capacity caused by elevated arousal (e.g. Fedorikhin & Patrick, 2010; Galentino et al., submitted; Mano, 1992; Reynolds et al., 2013). In this view, arousal acts as a distractor focusing motivation on a very narrow goal (e.g. an immediate reward). More specifically, arousal theories connect arousal to attention. For example, Anderson (2005) reports that increased arousal is associated with decreased attentional resources, enabling emotional significance to shape perceptual experience. A large amount of research suggests that in the presence of a source of elevated arousal an interference effect is produced and it has disrupting consequences on attention allocation and cognitive performance (Fernandes, Koji, Dixon, & Aquino, 2011; Gronau, Cohen, & Ben-Shakhar, 2003; P J Lang, Greenwald, Bradley, & Hamm, 1993; Sanbonmatsu & Kardes, 1988; Schimmack & Derryberry, 2005). Lang et al. (1993) showed that people look at arousing pictures for longer than unarousing pictures. In a consumer choice study, Sanbonmatsu & Kardes (1988) found that participants in an high arousal state were less accurate in evaluating advertisements compared to those in a low arousal state since they were distracted by peripheral cues. Schimmack & Derryberry (2005) demonstrated the presence of an attentional interference arising from presenting participants with arousing images (IAPS pictures). Participants were asked to ignore emotional pictures while solving math problems or detecting the location of lines. However, participants were unable to ignore emotional pictures and were subject to interference effects on both tasks; moreover, the more arousing were the pictures (unpleasant or pleasant) the greater the interference. Similarly, participants waiting to give a public speech were slower in learning the advantageous decks on the Iowa Gambling Task presumably because they were distracted by thoughts concerning the pending speech (Preston, Buchanan, Stansfield, & Bechara, 2007). Based on this evidence, we believe that introducing an arousing cue as part of the decisional context may interfere with normal decision making processes by subtracting attentional resources allocated on the choice task, thus altering the standard risk aversion tendency observed in neutral conditions.

In sum, evidence suggests that high levels of negative arousal are associated to increased risk taking but this evidence is fragmented as regards the type of arousal manipulation and the type of task used to measure risk aversion. In this study participants were asked to choose between a series of pairs of monetary gambles with same expected value but different risk. In line with previous literature on the effect of negative arousal on risk taking, we expect that the probability of making a risky choice would be higher when the monetary offers are contextually presented with an unpleasant arousing stimuli. We induced incidental negative arousal within subjects in order to have a more efficient comparison of the condition of people experiencing high arousal or low arousal on the same group of subjects. Therefore, all participants were exposed to both experimental treatments (high arousal and low arousal). Furthermore, our arousal manipulation was minimally contaminated by uncontrolled emotions, such as fear, anxiety or anger, that could have polluted previous ones. For example, asking subjects to give a public speech has often been used as a manipulation of negative arousal, however, one could complain that giving a public speech produces a cohort of emotions ranging from fear to excitement, which are both positive and negative in valence. We used IAPS images (Lang et al., 2005) to manipulate arousal and valence. This allowed us to control the level of arousal and the level of arousal induced by each image in two ways. First, by using records collected in previous studies with a similar population. Second, by asking our participants to report perceived arousal and perceived valence for each stimuli in an additional task at the end of the experiment. By adopting the technique of contextual priming (Yi, 1990), participants were simultaneously exposed to stimuli (i.e. the gambles) and a contextual factor (i.e. the affective picture). In contextual priming, the simultaneous presentation of a stimulus and a contextual cue is able to create an association which can prime specific attributes of the stimulus influencing decision making. Furthermore, we tested the interference effect hypothesis of arousal on visual attention. We used an eye-tracking to collect data on gaze direction and looking times. We gathered data on the percentage of time participants spent looking at the arousing (unarousing) picture, as well as probability information and monetary outcomes. According to arousal theories of attention (Anderson, 2005) participants should look at arousing pictures longer than unarousing pictures, and this should distract participants from the main choice. Therefore, the use of contextual priming represents a very efficient way in order to specifically test the interference effect of incidental affect on risky choice (distinguishing it from the effect of integral affect).

6.3 Method

Participants

Twenty-two undergraduate students participated in the study (M_{age} = 20.2 years; 10 females). Students were recruited by a campus email announcement promising credits for participation in an eye tracking decision-making task. Eligibility criteria were defined as follows: (i) being in good health; (ii) not having actual or previous episodes of psychopathology and not being under psychopharmacological treatment. Before confirming their participation in the study all participants were asked to carefully read an information sheet containing few information about the aim of the study, eligibility criteria, experimental procedure, and remuneration procedure.

Ethicality

Approval for this study was obtained by the *Office for Human Subjects Protection* of *Temple University*. This experiment was conducted in accordance with principles of Declaration of Helsinki.

Design

Negative arousal (high/low) was manipulated in a within-subjects design. All participants were exposed to both High arousal and Low arousal treatment.

Materials

Risk taking task. Risk taking was assessed by asking participants to choose between pairs of 48 two-outcome lotteries, G1 and G2. The degree of riskiness was determined by the variance between the two monetary outcomes, so that the higher the variance the higher the risk. All lotteries offered the participant the opportunity to win or lose a monetary reward. Three categories of stimuli were included: (i) stimuli with same level of probability; (ii) stimuli with large spread of probability; (iii) stimuli with low spread of probability; plus some fillers (see table 1, table 2 and table 3). 18 stimuli included pairs of lotteries which shared the same expected value (EV) and same probability (50% level). For example, gamble 1 offered a 50% probability to win $7 or a 50% probability to win $5 and gamble 2 offered a 50% probability to win $12 or a 50% probability to win \$0. Among the set of risky lotteries, six included a zero gain as outcome (e.g. \$12, 0.5; \$0, 0.5) and twelve included a loss as outcome (e.g. \$10, 0.5; \$-1, 0.5). 18 stimuli included pairs of lotteries which shared the same EV, but different probability. For example, gamble 1 offered a 60% probability to win \$11 or a 40% probability to win \$12 and gamble 2 offered a 60% probability to lose \$21 or a 40% to win \$60. Among these, 9 included stimuli with large spread of probability (i.e. 75% level of probability and 25% level of probability) and 9 included stimuli with small spread of probability (i.e. 60% level of probability and 40% probability). Table 1 reports the list of stimuli used in this study. The two lotteries were displayed in a nine-cell grid. Each cell was used as area of interest for eye tracking recording (see figure 1). The first raw included an empty cell and the two probability values. In the second raw there were displayed the label "G1" and the two monetary outcomes for G1. In the third raw there were displayed the label "G2" and the two monetary outcomes for G2.

(Empty)	0,6	0,4
G1	-5	28
G2	5	13

Figure 1. Nine-cell grids containing stimuli used for the risk taking task. Each cell represents an area of interest for eye tracking data.

In order to avoid changing participants' affective state, no feedback was provided after a choice was made. To ensure that participants paid attention to the task (i.e., did not choose randomly) we included 12 filler trials. The filler trials consisted of 12 choices between pairs of two-outcome lotteries that differed in their expected value. Participants who did not prefer the dominant option in at least five out of twelve filler trials were excluded from the analyses. In total, participants were presented with 48 stimuli (see table 1, table 2 and table 3).

	Riskier lottery		Safer lottery		
Decision #	Outcome A (50%)	Outcome B (50%)	Outcome A (50%)	Outcome B (50%)	Expected value (EV)
1	Winning $11	Winning $0	Winning $6	Winning $5	5.5
2	Winning $12	Winning $0	Winning $7	Winning $5	6
3	Winning $13	Winning $0	Winning $6	Winning $7	6.5
4	Winning $15	Winning $0	Winning $8	Winning $7	7.5
5	Winning $16	Winning $0	Winning $7	Winning $6	8
6	Winning $20	Winning $0	Winning $11	Winning $9	10
7	Winning $6	Losing $1	Winning $2	Winning $3	2.5
8	Winning $7	Losing $2	Winning $3	Winning $2	2.5
9	Winning $11	Losing $3	Winning $5	Winning $3	4
10	Winning $10	Losing $1	Winning $5	Winning $4	4.5
11	Winning $11	Losing $1	Winning $6	Winning $4	5
12	Winning $14	Losing $1	Winning $7	Winning $6	6.5
13	Winning $16	Losing $2	Winning $8	Winning $6	7
14	Winning $16	Losing $1	Winning $8	Winning $7	7.5
15	Winning $18	Losing $3	Winning $8	Winning $7	7.5
16	Winning $18	Losing $2	Winning $9	Winning $7	8
17	Winning $19	Losing $3	Winning $9	Winning $7	8
18	Winning $33	Losing $3	Winning $14	Winning $16	15

Table 3. Pairs of two-outcomes lotteries with same probability used in the risk taking task.

	Riskier lottery		Safer lottery		
Decision #	Outcome A (75%)	Outcome B (25%)	Outcome A (75%)	Outcome B (25%)	Expected value (EV)
1	Losing $20	Winning $94	Winning $7	Winning $13	8.5
2	Losing $4	Winning $54	Winning $13	Winning $3	10.5
3	Losing $15	Winning $85	Winning $11	Winning $7	10
4	Losing $7	Winning $43	Winning $2	Winning $16	5.5
5	Losing $13	Winning $65	Winning $5	Winning $11	6.5
6	Losing $10	Winning $70	Winning $9	Winning $13	10
7	Losing $22	Winning $89	Winning $13	Losing $16	5.75
8	Losing $20	Winning $78	Winning $7	Losing $3	4.5
9	Losing $15	Winning $81	Winning $16	Losing $12	9

Table 4. Pairs of two-outcomes lotteries with large spread of probability used in the risk taking task.

	Riskier lottery		Safer lottery		
Decision #	Outcome A (60%)	Outcome B (40%)	Outcome A (60%)	Outcome B (40%)	Expected value (EV)
1	Losing $21	Winning $60	Winning $11	Winning $12	11.4
2	Losing $12	Winning $47	Winning $8	Winning $17	11.6
3	Losing $13	Winning $29	Winning $3	Winning $5	3.8
4	Losing $23	Winning $57	Winning $11	Winning $6	9
5	Losing $5	Winning $28	Winning $5	Winning $13	8.2
6	Losing $9	Winning $32	Winning $7	Winning $8	7.4
7	Losing $28	Winning $72	Winning $32	Losing $18	12
8	Losing $44	Winning $81	Winning $26	Losing $24	6
9	Losing $16	Winning $50	Winning $24	Losing $10	9

Table 5. Pairs of two-outcomes lotteries with small spread of probability used in the risk taking task.

The order of presentation of the 48 trials was randomized between participants.

Affective induction. We induced affect using images chosen from the International Affective Picture System (IAPS; Lang et al., 2005) and selected according to the affective norms[5]. A total of 48 images were used for this experiment: among these, 24 were unpleasant emotional-eliciting stimuli high in arousal and 24 were unpleasant emotional-eliciting stimuli low in arousal. High arousal stimuli included images depicting scenes of mutilation, death, bloody pictures or surgeries. These are stimuli able to induce states of negative tension such as fear, disgust or terror, i.e. unpleasant affective reactions characterized by a high level of arousal. Low arousal stimuli included images depicting scenes of poverty, environmental pollution, cemeteries, children or adults crying. These stimuli can induce states of sadness, boredom or depression, i.e. unpleasant affective reactions characterized by a low level of arousal. Criteria for stimuli selection were set such that their range for valence dimension was 4.5 or less. High arousal stimuli had a range for arousal dimension of 5.5 or greater whereas low arousal stimuli had a range of 2.5 or less. Overall, high arousal stimuli had a mean of 1.33 in valence dimension and a mean of 7.5 in arousal dimension;

[5] List of IAPS pictures used in the study. *High arousal*: 3000; 3010; 3015; 3016; 3022; 3030; 3051; 3053; 3060; 3061; 3062; 3063; 3064; 3068; 3069; 3080; 3101; 3170; 3261; 3266; 6260; 6550; 9410; 9570. *Low arousal*: 2205; 2276; 2399; 2590; 2752; 2800; 2840; 3300; 5534; 7006; 7031; 7060; 9000; 9001; 9008; 9041; 9110; 9190; 9210; 9280; 9290; 9330; 9360; 9561.

for the law arousal stimuli the valence mean was 3.44 and the arousal mean was 2.61. Notably, a statistical analysis indicated a significant difference in arousal ratings, t (46) = 11.69 p < .001. However, also a difference in valence ratings has been registered, t (46) = 7.48 p < .001. Even though all the selected stimuli have a valence rating far below the neutral point (5) so that they must be considered unpleasant, it is reasonable to observe that arousing stimuli have been rated as more unpleasant than unarousing stimuli. Since stimuli selected for the affective manipulation differed significantly also along valence dimension, we tested the effect of arousal on risky choice controlling for differences in participants' levels of experienced valence.

Affective experience task. Following Lang et al. (2005), we used a computerized version of the two nine-point Self-Assessment Manikin (SAM) scales asking participants to rate their level of experienced valence and arousal while viewing each image selected for their specific experimental condition.

Post-task questionnaire. In a post-task questionnaire participants were asked to provide information about their age, gender and education level.

Procedure

The experiment was conducted in a quiet room at Center for Neural Decision Making of Temple University. On arrival all participants provided written informed consent before starting the experiment. Participants were told that they would complete two tasks: the risk-taking task and the affective experience task. A Tobii 1750 eye-tracker was used to collect data on gaze direction and looking times. The eye-tracker was integrated into a 17-in monitor. All the tasks were run on a PC (operating system: *Windows 7*®) connected to this monitor. Experimental protocol was developed using *E-prime*® software package. Each participant sat 50 cm from the monitor. Participants first read the instructions on the screen under the guide of the experimenter and then the experiment started with a five-point calibration procedure in which a red dot with a black fixation point in the middle appeared repeatedly on five different locations of the screen. Participants were instructed to look at the dot and their looks were used to calibrate the eye-tracker. The presentation was repeated until the calibration was considered successful (for further technical details about the calibration procedure see von Hofsten, Dahlström, & Fredriksson, 2005). To reduce errors due to differences in pupil size and to encourage individual focus on the task, the lights of the room were turned off. Then, the risk-taking task started with a practice trial.

At the beginning of each trial a fixation cross was displayed for a random interval between 100-300 ms. Next, the grid containing the pair of two-outcome lotteries and the associated image were displayed. To induce an affective state during choice we revealed the affective manipulation (i.e. the image) and the stimuli (i.e. the lotteries) in the exact time. The presentation of the riskier and safer lottery was randomized, so that in some trials G1 was the safer option and in the other trials G2 was the safer option. Images were presented in 6 blocks (2 high arousal blocks; 2 low arousal blocks; 2 mixed blocks). Each block was made of 8 trials. Mixed blocks included 4 high arousal trials and 4 low arousal trials. Block presentation and images presentation were randomized. After revealing the two lotteries (G1 and G2) with the associated image, participants could select the lottery they preferred by pressing the corresponding button on the keyboard. After completing the risk-taking task, participants were presented with the affective experience task: they saw all the previously seen pictures and asked to report their current affective state using the two SAM scales. At the end of the experiment, after completing the affective experience task, participants completed the post-task questionnaire. Finally they were debriefed and released.

6.4 Results

Choice made by participants across trials was used as dichotomous dependent variable. The safer lottery was coded as “0” and the riskier lottery as “1”.

Affective experience task. Ratings of valence and arousal provided for emotional stimuli at the affective experiencing task were averaged in order to obtain for each participant two overall indices of valence, one for arousing stimuli and one for unarousing stimuli, and two overall indices of arousal, one for arousing stimuli and one of unarousing stimuli. The affective induction worked as expected. Self-reported levels of arousal in response to arousing stimuli were higher than unarousing stimuli $t(20) = 9.1$ $p < .001$ (High arousal, M = 6.15 SD = 2; Low arousal, M = 2.45 SD = 1.27). In addition, self-reported levels of valence in response to arousing stimuli were lower than unarousing stimuli $t(20) = -15.31$ $p < .001$ (High arousal, M = 1.89 SD = .67; Low arousal, M = 3.9 SD = .68). Nevertheless for both, arousing and unarousing stimuli, participants reported a mean score of valence collocated below the neutral midpoint of the scale (5) indicating that in each trial participants experienced negative affect. Female participants reported lower levels of valence in response to both arousing stimuli $t(20) = -3.9$ $p < .001$ (Males, M = 2.28 SD = .65; Females, M = 1.43 SD = .33) and unarousing stimuli $t(20) = -2.9$ $p < .001$ (Males, M = 4.24 SD = .48; Females, M = 3.5 SD = .67). No gender differences emerged in levels of experienced arousal, all $p > .05$.

Arousal induction and risk taking. In order to test the influence of arousal on probability of making a risky choice, we developed the following generalized linear mixed model of logistic regression

$$\ln\left(\frac{p}{1-p}\right) = \bar{a} + a_j + \overline{b_1} + \overline{b_2} + \overline{b_3}$$

including arousal (b_1), gender (b_2) and the interaction between the two (b_3) as fixed effects, and the intercept estimated for each participant (a_j) as random effect, specifying the participants identification variable as a cluster, as required by the mixed models procedure. Choices made across trials were used as dependent variable specifying the safe choice as reference category. Analysis revealed a significant main effect of arousal on predicting risky choices $F(1, 788) = 4.32$ $p < .05$. In particular, the 35.5% of risky choices made by participants during the task was made in an high arousal trial (i.e. when an arousing stimuli was associated to the gambles) while the 23.9% was made in a low arousal trial (i.e. when an unarousing stimuli was associated to the gambles; see figure 2). Neither gender effect nor interaction between arousal and gender was found.

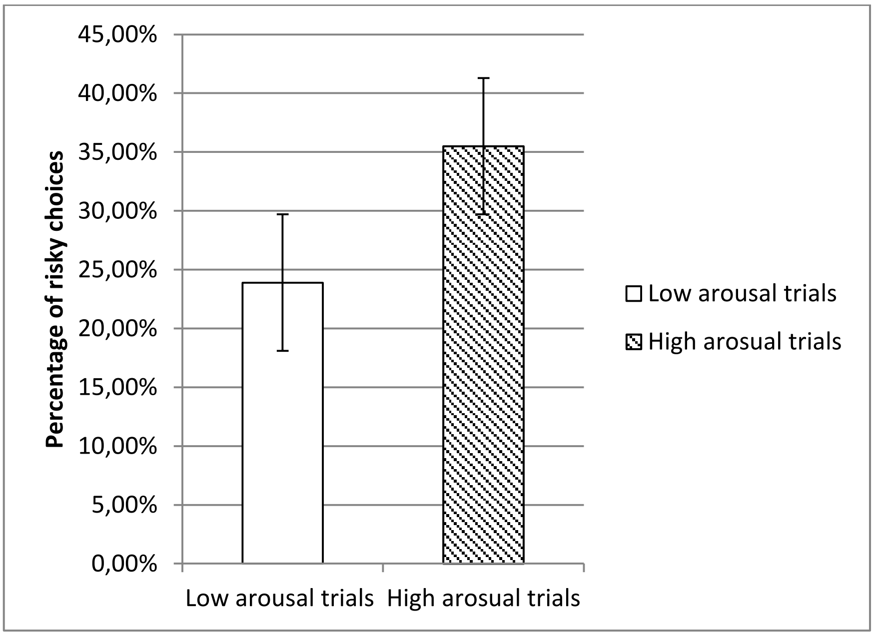

Figure 2. Percentage of risky choices made across trials.

Ratings provided during the affective experience task revealed that self-reported levels of arousal were higher for arousing stimuli. However, participants reported also lower levels of valence in response to arousing stimuli. For this reason, we performed the regression model again introducing valence ratings as covariate. Valence ratings did not influence directly risky choice, p = .81 while the effect of arousal on risk preference was one-tailed significant $F(1, 715) = 2.78$ $p = .09$.

We run additional analysis distinguishing between the three domains of stimuli used in this study (i.e. stimuli with 50% level of probability, stimuli with large spread of probability and stimuli with small spread of probability). No unique effect on a specific category of stimuli was found, all $p > .05$.

Looking times. We used eye tracking data collected during the risk-taking task in order to assess the influence of arousal on participants' attention allocation. We performed a linear mixed model including arousal and gender as fixed effects and the intercept estimated for each participant as random effect, specifying the participants identification variable as a cluster, as required by the mixed models procedure. The percentage of time spent looking at each area of interest was used as dependent variable (i.e. the arousing/unarousing image and the cells constituting the grid displayed in figure 1 providing information about probability level and monetary values for both safer and riskier lotteries). Analysis revealed that arousal was a significant predictor of the percentage of time spent fixating the arousing (unarousing) picture $F(1, 653) = 24.67$ $p < .001$. In particular, participants looked at arousing stimuli longer than unarousing stimuli (High arousal, M = .28 SD = .027; Low Arousal, M = .21 SD = .027). No other differences in other areas of interest emerged, all $p > .05$ (see table 4).

	High arousal trials	Low arousal trials
Image	.28*	.21*
Probability 1	.09	.11
Probability 2	.76	.78
Riskier 1	.15	.17
Riskier 2	.12	.12
Safer 1	.15	.15
Safer 2	.12	.13

Table 6. Percentage of time spent looking at each area of interest across trials in the risk taking task.

Summarizing, participants made more risky choices during high arousal trials (i.e. when an unpleasant arousing stimuli was presented), compared to low arousal trials (i.e. when an unpleasant unarousing stimuli was presented). Moreover, in the high arousal trials participants spent more time looking at the image compared to low arousal trials.

6.5 Discussion

In this study we investigated the effect of incidental negative arousal on preferences for monetary risk. In a within-subjects experiment, we experimentally manipulated participants' affective state in order to induce high-intensity and low-intensity negative affect. By adopting the technique of contextual priming (Yi, 1990) we introduced an unpleasant arousing or unarousing cues (IAPS pictures) as part of a decision scenario and we asked participants to make choices between couples of gambles with same expected value but different risk (as determined by the variance between the two monetary payoffs). We found that the probability of making a risky choice was higher when an arousing visual stimuli was contextually presented with the pair of gambles. This result is in line with previous evidence showing a positive relationship between distress and risk taking (e.g Mano, 1992; Porcelli & Delgado, 2009; Starcke et al., 2008). We also showed that this effect is not due to variations in probability since no unique effect among lotteries with same level of probability, large spread of probability or low spread of probability was found. In this study, participants experienced higher levels of arousal during high arousal trials as indicated by the self-reported indices provided during the affective experience task. However, in the high arousal trials they also reported lower levels of valence which means that they experienced a more unpleasant affective state when an arousing cue was presented. This data is not surprising since stimuli rated as more unpleasant are rated as more arousing as well (Bradeley & Lang, 2007). Furthermore, after inserting valence ratings as covariate we found that they do not predict risky choice as arousal does. Therefore, we can conclude that differences in risky choices are not better explained by differences in levels of affective valence experienced across trials.

At present, it has not been provided a valid explanation for why arousal should increase risk taking behavior. Some evidence seem to converge toward a cognitive explanation hypothesis: affective state characterized by high levels of intensity decrease cognitive capacity (on this point see Kaufman, 1999). It is well documented that arousing stimuli are capable of capturing attention and narrow attentional focus since they are evaluated as the most salient object in the context (e.g. Heuer & Reisberg, 1990; Loftus, 1979). Moreover, it has been shown that elevated arousal is often accompanied with decreased attentional resources (Anderson, 2005), hence it may interfere with the execution of a main task (Gronau et al., 2003; Schimmack & Derryberry, 2005). In our study we tested the influence of arousal on visual attention. Eye tracking data gathered during the risk-taking task revealed that participants looked at negative arousing pictures longer than negative unarousing pictures. A similar result was obtained by Lang et al. (1993) which demonstrated that participants presented with IAPS pictures spend more time looking at arousing images regardless of their valence. Given this data we may argue that including an arousing cue as part of the decision context captured participants' attention. This might interfere with the normal decision making process (i.e. the tendency to prefer a surer option over a riskier option). However, additional studies are needed in order to demonstrate the interference effect of attention on information processing of risk. Such effect may be associated to an enhanced sensitivity to rewards or to an overestimation of probabilities caused by elevated arousal. However, eye tracking data does not permit to address this question since no unique effect of arousal on rewards or probabilities have been found.

In summary, in this study we showed that incidental negative arousal influenced decision making under risk. In particular including an unpleasant arousing cue as part of the decision context increases the probability of making a risky choice. The robustness of such effect has been proved by manipulating arousal as a within subject variable. The effect does not seem to be influenced by variations in probability. Furthermore, we demonstrated that in line with attentional theories of arousal contextual arousing cues influence individual attention, however the link between decreased attentional resources caused by elevated arousal and increased risk taking remain still undetected. In the next paper, we will try to replicate and extend such effect to the domain of positive arousal.

6.6 References

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CHAPTER 7

Paper IV – Positive Arousal and Individual's Preferences for Risky Lotteries: an Eye-tracking Study

7.1 Abstract

In this study we examined the effect of incidental positive arousal, elicited through the exposure to contextual cues (IAPS pictures), on preferences for monetary risk. In chapter 6 of this dissertation we found that a negative arousing contextual cue increases individual preference for monetary risk and influence attention allocation. In the study presented in this chapter we seek to replicate and extend such evidence also to positive arousal. Previous research suggests a positive relationship between positive arousal and risk taking, however the mechanism underlying such relationship is still unclear. Combining evidence from studies on arousal and risk taking and arousal and attention, we tested the influence of arousal on visual attention suggesting a possible link between diminished attentional resources registered under conditions of elevated arousal and preference for risk. In a within-subjects experiment we repeatedly induced high and low levels of positive arousal and asked participants to make choices between pairs of two-outcomes gambles with same expected value but varying in risk and probability. We found that arousing stimuli capture attention and influence the processing of risk information (measured as time spent looking at the monetary values constituting the riskier gamble). Implications for future research are discussed.

7.2 Introduction

Consider Hans, a 33-year-old accountant in New York. He prepares herself for work, as any other day, except that, today is special. The woman he has been pining for all his life has invited him to dinner this evening. He is euphoric, excited, tense, and filled with joy. Today will seem very long to Hans. He is experiencing a multitude of exciting, positive emotions.

Now imagine that Hans is on vacation. He is “in heaven”. He is on his third day of vacation with his new girlfriend in the most relaxing spa he has ever experienced. He is completely relaxed and at peace. He thinks that nothing in the world could upset his mood in that moment. He is experiencing a multitude of positive, soothing emotions.

Now imagine that Hans was asked to choose between:

A: a sure win of 500.000 dollars

B: a 50% chance to win 1 million dollars and a 50% chance to win nothing.

Option A is safer while option B is riskier. What would he choose? Would his choice be the same in the two moments presented above? In both moments Hans is experiencing positive emotions, but at different levels of arousal, that is, the intensity with which the emotional reaction is actually experienced. In the first situation Hans is experiencing high arousal while in the second one he is experiencing low arousal. Experiencing an high-intensity positive affect (e.g. excitement) or a low-intensity positive affect (e.g. calm) would impact his choice differently?

There is accumulating evidence documenting a positive relationship between arousal and risk taking (e.g. Ariely & Loewenstein, 2006; Mano, 1994; Porcelli & Delgado, 2009). However previous studies mostly focused on the role of negative arousal (e.g. distress) while positive arousal has been examined less often. Nonetheless, many researchers seem to converge on the idea that experiencing high levels of positive arousal may increase risk taking behavior as well. Therefore, returning to the example presented above, Hans will be likely to choose the riskier alternative before his romantic dinner when he is excited and exuberant, than when he is calm and relaxed.

In this study we examine the effect of inducing high and low levels of incidental positive arousal (i.e. pleasant arousing/unarousing reactions unrelated to the decision at hand) on preferences for monetary risk. Previous research showed that experiencing high levels of positive arousal is associated to a risk prone behaviors (Ariely & Loewenstein, 2006; Fedorikhin & Patrick, 2010;

Galentino et al., submitted; Hirsch, 1995; Knutson, Wimmer, Kuhnen, & Winkielman, 2008; Laier, Pawlikowski, & Brand, 2013; Macht, Roth, & Ellgring, 2002; McAlvanah, 2009; Rook & Gardner, 1993; Rhodes & Pivik, 2011). For example, it has been proved that a positive mood which is associated to an elevated tone of arousal, is related to impulsive buying (Rook & Gardner, 1993). On the same vein, Macht et al. (2002) found that joy, which is often accompanied by arousing reactions, increases chocolate consumption. Fedorikhin & Patrick (2010), in a consumer choice study, provided experimental evidence that positive arousal is associated with cognitive depletion and results in a decreased resistance to temptation. More relevant for risk taking behavior, Ariely & Loewenstein (2006) studied the role of sexual arousal (i.e. a specific form of positive arousal) on sexual decision making. After inducing sexual arousal (through self-stimulation), authors required participants to express judgments and hypothetical decisions on the attractiveness of different sexual stimuli; on the willingness to take various morally dubious measures to procure sex; and willingness to engage in risky sexual activities. Authors reported that, compared to the condition in which the same participants answered the questions in a neutral unaroused state, sexual arousal acted as a strong amplifier of sorts, narrowing focus of motivation and increasing impulse to procure sex. Similarly, Laier et al. (2013) demonstrated that male participants performing a modified version of Iowa Gambling Task (IGT; Bechara, Damasio, & Damasio, 2000) exhibited a worse performance when sexual pictures were associated with disadvantageous decks. Authors explained that sexual arousal due to the sexual pictures distracted participants from task requirements interfering with feedback learning. Similarly, McAlvanah (2009) asked participants to evaluate a series of hypothetical gambles before and after viewing opposite sex faces pictures. The control group viewed pictures depicting cars. Both males and females exhibited an increased risk tolerance after viewing opposite sex-faces, while participants in the control group did not show a substantial change. This effect has been attributed to the activation of either a mating mindset or to the presence of others i.e.,(the person in the picture) that may trigger increases in both competitiveness and risk taking. In our view, exposure to opposite sex-faces might be considered a positive arousal activation. Neuroscientific evidence suggests that the exposure to highly arousing stimuli (e.g. erotic images) activates the same reward system associated to monetary rewards (Stark et al., 2005). Such reward system lies along the dopaminergic mesolimbic pathway in the brain and its activity has been found to correlate with self-reported levels of positive affect (Knutson, Adams, Fong, & Hommer, 2001a; Knutson, Fong, Adams, Varner, & Hommer, 2001b). Positive arousal, indeed, was also found to have impact on the sensibility for monetary rewards (e.g. Van den Bergh & Dewitte, 2006). More important to us, Knutson et al. (2008) showed that presenting participants with pleasant incidental cues (erotic pictures) increased risk taking behavior and that this effect was partially mediated by nucleus accumbens activation. Similarly, Galentino et al. (submitted) showed that subjects positively aroused through IAPS images with different activators of positive arousal were more risk taking in real monetary gambles.

Taken together. This evidence suggests that when an emotional state is accompanied by increased arousal it may lead to risk prone behavior. Therefore, we expect to observe an increased preference for risk when participants are induced into a high positive arousal compared to when the same participants are induced into a low positive arousal state. In this study we manipulated positive arousal by presenting participants with affective eliciting cues (IAPS pictures) varying in the level of positive arousal and asked them to make choices between pairs of gambles with the same expected value . As it has been done for the other studies described throughout this dissertation, we adopted the technique of contextual priming (Yi, 1990) which requires that a stimuli (the gambles) is associated to a contextual factor. The simultaneous presentation of the stimulus and the contextual factor creates an association such that the contextual factor can prime certain attributes of the stimuli influencing preferences for choice option (see Mandel & Johnson, 2002). For this reason, in a within-subjects experiment, we induced arousal repeatedly in each trial of choice by presenting the arousing (unarousing) image as contextual factor of the decision making scenario.

The reason for why an increase in the tone of arousal should increase risk taking behavior is still not clear. Some authors have found that arousal increases sensitivity to rewards and immediate gratification (Ariely & Loewenstein, 2006). Others, by adopting the dual-process approach, argue that experiencing high-intensity affective states may lead people to adopt more automatized risk biases (Porcelli & Delgado, 2009). Nevertheless, there is a wide convergence on the fact that an elevated tone of arousal is associated with cognitive depletion (i.e. few cognitive resources) which results in heuristic or superficial processing (e.g. Fedorikhin & Patrick, 2010). As suggested by Yerkes and Dodson (1908), cognitive performance is related to arousal through an inverted U-shaped relationship: according to this view, an optimal human performance requires a moderate level of arousal, while too little or too much emotional intensity may result in a cognitive breakdown and then impaired performance. Related to this assumption, Anderson (2005) reported that increased arousal is associated with decreased attentional resources, thus enabling emotional significance to shape perceptual experience. This statement has been empirically investigated showing that arousal produces an interference effect which has consequences on attention allocation and cognitive performance (Fernandes, Koji, Dixon, & Aquino, 2011; Gronau, Cohen, & Ben-Shakhar, 2003; Lang, Greenwald, Bradley, & Hamm, 1993; Schimmack & Derryberry, 2005). For example, Lang et al. (1993) showed that participants look at arousing pictures longer than unarousing pictures (regardless of valence), indicating that arousing stimuli influence attention allocation. In a study by Schimmack and Derryberry (2005) participants were asked to ignore arousing stimuli (IAPS pictures) while solving math problems or detecting the location of lines. It was found that participants were unable to ignore emotional pictures. Furthermore, the more arousing were the pictures, the greater was the interference effect on both cognitive tasks. Taken together this evidence indicate that arousal may capture attention interfering with the execution of the task at hand. Therefore, we predicted that when participants are presented with pleasant arousing stimuli their attention would be captured by the emotional picture leaving few attentional resources to be allocated to the processing of risky information. In order to achieve this goal, we used an eye tracker for gathering data on participants' gaze direction and looking times while they were exposed to arousing (unarousing) pictures and asked to make their own choices.

7.3 Method

Participants

Twenty-four undergraduate students participated in the study (M_{age} = 20.14 years; 11 females). Students were recruited by a campus email announcement promising credits for participation in an eye tracking decision-making task. Eligibility criteria were defined as follows: (i) being in good health; (ii) not having actual or previous episodes of psychopathology and not being under psychopharmacological treatment. Before confirming their participation in the study all participants were asked to carefully read an information sheet containing few information about the aim of the study, eligibility criteria, experimental procedure, and remuneration procedure.

Ethicality

Approval for this study was obtained by the *Office for Human Subjects Protection* of *Temple University*. This experiment was conducted in accordance with principles of Declaration of Helsinki.

Design

Positive arousal (high/low) was manipulated in a within-subjects design. All participants were exposed to both High arousal and Low arousal treatment.

Materials

Risk taking task. Risk taking was assessed by asking participants to choose between pairs of 48 two-outcome lotteries, G1 and G2.. The degree of riskiness was determined by the variance between the two monetary outcomes, so that the higher the variance the higher the risk. All lotteries offered the participant the opportunity to win or lose a monetary reward. Three categories of stimuli were included: (i) stimuli with same level of probability; (ii) stimuli with large spread of probability; (iii) stimuli with low spread of probability; plus some fillers (see table 1, table 2, table 3). Eighteen stimuli included pairs of lotteries which shared the same expected value (EV) and same probability (50% level). For example, gamble 1 offered a 50% probability to win $7 or a 50% probability to win $5 and gamble 2 offered a 50% probability to win $12 or a 50% probability to win $0. Among this set of 18 equal EV lotteries, 6 included a gamble with a zero gain as outcome (e.g. $12, 0.5; $0, 0.5) and 12 included a gamble with a loss as outcome (e.g. $10, 0.5; $-1, 0.5). Eighteen stimuli included pairs of lotteries which shared the same EV, but different probability. For example, gamble 1 offered a 60% probability to win $11 or a 40% probability to win $12 and gamble 2 offered a 60% probability to lose $21 or a 40% to win $60. Among these, 9 included gambles with large spread of probability (i.e. 75% level of probability and 25% level of probability) and 9 included gambles with small spread of probability (i.e. 60% level of probability and 40% probability). The two lotteries were displayed in a nine-cell grid. Each cell was used as area of interest for eye tracking recording (see figure …). The first row included an empty cell and the two probability values. In the second row it was displayed the label "G1" and the two monetary outcomes for G1. In the third raw it was displayed the label "G2" and the two monetary outcomes for G2.

(Empty)	0,6	0,4
G1	-5	28
G2	5	13

Figure 9. Nine-cell grids containing stimuli used for the risk taking task. Each cell represents an area of interest for eye tracking data.

In order to avoid changing participants' affective state, no feedback was provided after a choice was made. To ensure that participants paid attention to the task (i.e., did not choose randomly) we included 12 filler trials. The filler trials consisted of 12 choices between pairs of two-outcome lotteries that differed in their expected value. Participants who did not prefer the dominant option in at least five out of twelve filler trials were excluded from the analyses. In total, participants were presented with 48 stimuli.

	Riskier lottery		Safer lottery		
Decision #	Outcome A (50%)	Outcome B (50%)	Outcome A (50%)	Outcome B (50%)	Expected value (EV)
1	Winning $11	Winning $0	Winning $6	Winning $5	5.5
2	Winning $12	Winning $0	Winning $7	Winning $5	6
3	Winning $13	Winning $0	Winning $6	Winning $7	6.5
4	Winning $15	Winning $0	Winning $8	Winning $7	7.5
5	Winning $16	Winning $0	Winning $7	Winning $6	8
6	Winning $20	Winning $0	Winning $11	Winning $9	10
7	Winning $6	Losing $1	Winning $2	Winning $3	2.5
8	Winning $7	Losing $2	Winning $3	Winning $2	2.5
9	Winning $11	Losing $3	Winning $5	Winning $3	4
10	Winning $10	Losing $1	Winning $5	Winning $4	4.5
11	Winning $11	Losing $1	Winning $6	Winning $4	5
12	Winning $14	Losing $1	Winning $7	Winning $6	6.5
13	Winning $16	Losing $2	Winning $8	Winning $6	7
14	Winning $16	Losing $1	Winning $8	Winning $7	7.5
15	Winning $18	Losing $3	Winning $8	Winning $7	7.5
16	Winning $18	Losing $2	Winning $9	Winning $7	8
17	Winning $19	Losing $3	Winning $9	Winning $7	8
18	Winning $33	Losing $3	Winning $14	Winning $16	15

Table 7. Pairs of two-outcomes lotteries with same probability used in the risk taking task.

	Riskier lottery		Safer lottery		
Decision #	Outcome A (75%)	Outcome B (25%)	Outcome A (75%)	Outcome B (25%)	Expected value (EV)
1	Losing $20	Winning $94	Winning $7	Winning $13	8.5
2	Losing $4	Winning $54	Winning $13	Winning $3	10.5
3	Losing $15	Winning $85	Winning $11	Winning $7	10
4	Losing $7	Winning $43	Winning $2	Winning $16	5.5
5	Losing $13	Winning $65	Winning $5	Winning $11	6.5
6	Losing $10	Winning $70	Winning $9	Winning $13	10
7	Losing $22	Winning $89	Winning $13	Losing $16	5.75
8	Losing $20	Winning $78	Winning $7	Losing $3	4.5
9	Losing $15	Winning $81	Winning $16	Losing $12	9

Table 8. Pairs of two-outcomes lotteries with large spread of probability used in the risk taking task.

	Riskier lottery		Safer lottery		
Decision #	Outcome A (60%)	Outcome B (40%)	Outcome A (60%)	Outcome B (40%)	Expected value (EV)
1	Losing $21	Winning $60	Winning $11	Winning $12	11.4
2	Losing $12	Winning $47	Winning $8	Winning $17	11.6
3	Losing $13	Winning $29	Winning $3	Winning $5	3.8
4	Losing $23	Winning $57	Winning $11	Winning $6	9
5	Losing $5	Winning $28	Winning $5	Winning $13	8.2
6	Losing $9	Winning $32	Winning $7	Winning $8	7.4
7	Losing $28	Winning $72	Winning $32	Losing $18	12
8	Losing $44	Winning $81	Winning $26	Losing $24	6
9	Losing $16	Winning $50	Winning $24	Losing $10	9

Table 9. Pairs of two-outcomes lotteries with small spread of probability used in the risk taking task.

The order of presentation of the 48 trials was randomized between participants.

Affective induction. We induced affect using images chosen from the International Affective Picture System (IAPS; Lang et al., 2005) and selected according to the affective norms[6]. A total of 48 images were used for this experiment: among these, 24 were pleasant emotional-eliciting stimuli high in arousal and 24 were pleasant emotional-eliciting stimuli low in arousal. Since images involving people tend to be rated as more arousing, especially pictures with erotic content, pleasant high arousal images included pictures depicting situations with people having fun or playing extreme sports as well as erotic stimuli. The latter were selected among those involving double-sex couples. These are stimuli able to elicit states of excitement and euphoria, i.e. pleasant affective reactions characterized by a high level of arousal. Pleasant low arousal images included pictures depicting landscapes, flowers, scenes from outer space, cute animals, and serene faces. These stimuli are generally expected to elicit a sense of calm and peacefulness, i.e. positive affective states usually associated with a low level of arousal. Criteria for stimuli selection were set

[6] List of IAPS pictures used in the study. *High arousal*: 2352; 4670; 8370; 4658; 4653; 8501; 4660; 4652; 2344; 4683; 4664; 5629; 4681; 8210; 8030; 4659; 8490; 4656; 8300; 4800; 4810; 4695; 8400; 8191. *Low arousal*: 7140; 7900; 5300; 5220; 5731; 5779; 2514; 5250; 5780; 7490; 5030; 5000; 5635; 2397; 2580; 5891; 5500; 2850; 5764; 5720; 7180; 5631; 5520; 5020.

such that their range for valence dimension was 5.5 or greater. High arousal stimuli had a range for arousal dimension of 5.5 or greater whereas low arousal stimuli had a range of 2.5 or less. Overall, high arousal stimuli had a mean of 6.91 in valence dimension and a mean of 6.42 in arousal dimension; for the law arousal stimuli the valence mean was 6.09 and the arousal mean was 3.15. Notably, a statistical analysis indicated a significant difference in arousal ratings, t (46) = 20.43 $p <$ .001. However, also a difference in valence ratings has been registered, t (46) = 4.26 $p < .001$. Even though all the selected stimuli have a valence rating far below the neutral point (5) so that they must be considered pleasant, it is reasonable to observe that arousing stimuli have been rated as more pleasant than unarousing stimuli (Bradley & Lang, 2007). Since stimuli selected for the affective manipulation differed significantly also along valence dimension, we tested the effect of arousal on risky choice controlling for differences in participants' levels of experienced valence.

Affective experience task. Following Lang et al. (2005), we used a computerized version of the two nine-point Self-Assessment Manikin (SAM) scales asking participants to rate their level of experienced valence and arousal while viewing each image selected for their specific experimental condition.

Post-task questionnaire. In a post-task questionnaire participants were asked to provide information about their age, gender and education level.

Procedure

The experiment was conducted in a quiet room at Center for Neural Decision Making of Temple University. On arrival all participants provided written informed consent before starting the experiment. Participants were told that they would complete two tasks: the risk-taking task and the affective experience task. A Tobii 1750 eye-tracker was used to collect data on gaze direction and looking times. The eye-tracker was integrated into a 17-in monitor. All the tasks were run on a PC (operating system: *Windows 7*®) connected to this monitor. Experimental protocol was developed using *E-prime*® software package. Each participant sat 50 cm from the monitor. Participants first read the instructions on the screen under the guide of the experimenter and then the experiment started with a five-point calibration procedure in which a red dot with a black fixation point in the middle appeared repeatedly on five different locations of the screen. Participants were instructed to look at the dot and their looks were used to calibrate the eye-tracker. The presentation was repeated until the calibration was considered successful (for further technical details about the calibration procedure see von Hofsten, Dahlström, & Fredriksson, 2005). To reduce errors due to differences in pupil size and to encourage individual focus on the task, the lights of the room were turned off. Then, the risk-taking task started with a practice trial.

At the beginning of each trial a fixation cross was displayed for a random interval between 100-300 ms. Next, the grid containing the pair of two-outcome lotteries and the associated image were displayed (see figure 2).

	0,6	0,4
G1	-5	28
G2	5	13

Figure 10 Example of high arousal trial in the risk taking task.

To induce an affective state during choice we revealed the affective manipulation (i.e. the image) and the stimuli (i.e. the lotteries) in the exact time. The presentation of the riskier and safer lottery was randomized, so that in some trials G1 was the safer option and in the other trials G2 was the safer option. Images were presented in 6 blocks (2 high arousal blocks; 2 low arousal blocks; 2 mixed blocks). Each block was made of 8 trials. Mixed blocks included 4 high arousal trials and 4 low arousal trials. Block presentation and images presentation were randomized. After revealing the two lotteries (G1 and G2) with the associated image, participants could select the lottery they preferred by pressing the corresponding button on the keyboard. After completing the risk-taking task, participants were presented with the affective experience task: they saw all the previously seen pictures and asked to report their current affective state using the two SAM scales. At the end of the experiment, after completing the affective experience task, participants completed the post-task questionnaire. Finally they were debriefed and released.

7.4 Results

Choice made by participants across trials was used as dichotomous dependent variable. The safer lottery was coded as “0” and the riskier lottery as “1”.

Affective experience task. Ratings of valence and arousal provided for emotional stimuli at the affective experiencing task were averaged in order to obtain for each participant two overall indices of valence, one for arousing stimuli and one for unarousing stimuli, and two overall indices of arousal, one for arousing stimuli and one of unarousing stimuli. The affective induction worked as expected. Self-reported levels of arousal in response to arousing stimuli were higher than unarousing stimuli $t(23) = 8.71$ $p < .001$ (High arousal, M = 5.05 SD = 1.56; Low arousal, M = 3.08 SD = 1.27). In addition, self-reported levels of valence in response to arousing stimuli were higher than unarousing stimuli $t(20) = 3.75$ $p = .001$ (High arousal, M = 6.32 SD = .96; Low arousal, M = 5.54 SD = .86). Nevertheless for both, arousing and unarousing stimuli, participants reported a mean score of valence collocated below the neutral midpoint of the scale (5) indicating that in each trial participants experienced positive affect. No gender differences emerged in the levels of experienced valence and arousal for both arousing and unarousing stimuli, all $p > .05$.

Arousal induction and risk taking. In order to test the influence of arousal on probability of making a risky choice, we developed the following generalized linear mixed model of logistic regression

$$\ln\left(\frac{p}{1-p}\right) = \bar{a} + a_j + \overline{b_1} + \overline{b_2} + \overline{b_3}$$

including arousal (b_1), gender (b_2) and the interaction between the two (b_3) as fixed effects, and the intercept estimated for each participant (a_j) as random effect, specifying the participants identification variable as a cluster, as required by the mixed models procedure. Choices made across trials were used as dependent variable specifying the safe choice as reference category. Analysis revealed no main effect of arousal on predicting risky choices $p > .05$. Specifically, participants induced in an high-arousal state (i.e. when an arousing stimuli was associated to the gambles) made the 32.8% of risky choices while participants induced in a low-arousal state (i.e. when an unarousing stimuli was associated to the gambles) made the 30.5% of risky choices (see figure 3). Neither gender effect nor interaction effect between arousal and gender was found.

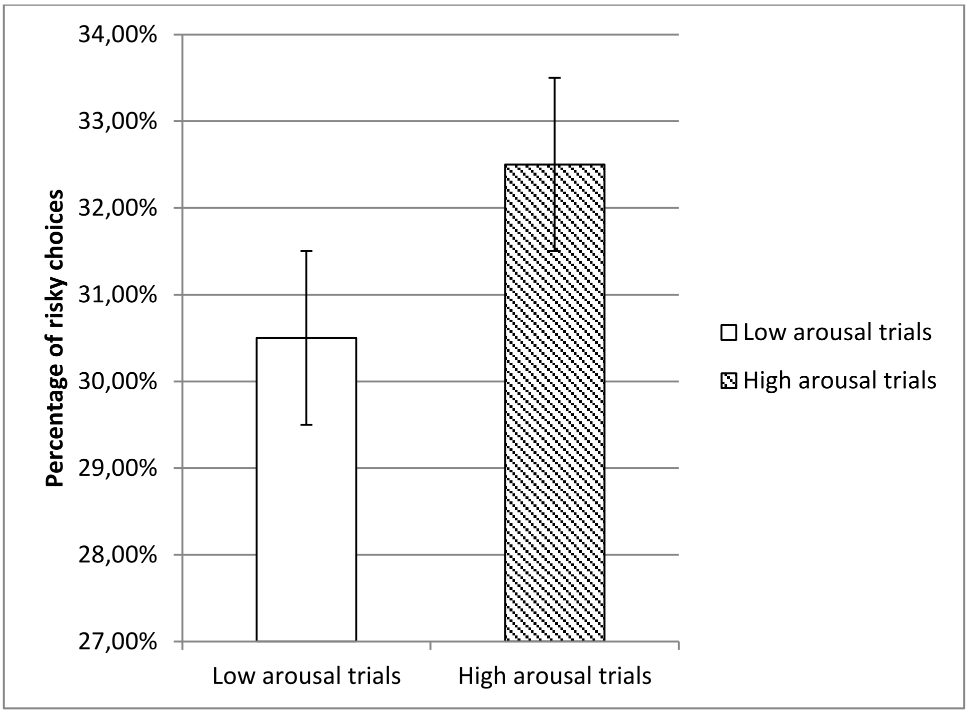

Figure 3. Percentage of risky choices made across trials.

We run additional analysis distinguishing between three types of stimuli used in this study, and namely, the stimuli with 50% level of probability, the stimuli with large spread of probability and the stimuli with small spread of probability. No unique effect on a specific category of stimuli was found, all $p > .05$.

However, participants spent more time for making decisions during high arousal trials compared to low arousal trials $F(1, 733) = 4.65$ $p < .05$ (High arousal, M = 5168 SD = 554; Low arousal, M = 4693 SD = 555).

Looking times. We used eye tracking data collected during the risk-taking task in order to assess the influence of arousal on participants' attention allocation. We performed a linear mixed model including arousal and gender as fixed effects and the intercept estimated for each participant as random effect, specifying the participants identification variable as a cluster, as required by the mixed models procedure. The percentage of time spent looking at each area of interest was used as dependent variable (i.e. the arousing/unarousing image as well as the cells constituting the grid displayed in figure 1 containing information about probability level and monetary values for both safer and riskier lotteries). Analysis revealed that arousal was a significant predictor of the percentage of time spent fixating the arousing (unarousing) picture $F(1, 620) = 24.87$ $p < .001$. In particular, participants looked at arousing stimuli longer than unarousing stimuli (High arousal, M = .23 SD = .018; Low Arousal, M = .17 SD = .019). Neither gender effect nor interaction effect between arousal and gender were found. Furthermore, arousal was a significant predictor of the percentage of time spent fixating at each grid containing the monetary values constituting the riskier gamble (in figure 1 the two cells related to G1): first riskier cell $F(1, 672) = 6.31$ $p = .01$; second riskier cell $F(1, 638) = 9.92$ $p < .01$. Specifically, during high arousal trials participants fixated at the monetary values constituting the riskier gamble less compared to low arousal trials (Risk cell 1: High arousal, M = .15 SD = .01; Low Arousal, M = .16 SD = .01; Risk cell 2: High Arousal, M = .11 SD = .00; Low arousal, M = .13 SD = .00 see figure 4). This was not the case for the percentage of time spent fixating the monetary values constituting the safer gamble: safer cell 1, $p > .05$; safer cell 2, $p > .05$.

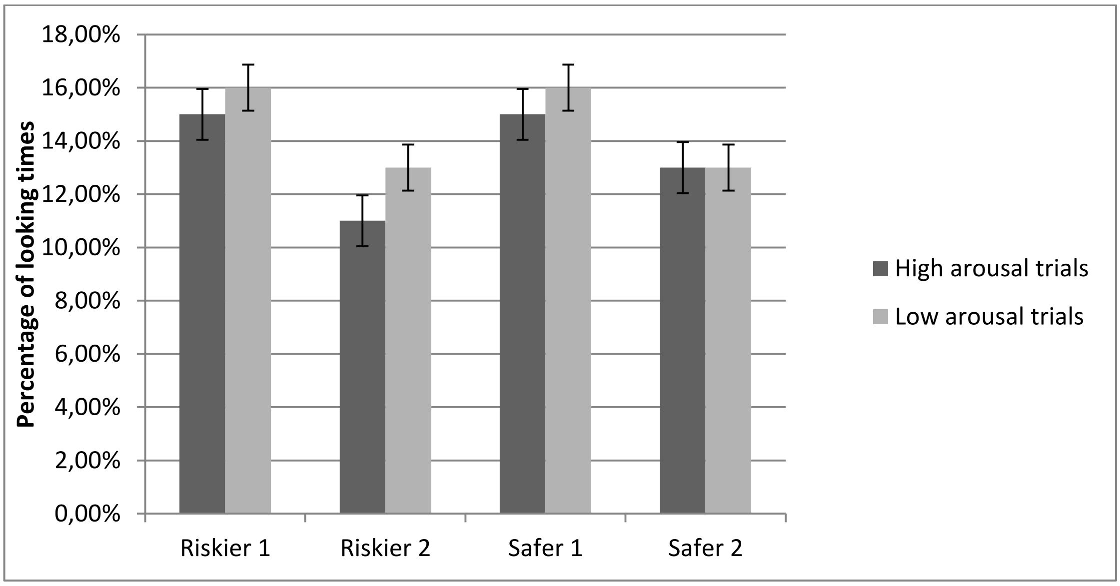

Figure 4. Percentage of looking times toward the two monetary offers constituting the riskier option across trials in the risk taking task.

No further differences in looking times emerged for other areas of interest; all p > .05 (see table 4).

	High arousal trials	Low arousal trials
Image	.23*	.17*
Probability 1	.09	.1
Probability 2	.08*	.07*
Riskier 1	.15*	.16*
Riskier 2	.11*	.13*
Safer 1	.15	.16
Safer 2	.13	.13

Table 10. Percentage of time spent looking at each area of interest across trials in the risk taking task.

Summarizing, the kind of image (high arousal or low arousal) associated with the two gambles was not a predictor of risky choices made by participants. However, in the high arousal trials participants spent more time for making decisions. Furthermore, they looked at arousing pictures longer than unarousing pictures. More important, arousal influenced the percentage of time spent fixating at the riskier option. In particular, during high arousal trials participants look at the riskier option *less* than low arousal trials. This indicates that participants paid *less* attention to process risky information during high arousal trials.

7.5 Discussion

The aim of this study was to investigate the effect of incidental positive arousal on preferences for monetary risk. In a within-subjects experiment, we manipulated participants' affective state in order to induce high and low levels of positive arousal. As it has been done for previous studies presented in this dissertation, we adopted the technique of contextual priming (Yi, 1990). Therefore we inserted a pleasant arousing (unarousing) cue (IAPS pictures) as contextual factor of a decision scenario and required participants to play a risk taking task where they had to make choices between couples of two-outcomes lotteries with same expected value but different risk (determined through the variance between payoffs). Furthermore, we tested the influence of positive arousal on visual attention. By using an eye tracker we gathered data about participants' gaze direction and measured looking times for the different areas of interest present in the context.

We found that arousal was a significant predictor of the time taken for making decisions. In particular participants spent more time during high arousal trials compared to low arousal trials. Contrary to what we found in previous studies contained in this dissertation (see chapter 4 and 5), an effect of arousal on predicting the probability of making a risky choice did not emerged in this experiment. The reasons for this could be various. First, sample size for this experiment may not be large enough to make the effect of arousal evident, considering that frequency of choices follows the same trend found from previous studies presented in this dissertation. Indeed, the 32.8% of risky choices is made during a high arousal trial, while the 30.5% is made during a low arousal trial. Second, differently from previous studies we manipulated arousal within-subjects. This may have provided participants information about experimenter's aim, encouraging the searching of strategies to deal with the task (on this point see Kahneman, 2003).Third, there could be some cultural differences in the way people experience positive arousal. On this regard, it should be noted that the current study and studies described in chapter 4 and 5 have been conducted on different populations (Americans vs. Italians). Fourth, contrary to previous studies presented in this dissertation, the current study was not incentivized, this might have reduced participants' motivation to perform the task consistently with their own preferences. These, or others factors, may have make the effect of arousal on risky choice not replicable for this experiment.

Importantly, eye tracking data are more informative about a possible explanation about the relationship between arousal and risk taking. Consistently with previous evidence (Lang et al., 1993) and with the result found in the current study on decision times, we found that participants looked at arousing stimuli longer than unarousing stimuli. This data is in line with arousal theories of attention which show that arousing stimuli are capable of capturing attention (Anderson, 2005). Furthermore, we found that in the arousing trials *participants looked at risky information (monetary values) less* than in the unarousing trials. We can conclude that arousal influenced the way participants paid attention to and then the way they processed risky information. Such effect of arousal on visual attention is consistent with the cognitive depletion hypothesis (Fedorikhin & Patrick, 2010) and may be related to what in literature has been defined as the interference effect of arousal: i.e. arousing stimuli presented in concomitance with the execution of a cognitive task may interfere with individual performance (e.g. Gronau et al., 2003; Schimmack & Derryberry, 2005).

Evidence show that a reduced cognitive capacity is accompanied by an altered sensitivity to rewards which triggers increased risk taking (e.g. Ferrara et al., 2015; Killgore, Kamimori, & Balkin, 2011; Venkatraman, Clithero, Fitzsimons, & Huettel, 2012). Experiencing high levels of positive arousal has been linked to increased anticipatory desire for rewards (Knutson et al., 2008). This may explain the increase in risk taking behavior in conditions of high positive arousal found in previous studies (Ariely & Loewenstein, 2006; Galentino et al., submitted; Laier et al., 2013). However, we cannot state that less processing of risky information is associated with increased sensitivity to rewards since participants did not look at the riskier option longer. Conversely, they looked at the riskier option less. At the same time, we cannot conclude that cognitive depletion lead participants to make a superficial processing of choice options. If it was so, they would have looked less to all information, but this was not the case. Future studies may help to fill the gap between information processing of risk and risk taking behavior.

In summary, we found that incidental arousal, induced through the exposure to pleasant arousing contextual cues, influenced decision times, as well as individual's visual attention and information processing of choice option (as resulted from reduced looking times toward riskier gamble during arousing trials). This evidence suggests that a pleasant and arousing cue inserted as a contextual factor of a decisional scenario is able to influence individual attention, information processing and, in some cases, individual's preference for choice options.

7.6 References

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Part III

Conclusion

Every time you decide, there is a loss, no matter how you decide.
It's always a question of what you cannot afford to lose

F. X. Stork

CHAPTER 8

General Discussion

Through the experimental work presented in this dissertation I studied the influence of incidental affective states on decision making under risk, in particular, I explored the role of affective arousal on shaping preferences for economic risk. I systematically examined the effect of experimentally inducing high or low levels of incidental positive and negative arousal, elicited through the exposure to affective-eliciting peripheral cues inserted as part of the decision context, on preferences for monetary offers varying in risk. For all studies presented in the four papers reported here I adopted the same methodological framework. Participants were required to play a risk taking task where they had to choose between couples of two-outcomes lotteries varying in risk (as determined by the variance between the two monetary payoffs) but equivalent in their expected value and, in paper 1 and 2, also in probability. Arousal (high/low) was manipulated (between subjects – paper 1 and 2 – or within subjects – paper 3 and 4) by presenting participants with emotional images (IAPS pictures), selected according to the affective norms, varying in the levels of positive arousal (paper 1, 2 and 4) or negative arousal (paper 1 and 3) and inserted as contextual factor of the decision scenario (contextual priming). Results from studies presented here seem to converge on the fact that affective arousal matters and it does influence individual's risk preferences. In particular, experiencing an elevated tone of arousal may increase risk taking behavior, even though in some cases this effect may intecarct with gender and valence (see paper 1, chapter 4): in one instance we found that positive arousal (but not negative) increased risk taking only in males (but decreased it in femanles).

These findings confirm existing evidence about the role of arousal on decision making, showing that experiencing high intensity affective states (pleasant or unpleasant) may lead people to adopt a risk prone behavior.

As I explained earlier, it is not surprising to find that both positive and negative arousal have similar effects on risk taking since both form of arousal (or stress) elicit the same physiological changes through the activity of the autonomic nervous system. Therefore, to the extent that physiological reactions are the same it is reasonable to expect that also the behavior would be the same.

However, in this dissertation I made a step further to try to understand the mechanism underlying the effect of arousal on risk preferences. I tested an attentional-cognitive depletion hypothesis, according to which high-arousing contextual stimuli capture attention and leave less cognitive resources to the task at hand. I wished to demonstrate that less cognitive resources meant less attention to the risk information and hence, less protective, risk-averse reactions towards risk. Results from studies presented in paper 3 (chapter 6) and 4 (chapter 7) show that inserting the arousing stimuli as part of the decision scenario was able to capture visual attention and to influence the way people process risk information. In particular, as it has been shown in paper 4 (chapter 7), under conditions of elevated (positive) arousal, participants looked at the riskier gamble less, maybe because distracted by the presence of the arousing stimuli considered as the most relevant stimuli. Furthermore, this was not the case for the safer gamble. Looking times calculated for fixations toward the safer option were identical in both conditions of high and low arousal. This suggests that my hypothesis could be right: high arousal may lead people to process risky information in a more superficial way.

Many researchers already argued that a condition of elevated arousal represents an instance of cognitive depletion in which cognitive resources are minimized (see section 2.4.1 of this dissertation). If pure cognitive depletion was the explanation for the effect of arousal on risk taking I would have found that, when induced to experience an high arousal affective state, participants would look less to all the information, thus resulting in a more superficial processing of both choice options (the safer option and the riskier option). But, this was not the case. As I show in the last study (paper 4, chapter 7) participants processed less only the riskier information when this was contextually presented with an arousing stimuli, but not the safer information. Therefore, increased risk taking under conditions of elevated arousal is not *only* due to cognitive depletion, at least for the studies presented here.

Some authors, argued that a consequence of the reduced cognitive capacity is an altered sensitivity to rewards. If this was true, participants should look longer at higher rewards, but this was not the case.

A second important results from these studies is that, for both positive and negative arousal, participants looked at arousing stimuli longer than unarousing stimuli (see paper 3, chapter 6 and paper 4, chapter 7). Since in this experimental work incidental arousal was elicited through contextual features presented in association with choice options, I may conclude that the reduced processing of risky information might be a consequence of the increased attention directed toward the arousing stimuli. Nevertheless, the reason for why a reduced information processing of risk may lead to increased risk taking behavior remains still an unsolved problem and future studies adopting the same experimental protocol I adopted in this work may help to fill this gap. Some, indeed, could argue that rik information is more difficult to process than sfe information, and hence, a simple cognitive depletion hypothesis could explain individual behaviors.

Elements of novelties from this experimental work are various. First, in this work I assessed the role of arousal on risk taking keeping the valence controlled (positive or negative) and using the same task across all studies. Thus, I was able to test the effect of positive and negative arousal on risk taking separately making results more generalizable and comparable across conditions.

Second, I extended the scientific investigation about the influence of arousal on risk taking to the domain of positive affect which has often been ignored from previous studies. On this point, precedent studies mostly studied the effect of sexual arousal (which is considered a specific form of positive arousal) and most of them used male samples only. In studies presented here samples were balanced in terms of gender and different activators of positive arousal have been used (i.e. erotic stimuli but also stimuli inducing feelings of happiness, joy, enjoyment and so forth).

Third, due to the arousal manipulation adopted in this experimental work (i.e. the exposure to affective eliciting pictures) I was able to manipulate both valence and arousal avoiding the induction of one specific kind of emotion (e.g. fear or happiness). Furthermore, in all studies presented in this dissertation, after completing the risk taking task participants played the affective experienced task in which they were asked to report the levels of experienced valence and arousal in response to all stimuli used for the affective manipulation. In this way, I was able to double-check the efficacy of the arousal induction and I was able to estimate the effect of arousal on risk preferences controlling for differences in the levels of experienced valence and arousal.

Fourth, with the use of the eye tracker I was able to collect data about participants' gaze direction and record looking times (paper 3 and 4). In this way I was able to investigate the effect of arousal on visual attention. Moreover, I could test the presence of an interference effect of arousal on the processing of risk information.

There are also some limitations to this experimental work. First, the use of IAPS pictures for arousal manipulation represent a good way to study the influence of incidental affect (i.e. affective states unrelated to the decision at hand) on choice but at the same time it is not a powerful arousal activator since people are repeatedly exposed to emotional visual stimuli which can be find on the TV, Internet, newspapers and so on. This contributes to create a sort of habituation effect which may have made the affective manipulation less efficient. Second, studies presented in paper 1 and 2 were incentivized, while studies presented in paper 3 and 4 were not. This makes studies less comparable and may explain some inconsistencies found among them. Third, different populations of subjects have been recruited for this research project. Studies described in paper 1 and 2 have been conducted on a sample of Italian undergraduate students while studies described in paper 3 and 4 have been conducted on a sample of American undergraduate students. Such discrepancy carries over a series of cultural issues related to differences in risk perception and risk taking behavior, differences in the way people experience affect and emotions as well as heightened or reduced gender differences.

8.1 Practical implications

Even though the effect of affective arousal on decision making has been largely ignored from previous experimental studies, experts in the field of marketing repeatedly seek to induce high-intensity emotions in consumers which could be associated to a specific consumer good and experienced as a reaction to it. As it has been illustrated in chapter 2 of this dissertation, arousal can be easily misattributed or transferred to unrelated objects or events when the source of arousal is associated to the object of the decision and is experienced as a reaction to that. Similarly to the way we manipulated arousal in our studies (contextual priming), the simultaneous presentation of the consumer good and the contextual arousing stimuli can influence consumers' decisions, for example by anticipating future emotions related to that specific good. Such strategy has been largely exploited by marketing companies especially in advertising. A case can clearly explain this. In 2009 a famous brand of beer made a new TV commercial showing a naked woman lying face down with a bottle of beer on her back (see figure 1).

Figure 11. TV commercial of a famous beer brand.

The scene shows the woman moving making the bottle swing in a lateral direction. Subsequently, it shows hands of men taking the bottle from different angles and placing it back on the woman's back. Therefore, the commercial clearly shows a sexual act between people in order to elicit a state of excitement in consumers in a way to make them experience it, as a response to the beer. To make this clearer, at the end of the commercial a label is displayed, citing "*Share it one with a friend. Or two*." Aim of the TV commercial was to elicit sexual arousal in consumers so that it could be easily be transferred to the product (the beer) by anticipating future pleasures deriving from drinking it. In a similar way, other marketing companies resorted to the strategy of introducing arousing contextual stimuli in commercials in order to make products more desirable. For example, cars advertisings often include beautiful women or high-speed driving scenarios; liquors advertisings often present scenes of people having fun or partying in clubs; and so on and so forth. Since every choice we make in our daily life is not risk-free, evidence from this experimental work result of interests for the developing of new marketing strategies. More important, it is of relevance also for consumers in order to make them aware of the mechanisms through which arousal, or more in general affect and emotions have impact on our choices.

8.1 Concluding remarks

To conclude, the research presented throughout this dissertation highlights the importance of assessing both dimensions of valence and arousal when affective state is used as explanatory variable of differences in individual risk preferences. In particular, this experimental work demonstrates that incidental affective states characterized by high levels of positive and negative arousal may influence attention allocation, may absorb cognitive resources and influence the way risky information are processed. This may lead people to increase risk taking behavior. This research has relevance for studies which currently seek to understand the mechanisms which underlie the interplay between affect and cognition which is still poorly understood. Furthermore, several life decisions (e.g. purchases, insurance choice, financial investments, healthcare, and so forth) are influenced by decision maker's current mood and involve a significant emotional trade-off. Therefore, the understanding of such mechanisms would provide valuable insights into the development of policies and interventions for improving marketing strategies as well as decision making.

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