Title: Risk-Taking Behavior Under the Effect of Emotional Stimuli Among Children and Adults

Running title: Emotional risk-taking in adults and children

Authors: Fatemeh Shahrabi Farahani1, Reza Khosrowabadi1, Gholamreza Jaafari2,*

1. Institute for Cognitive & Brain Sciences, Shahid beheshti University, Tehran, Iran.
2. Department of Physics, Shahid beheshti University, Tehran, Iran.

*Corresponding Author: Email: gjafari@gmail.com

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**Highlights**

- Children perform riskier than adults in our new version of the game of dice task.
- Children affected by choosing riskier options by positive priming.
- Adults affected by choosing less risky options by negative priming.
- Results were proofed dual-process theory.

**Plain Language Summary**

Every second of our life is consistent with making a decision. When you decide you face conditions that you don’t know the result when you choose them. There is some risk with the choice of these options. Choosing these options could have both advantages and disadvantages. So it will be very useful for communities if they can find a way to control it. In this study, we aimed to test whether it is possible to control risk-taking by seeing emotional pictures before decision-making or not. So we design gambling like experiment and test adults and children using this experiment. These two age groups were used to test if there is any difference or similarity between their behavior. We used three main emotions to check their result on people's choices. We wanted to check what happens to people’s decisions if they faced with positive, negative or neutral images before their choice. Results showed that children were riskier than adults and affected more while faced with positive images and select riskier options. On the other hand, adults affected more by negative images and chose safer options after seeing the pictures in this emotion.
Abstract

Risk-taking has an important role in human’s life, either positive or negative. Thus, finding a method to control or drive this in a particular way could affect individuals and communities’ health by discouraging negative risks such as reckless driving or encouraging positive risks. Emotion induction is one of the methods that can enhance or reinforce risk-taking according to the perceived emotion. Among the studies which had taken, most of them focus on adolescents’ which is known as the peaked age of risk-taking behavior, while from a developmental learning point of view if there is a way to control or educate people’s behavior childhood could be the best time. Thus, this study along with the introduction of a new risk-taking task, aims to investigate two less studied groups (children and adults) risk-taking behavior, and also their behavioral response after they influence by positive or negative emotional pictures, to test whether these affect their risk-taking or not. 21 children and 20 adults participate in this experiment. Their risk-taking behavior is obtained using a new version of game of dice task combined with emotional stimuli. Results show that children have higher tendency to choose riskier options while they affected by positive emotion while adults are more risk-averse after primed by negative emotion. These findings could be helpful for policy makers and tutoring planners to control risk-taking behavior over different ages using priming effect of positive and negative emotions.

**Keywords:** Risk-taking behavior, Emotional priming, dual system theory, Development
1 Introduction

Risk taking is defined as a behavior that may result in a positive outcome (e.g., financial reward, pleasant physical or psychological sensations) and also carries some probabilities of a negative outcome (e.g., injury, financial loss) (Lejuez et al., 2002; MacPherson et al., 2010). There is experimental evidence in distinctions between risk-taking of different age groups (Cauffman et al., 2010; Duell et al., 2018; I. Levin et al., 2007; I. P. Levin et al., 2014). These differences are explained as interactions between cognitive processes, neurodevelopmental changes, and experience (Duell et al., 2018; Mitchell et al., 2008). This developmental behavior follows an Inverted-U shape across age groups with greater risk taking among adolescents because of the variation of the relation between cognitive control and reward processing systems (Duell et al., 2018; Somerville et al., 2011; Willoughby et al., 2013). This relation between these two developmental systems leads to a difference in vulnerability of risk-taking (Willoughby et al., 2013). Research confirms that risk-taking behavior can be affected by emotions (Kozlowski et al., 2017; Vinckier et al., 2018). Previous research on young adults showed positive affect led to lower risk perceptions than neutral (Haase & Silbereisen, 2011).

There is an ongoing debate about which emotional category has more influence on risky behavior. For instance, Grable and his colleagues (Grable & Roszkowski, 2008) showed that adults in a positive (happy) mood have higher levels of financial risk tolerance while Stanton et al. (Stanton et al., 2014) reported that a positive (happy) mood induction increased risk-seeking behavior compared to neutral mood, whereas a sad mood induction procedure did not induce behavioral differences in comparison to neutral mood. These moods are internal induced tempers. Other studies have linked positive mood or emotional states to reduced risk-taking (Isen, 1987; Isen et al., 1988; Loewenstein et al., 2001). Consensus in the scientific literature regarding the effects of negative emotions on risk-taking is also lacking. Whereas some papers documented the fact that experimentally induced negative emotions as well as anxious and
Depressive states lead to more risk-averse preferences (Heilman et al., 2010; Kusev et al., 2017) other authors provide empirical evidence supporting a positive relation between negative emotions and risk-seeking (Mittal & Ross Jr, 1998).

According to the appraisal tendency hypothesis (Lerner & Keltner, 2000; Smith & Ellsworth, 1985) each emotion is associated with a specific appraisal dimension (certainty, pleasantness, attentional activity, control, anticipated effort, and responsibility (Smith & Ellsworth, 1985)), which, in turn, will determine the influence of specific emotions on judgements and decisions. For instance, induced fear was associated with pessimistic judgements of future events and risk-averse choices, whereas induced anger was associated with more optimistic judgements and a more risk-seeking behavioral pattern (Han et al., 2007). Happiness, although of positive valence, is associated with an elevated sense of certainty and individual control (Han et al., 2007). Patterns of appraisals along these dimensions, thus, provide a basis for comparing and contrasting discrete emotions. Because adolescence is associated with riskier activities there is a lot of attention towards risk taking behaviors of this age group (Figner & Weber, 2011; Steinberg, 2007, 2010), while there has been scarce research to study the behavior of children and adults (Steinberg, 2008). Behavioral data regarding emotional influences on risk-taking are also less consistent and most of them were conducted only for adults. In this study risk-taking behavior is examined under the effect of emotional stimuli in two opposite ranges of valence to shed light on emotions effect on two less examined age groups (children vs adults). It is hypothesized that due to lack of maturation in children’s brain (Defoe et al., 2015; I. P. Levin & Hart, 2003; Romer et al., 2017) they engage more in risky behaviors than adults. It is also proposed that positive emotions tend to lead to greater risk-seeking because people become more optimistic about future outcomes when they are feeling good. Similarly, negative emotions, such as anxiety, tend to make individuals more pessimistic about future outcomes, and this can lead to risk aversion (Johnson & Tversky, 1983). This study designed to address
mentioned shortage in the existing literature. To did so the effect of three conditions of two positive and negative emotional stimuli and one neutral condition were investigated in a within subject design on two age groups of adults and children. It is therefore expected that positive emotion encourage riskier behavior while negative emotion has the opposite effect on children and adults.

2 Materials and Methods

2.1 Emotional stimuli

The effects of these two categories of International Affective Picture System (IAPS) (Lang et al., 2008) on risk-taking behavior was investigated in this paper. These categories included 50 pictures with different valence rates (Appendix 1 lists their IAPS numbers). They were used as emotional stimuli in a modified version of the game of dice task (Brand et al., 2005). The norms which were used in this experiment were provided by Libkuman (Libkuman et al., 2007). Mean and standard deviation of these images are shown in Table 1. They were mainly categorized as positive (happy) and negative (fear) emotions. Valence refers to how pleasant or unpleasant a stimulus is. Arousal refers to levels of activation as reflected in physiological responses such as skin conductance, heart rate, and the startle response. Specific emotions can be placed on this two-dimensional space. For example, happiness is considered to be moderately arousing with positive valence, excitement is highly arousing with positive valence, sadness is moderately arousing with negative valence, and anger is highly arousing with negative valence.

<table>
<thead>
<tr>
<th>Table 1: Mean and standard deviation of the images</th>
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<tbody>
<tr>
<td>Happy Valence</td>
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<tr>
<td>Mean</td>
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<td>standard deviation</td>
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2.2 Task

The original type of this game (GDT) was developed by Brand and his colleagues in 2005 to measure decision-making impairments in korsakoff patients (Brand et al., 2005). The goal in playing the original GDT was to maximize the fictitious score within 18 throws of a single virtual die. Subjects had to guess one number of the die (1 to 6) which they think is more probable to be thrown. They can choose one certain number or a combination of two, three, or four numbers. In this task each alternative was associated with a determined amount of money dependent upon the winning probability: 1000 gain/loss for the choice of a single number, 500 gain/loss for two numbers, 200 gain/loss for three numbers, and 100 gain/loss for four numbers. Participants won mentioned amount of money if their guess was true (the number they chose was thrown) and lost the same amount of money on the other hand. Related gain/loss was 500 while choosing two numbers, such as the numbers “3” and “4”. In this case, participants won 500 if either the number “3” or the number “4” was thrown, and they lost 500 if one of the other numbers were occurred (the 1, 2, 5, or 6). The same principle was applied for the combinations of three and four numbers (Brand et al., 2005). The reason of producing a new task is to change the game design and make it easier for understanding specially for children. The first challenge to do so is to have groups of options with equal distribution over screen. This solved by putting each group of dice in a diagonal symmetricity on the screen. It changes number of available options in each group. Another change is the number of trials. It is hard for people to understand the task at first trials thus it is better to have more trials than the original one. It is also enhancing the reliability of the overall results. Thus we increased the number of trials from 18 in the original experiment to 50 in current version. This gave the ability to follow the process of decision making in a symmetric design. Shorter distance from the center of the screen represented a riskier option, whereas a greater distance represented a safer choice. The expected value for the single dice is $(1000 \times \frac{1}{6}) - (1000 \times \frac{5}{6}) = -666.6667$, for two numbers dice is
\((500 \times 2/6) - (500 \times 4/6) = -166.67\), for three numbers dice is \((200\times3/6) - (200\times3/6) = 0\) and for four numbers dice is \((100\times4/6) - (100\times2/6) = 33.33\). These are the same as the original task. Choosing any option results a positive when they guessed true or negative value when they guessed false.

2.3 Emotional task

Another addition to the original GDT is emotional stimuli. Because this game assessed the influence of emotional pictures on decision making. In each trial, before any selection, one emotional image was displayed on the screen. These pictures were selected from positive and negative sets of IAPS as mentioned earlier. For the control group a uniform gray colored rectangle with the rgb code \((128, 128, 128)\) was used as neutral stimuli. Participants were treated with all emotional stimuli with different between-group and similar within-group sequences. The task starts while participant see Fig. 1. It allows them to make their choice by selecting their guess from the game screen. Result of the throws were randomized and saved previously and is the same for everyone to control effect of win/loss over next choice.
The game process as it depicts in Fig. 2 was as follows: They start the game with the initial balance of 10000 points. First, they were selected their choice from the screen. Then the result of their choice appeared on the screen for one second. If their guess was true, a green number with a positive sign was shown on the screen. This number was added to their total score as a reward. However, on the other hand, if their guess was wrong, it was shown in red color with a minus sign. This value decreased from their total score as a punishment. Following this part, a fixation cross appeared on the screen for 0.2 seconds to move participants’ attention to the center of the screen. According to those treatments which they had been participating in it - positive, negative or neutral- one emotional image was displayed for 1 second followed by another fixation point appeared for 0.2 seconds and mouse pointer placed in the center. This procedure was repeated for each person 50 times in the positive group, 50 times in the negative.
group and 50 times in the neutral group. One number dice are riskier and four number dice are safer choices. These selected options and their reaction times were saved for further analysis.

2.4 Participants
A total of 21 children (9-11 years old) from four classes of a Karimeh Ahlebait primary school Tehran and 10 adults from the Physics Department of Shahid Beheshti University and 10 adults from Arianpardaz company (25-28 years old) randomly selected and enrolled in the study. They were all students. They did the study in a within subject design. Each person played the game in all conditions of positive, negative and neutral emotional images. The study took place in Tehran, Iran. A detailed study protocol which explained the study goal and methodology was approved by the institutional review board. Participants received an information sheet, which assured them that the data obtained would be handled confidentially and anonymously, and they were asked to give written informed consent. Parents were required to provide consent on behalf of their children. All parents gave their permission.
2.5 Procedure

Participants were tested independently in a quiet room with a laptop with 1920×1080 screen resolution. At the beginning, the experimenter gave participants a consent statement to read over. In addition, the experimenter reviewed the instructions with the participants and answered any questions. Participants were tested randomly at three separate sessions, which were framed as emotional conditions named as positive, negative and neutral. They didn’t know the reason of showing pictures. They were told that you need to choose one of the options on the screen to enhance your overall points.

2.6 Analysis

To analyze the effects of emotional treatments on children and adults risk taking, their choices (as a dependent variable) were classified based on selected numbers. Here choosing one option dice gets 1, two option dice gets 2, three option dice gets 3, and four option dice gets 4. The time of the selection of options is also recorded as their reaction time to compare between groups. Based on Hardy et al (Hardy et al., 2006) that classified dice groups with one or two numbers as risky or disadvantageous whereas three and four numbers as non-risky or advantageous, participants’ overall index of performance which here is defined as index of risk-taking behavior calculates from the number of options chosen from a “risky” group (two and one dice groups) minus the number of choices from a “safe” group (i.e., from three and four dice groups). Thus, higher scores indicate riskier task performance while lower scores indicate more optimal performance (i.e., winnings will be greater). All statistical analyses were carried out with MATLAB. Here ANOVA and ttest were used to determine if there was a significant difference between the values of age groups × emotional priming in reaction-time and risk-taking or not. Because the task was run for 50 trials, each person has 50 values for each emotional treatment. Thus each person had 150 values, 50 for positive priming, 50 for negative
priming, and 50 for neutral priming. For each of these 50 rounds, the total of the risky and non-risky choices, mean reaction time and Hardy’s index were calculated. These values were calculated for every person for all 50 rounds. Thus each person has six values. Reaction time and Hardy’s index for positive, negative and neutral conditions. Since we run the experiment over two groups of children and adults, we also had 2 age groups. So there were six groups in total (children affected by positive emotions, adults affected by positive emotion, children affected by negative emotion, adults affected by negative emotion, children affected by neutral emotion, adults affected by neutral emotion). To answer the research question whether emotional stimuli could affect risk-taking or whether they affect different age groups differently, a 1-way ANOVA was used. If there was a significant group difference, then a follow-up ttest analysis was conducted to examine the hypotheses.

3 Results

Using ttest over risk-taking index of Hardy (Hardy et al., 2006) shows significant difference between two age groups while children perform riskier than adults (p value = 0.0181). However, there is not any significant effect on emotional priming. Comparing emotional groups and age groups based on reaction time shows that there is not any significant effect between emotional stimuli and reaction time and also age and reaction time. So emotional stimuli have not different effect on children and adult’s reaction time in our experiment. As a result of seeing age difference between all groups the next step is finding significant groups. Thus the comparisons conduct here is between adults and children in positive, negative and neutral emotions separately while there is one significant difference in positive emotion (p value = 0.0094) and children perform riskier than adults. Rational decision-makers decide based on expected value, thus they looking for options with higher expected outcome. But in this study there is just one class of options with positive expected value, which classified as rational, four number dice
group. However, in the whole experiment participants made only 35.8% of their choices on this option. By looking at number of the times that rational option was chosen by each age group considering emotional priming, there is no significant difference that indicates the effect of emotion on choosing rationally. This difference manifests itself considerably regardless of priming in both children and adults group, meaning that adults made more rational decisions overall (p = 0.0346). Post-hoc comparison of this part shows significant difference between adults and children in negative emotion (p value = 0.0450). While adults chose more from rational option than children. However, this includes only 40.06% of adult’s choices which shows that they did not decide rationally.

4 Discussion

As it hypothesized, in this study children performed riskier in comparison with adults specially in positive emotion. These findings are compatible with longitudinal and brain studies of the risk-taking behavior (Harden & Tucker-Drob, 2011; Willoughby et al., 2013). According to dual process decision-making models there is an intuitive, automatic system, which is often reliant on affect, reward and current emotions for making decisions (“system 1”), versus a controlled, and reflective system (“system 2”) (Harden & Tucker-Drob, 2011; Willoughby et al., 2013). System 1 has emerged early from birth while sensitivity of system 2 increased later (Harden & Tucker-Drob, 2011; Willoughby et al., 2013). Relation between these two developmental systems leads to difference in vulnerability of risk-taking (Willoughby et al., 2013). So it is concluded that children perform riskier than adults due to their higher amount of reward seeking in comparison with their immature cognitive control. This is also brain regions responsible for reward processing and those necessary for cognitive control vary dynamically across development (Duell et al., 2018; Somerville et al., 2011). Therefore, the task is introduced in this paper can measure risk-taking behavior properly. Among different affective
groups children’s response affected by positive emotion (happy) towards riskier choice. While negative emotion (fear) has a significant effect on adults. It results in less risk seeking compared with other groups. Inhibitory control which is a part of system 2 operates according to formal rules of logic and can block affective impulses. It works actively for adults but not children. Positive impulses enhance risky behavior by optimizing the outcome of the decision and reinforcing the risky behavior. In adults, however, a stronger control system prevents further risk. But this system does not work like this in children and reinforce risk-taking among them. On the other hand, negative impulses cause pessimism about the outcome of the decision and reinforce the non-risky behavior that enters the control system as a further warning alarm. Therefore, it puts adults at greater risk-aversion than children who do not yet benefit from this mature system. The current study was performed on only 41 people in two age groups, children and adults. It is recommended that in addition to increasing the number of samples to improve experimental power, the adolescent group is also added that helps us to observe developmental changes under this experimental condition.
References


Illustrations:

Figure Legends

Figure 1: Screen-shot of the task, this picture has four dice groups. Group one, that contains 6 separate dice, group two, that has 6 two dice options, group three which has 4 three options and group four that has 6 four options. One dice group pays 1000, two dice group pays 500, third dice group pays 200 and fourth dice group pays 100. This is what a participant face when doing the task. He/she should select one of these options for each round.

Figure 2: Process of the experiment. This figure depicts what happens in one trial of the experiment. First participants see the dice option screen. It appears until someone chooses one option. Then the result of the choice shows on the screen for 1 second. If the choice was correct it is green with a positive sign and it adds to the overall outcome but if it was wrong it is red with the negative sign and it subtracts from the overall outcome. Following this part, a fixation cross shows for 0.2 seconds. Then depending on the emotional treatment of the current group (positive, negative, or neutral), one of the prerecord IAPS pictures appears on the screen for 1 second. This is emotional priming that supposed to affect the next round’s choice. Again a fixation cross shows on the screen that finishes one round and makes participants ready for the next round.
Tables

Table 1: IAPS Libkumen mean and standard deviation. This table illustrates the values for valence and arousal of the average pictures which are used for emotional groups. (page 4)

Table 2: Mean and standard deviation of the images

<table>
<thead>
<tr>
<th></th>
<th>Happy Valence</th>
<th>Happy Arousal</th>
<th>Fear Valence</th>
<th>Fear Arousal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>31.12</td>
<td>1.74</td>
<td>32.28</td>
<td>1.48</td>
</tr>
<tr>
<td>standard deviation</td>
<td>9.6</td>
<td>0.29</td>
<td>12.05</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Author Contributions:

F.S.F., R.K., and G.R.J. conceived and planned the experiment. F.S.F., carried out the experiment. F.S.F. wrote the manuscript. R.K., and G.R.J. helped supervise the project. F.S.F. discussed the results and contributed to the final manuscript.

Additional Information

Competing interests

The author(s) declare no competing interests.
Appendix

IAPS numbers which are used in this study:

1300 1340 1301 1440 1302 1460 1303 1463 1930 1602 1931 1610 3500 1710 5970 1721 5971
1722 5972 1750
6190 1811 6200 1812 6210 1920 6213 1999 6230 2040 6242 2057 6243 2070 6250 2091 6260
2150 6300 2216
6312 2303 6313 2310 6314 2311 6350 2331 6370 2341 6510 2345 6540 2352 6550 2360 6560
2510 6570 2530
6571 2540 6821 2550 6830 2655 7640 2660 8480 2791 9911 4603 1022 5621 1040 5628 1050
5760 1051 5779
1052 5780 1070 5800 1101 5830 1113 5870 1120 5910 1200 5982 1201 5990 1220 7282 1240
7325 1274 8497