

1 **Positive Cognitive Reappraisal is beneficial for Women's but not for Men's IGT**
2 **Decision-Making.**

3 Real-life decision-making involves a balance between emotion and cognition, a
4 process that is mirrored in the Iowa Gambling Task (IGT). Previous studies
5 suggest that negative emotion affects IGT performance, and that this effect may
6 be moderated by gender. In the current study, we experimentally instructed the
7 use of a strategy for ameliorating the incidental negative emotion induced by
8 negative images while men and women solved the IGT. To do this, we asked 38
9 men and 38 women to either only look at negative images (non-reappraisal
10 group) or to use positive cognitive reappraisal when facing these negative
11 images (reappraisal group) to ameliorate the negative emotion associated with
12 them while trying to solve the IGT. Both men and women in the reappraisal
13 group successfully used positive reappraisal to decrease their negative emotion
14 compared to the control, non-reappraisal group. Critically, we observed that
15 women performed *better* in the reappraisal group compared with the non-
16 reappraisal group, in the second half of the task (performance phase).
17 Conversely, men performed worse in the reappraisal group compared to the non-
18 reappraisal group in the second half of the task (performance phase). Finally, a
19 multigroup analysis revealed a gender moderation of the direct and indirect
20 effects of positive reappraisal on IGT performance, indicating that reappraisal
21 benefited women IGT performance through the regulation of negative emotions.
22 Conversely, for the men the decrease of negative emotions through reappraisal
23 did not impact IGT performance. Our results demonstrate that while the use of
24 positive reappraisal is useful to ameliorate negative emotions regardless of
25 gender, positive reappraisal benefits women's decision-making, and impaired
26 men's.

27 **Keywords:** positive cognitive reappraisal; negative emotion; Iowa Gambling
28 **Task;** decision-making and gender differences.

29

1 **Introduction**

2 Emotions are known to be a critical contributor to decision-making (Lerner, Li, Valdesolo
3 & Kassam, 2015; Hiser & Koenigs, 2018; Higgs, McIntosh, Connelly & Mumford, 2020).
4 One of the most popular tasks to measure the influence of emotions on decision-making
5 is the Iowa Gambling Task (IGT; Bechara et al., 1994). The IGT was initially developed
6 to assess decision-making deficits in patients with damage in the prefrontal cortex
7 (Bechara, 2004), and subsequently used in other disorders characterized by high
8 impulsivity and poor decision-making (e. g., substance abuse or pathological gambling;
9 Kovács, Richman, Janka, Maraz, & Andó, 2017). Nowadays, it is also broadly used in
10 research with nonclinical samples, and associations have been reported between poor IGT
11 performance and several important psychological characteristics, such as reward
12 responsiveness and fun-seeking (Suhr & Tsanadis, 2007), impulsivity (Giustiniani et al.,
13 2019; Sweitzer, Allen, & Kaut, 2008), and physiological indicators of inhibitory control
14 (Forte, Morelli, & Casagrande, 2021).

15 During the IGT, participants are presented with four decks of cards and asked to learn to
16 choose those that allow them to accumulate more monetary gains (rewards) or avoid those
17 that lead to more losses (punishments). Although participants do not know how the decks
18 represent different ratios of rewards and punishments, they try to learn and optimize their
19 behavior as they play, based on the outcomes they receive during each trial (Bechara et
20 al., 1994). Advantageous decks are centered on small, immediate rewards but with small
21 monetary punishments, allowing the accumulation of profit in the long term. On the
22 contrary, disadvantageous decks are centered on large, immediate rewards but with large
23 monetary punishments, hindering the accumulation of profits in the long term (Bechara.,
24 2005; Dunn et al., 2006; van den Bos et al., 2013). IGT performance is classically
25 computed as the difference score between advantageous and disadvantageous deck
26 selection in a set of five blocks of 20 choices. The first two blocks are thought to be

1 crucial and are considered the learning stage of the task. During this stage, participants
2 explore deck options to learn deck contingencies associated with reward and punishment
3 (i.e., emotional processing of monetary feedback; Bechara, 2005; van den Bos et al.,
4 2013). Players are mostly focused on immediate large rewards, overlooking the risk of
5 accumulating losses. Eventually, successful participants abandon this high-risk default
6 strategy and settle into choices that provide small gains, but at the same time result in
7 even smaller losses. Thereby, subsequent blocks three, four, and five are considered the
8 “performance stage”, when participants theoretically decrease or overcome the emotions
9 associated with large gains and losses so they can exploit advantageous cumulative long-
10 term choices (Bechara, 2005; van den Bos et al., 2013).

11 There are established gender differences in IGT performance (Byrne & Worthy, 2016;
12 Flores-Torres et al., 2019; Singh et al., 2020; van den Bos et al., 2012; van den Bos et al.,
13 2013) such that men tend to achieve higher performance on the task than women.
14 Specifically, women tend to require more trials to demonstrate the ability to consistently
15 choose from the advantageous long-term deck-cards compared with men (van den Bos et
16 al., 2012; van den Bos et al., 2013). These gender performance differences typically
17 appear during the “performance stage” (Overman et al., 2006; Weller et al., 2010). One
18 potential mechanism for the gender differences in IGT performance is negative emotion.
19 According to the Somatic Marker Theory (SMT; Damasio, 1999), negative emotion is
20 especially important for guiding decision-making when there is no information to decide
21 rationally, as it occurs when solving the IGT. Moreover, a few studies have shown that
22 IGT performance is affected by incidental negative emotion (Bagneux, Font, & Bollon,
23 2013; Buelow & Suhr, 2013; de Vries, Holland, and Witteman, 2008; Suhr & Tsanadis,
24 2007). For example, Bagneux et al., (2013) found that participants induced to feel fear or
25 sadness were found to decide less advantageously during the IGT than those induced to

1 feel anger, happiness, or disgust. In the same vein, de Vries et al. (2008) found that
2 participants conducting the IGT in a positive mood condition performed significantly
3 better than players in a negative mood condition, but only during block two of the IGT.
4 Furthermore, negative mood has been directly correlated with Deck B selection
5 (disadvantageous deck) and inversely correlated with Deck D selections (advantageous
6 deck) (Buelow & Suhr, 2013) as well as with riskier IGT decisions (Suhr & Tsanadis,
7 2007).

8 Previous research has demonstrated that women exhibit stronger negative emotions than
9 men (Aluja, Rossier, Blanch, Blanco, Martí-Guiu, & Balada, 2015; Bradley, Codispoti,
10 Sabatinelli, & Lang, 2001; Stevens & Hamann, 2012). For example, Bradley et al., (2001)
11 found that women presented a broad disposition to respond with greater defensive
12 reactivity to aversive pictures, regardless of specific content. In another study, conducted
13 with Spanish and Swiss participants, women of both countries showed significantly
14 higher scores than men in response to those IAPS pictures categorized as having negative
15 valence–high arousal (Aluja et al., 2015). Evidence about the neural mechanisms
16 underlying these gender differences is described in detail in the meta-analyses of Stevens
17 & Hamann (2012) who reported that, when processing negative emotions, women
18 exhibited greater activation than men in the left amygdala, a key region for emotion
19 processing (as well as in other regions including the left thalamus, hypothalamus,
20 mammillary bodies, left caudate, and medial prefrontal cortex). This suggests that women
21 respond more strongly to negative emotional stimuli than men. Since negative emotion
22 may negatively affect decision-making, this seems to be especially consequential for
23 women, who during punishment anticipation, decrease the economic utility of their
24 choices more than men (Brody, 1993; Fujita Diener & Sandvik, 1991; Croson & Gneezy,
25 2009). However, whether the source of decreased baseline IGT performance in women is

1 an incidental or task-related negative emotion, conditions that mitigate negative emotion
2 during the IGT should improve their IGT performance. Furthermore, if women are more
3 negatively impacted by negative emotion than men, in decision-making contexts and
4 more generally, these mitigating conditions should have a stronger effect on the IGT
5 performance for women than men.

6 Consistent with this prediction, we have previously found that exposure to incidental
7 humor (which reduces negative emotion; Fredrickson, 2001; Tugade & Fredrickson,
8 2007; Speer & Delgado, 2017) also selectively improves women’s IGT decision-making
9 (Flores-Torres et al., 2019). Men, by contrast, perform worse on the IGT under humorous
10 conditions.

11 Certainly, humor is not the only way we mitigate negative emotions. Cognitive
12 reappraisal is an emotion regulation strategy used to transform the meaning of a specific
13 situation, which then changes the subsequent emotion (Gross, 2001). Reappraisal
14 includes reinterpretation, reconsideration, and reframing of negative information
15 which can result in a reduction in negative emotions, such as when a student reframes a
16 poor test grade as a learning opportunity rather than a failure. Cognitive reappraisal is a
17 useful strategy to mitigate negative emotion, resulting in successful modulation of self-
18 reported emotion, peripheral psychophysiology, and neural measures of emotion (for a
19 brief review, see McRae & Gross, 2020). If mitigating negative emotion with humor helps
20 women improve their IGT performance, then, cognitive reappraisal may also result in
21 greater performance on the IGT. However, the effect of cognitive reappraisal on women’s
22 IGT performance has not been previously examined. While positive reappraisal and
23 humor may have similar emotional effects, it is notable that cognitive reappraisal is
24 thought to be an effortful, relatively cognitively costly strategy (Gross, 2001; Ortner et
25 al., 2016; Ortner & Koning, 2013; Sheppes et al., 2014; Troy et al., 2018). Therefore, it

1 is unknown whether the effect of reappraisal on women's IGT performance will be similar
2 to that of humor, or whether this way of diminishing negative emotion will take up
3 valuable cognitive resources that would otherwise help solve the IGT.

4 It is possible that mitigating negative emotions could impair men's IGT performance. We
5 recently observed that, unlike women, humor impaired men's IGT performance,
6 specifically during the performance stage of the task (Flores-Torres et al., 2019).
7 Furthermore, there is evidence suggesting that women are more skilled at performing
8 positive reappraisal (cognitively changing negative emotion into positive emotion) to
9 mitigate their negative emotion compared with men (McRae et al., 2008). As such,
10 positive reappraisal may likely have a stronger benefit on IGT performance for women
11 than men. The objective of the present study is to explore whether using positive
12 reappraisal to mitigate negative emotion in response to negative pictures impacts IGT
13 decision-making and whether this effect is moderated by gender. To pursue this aim, we
14 conducted a study, in which we interspersed negative pictures (which were incidental to
15 the IGT) with small blocks of IGT trials. Participants were randomly assigned to either
16 an experimental (reappraisal group: instructed positive reinterpretation of negative
17 pictures) or a control group (non-reappraisal group: instructed to react naturally to
18 negative pictures). All participants viewed and rated the same negative pictures while
19 solving the IGT, with the only difference being the instruction to re-interpret the meaning
20 of the pictures so that their negative emotion decreased in the positive reappraisal group.

21 We expected that both women and men in the experimental group would report lesser
22 negative emotion than those in the control group, as positive reappraisal would be helpful
23 to decrease negative emotion (Hypothesis 1). We predicted that women in the
24 experimental group would demonstrate higher IGT performance than women in the

1 control group, specifically during the performance stage (Blocks 21-25)¹ as previously
2 reported (Hypothesis 2). We also predicted that the effect of reappraisal on IGT
3 performance would be stronger for women than men, especially during the performance
4 stage. However, we were unsure whether the direction of the effect of reappraisal would
5 be the same (but significantly reduced), equal to zero, or, as we have previously observed,
6 significant in the opposite direction (Hypothesis 3).”

7 **Methods**

8 *Participants*

9 Inclusion criteria, determined *a priori*, were (1) being an undergraduate student at the
10 University of Denver (this is due to the availability of the sample), (2) speaking English
11 fluently (participants needed to engage in the consent procedure, follow written
12 instructions, and complete questionnaires written in English), and (3) having normal or
13 corrected-to-normal vision (participants needed to see the IAPS pictures clearly and read
14 and understand the instructions presented relatively briefly). Exclusion criteria were (1)
15 reporting a current diagnosis of a neuropsychiatric disorder (severe mood and psychiatric
16 disorders may affect the results of the IGT (See meta-analysis of Mukherjee & Kable,
17 2014; Hegedus et al., 2018)), (2) presenting scores in the Beck depression inventory (BDI;
18 Beck, Steer & Brown, 1996) over the cutoff score for depression in the US population,
19 (3) reporting a history of drug or alcohol abuse and/or consumption of drugs within 24 of
20 participating in the experimental task (drug and alcohol abuse may affect IGT results as
21 well (O’Brien, Lichtenstein & Hill, 2014)).

¹ According to previous studies (Weller et al., 2010; Flores-Torres et al., 2019), we expected to find differences in the last blocks. In the present study, blocks 21 to 25. Although we cannot precisely determine **a priori** in a 450 trial-task where the learning stage ends, we assume that near the end of the task (last 20%), participants are in the performance stage.

1 The sample size was determined before data collection, based on our previous study
2 (Flores-Torres et al., 2019), in which, we reported a large effect size of Cohen's $f = .47$
3 for the hypothesized triple interaction (Gender by Group by Blocks). Using the same
4 design, we estimated large effect size ($f = .40$), $\alpha (.05)$, and power of (.80), which leads
5 to a minimum of 64 participants required (32 women and 32 men) using G* power 3.1
6 (Faul, Erdfelder, Lang & Buchner, 2007). When we had enrolled 32 women, there were
7 still not enough men enrolled, so we continued recruitment until we reached the
8 recommended sample size for men (with room to exclude non-compliant participants),
9 and over-sampled women. As such, 103 (62 women and 39 men) participants completed
10 the study. Exclusions (one man and three women) were: one participant (a man) reported
11 consuming drugs before the session and the other three participants (three women)
12 presented severe depressive symptomatology according to the BDI. Therefore, a random
13 selection of the women and all eligible men (38 men; mean age 20.05, SD = 2.71 and 38
14 women; mean age 19.68, SD = 1.77) were included in the final analyses.

15 To evaluate independently sex and gender, we asked participants to report their sex
16 assigned at birth (male, female) and gender identity (i.e., man, woman, no answer). For
17 all the participants reported here, sex assigned at birth matched with the most commonly
18 co-occurring gender identity.

19 ***Questionnaires and instruments.***

20 *The State-Trait Anxiety Inventory* (STAI; Spielberger et al, 1970).

21 It was used to assess anxiety symptoms. It consists of 40 questions divided into two
22 subscales: the state anxiety (SA; Cronbach's alpha = .924 in the present sample) and the
23 trait anxiety (TA; Cronbach's alpha = .948 in the present sample) scales. Higher TA
24 scores have been associated with differences in emotional reactivity and impairments in

1 women's decision-making that could potentially affect our results (Miu et al., 2008; de
2 Visser et al., 2011).

3 *The Sensitivity to Punishment and Sensitivity to Reward Questionnaire* (SPSRQ; Torrubia
4 et al., 2001).

5 It consists of 48 yes-or-no questions, divided into two subscales: sensitivity to punishment
6 (SP; Cronbach's alpha = .946) and sensitivity to reward (SR; Cronbach's alpha = .89).

7 The questionnaire has been extensively used both in behavioral and psychophysiological
8 studies (Black et al., 2014). In our current study, we administered the SPSRQ-20, which
9 has demonstrated better fit adjustment, validity, and reliability than the original version
10 (Aluja & Blanch, 2011). The use of SPSRQ will inform us whether the performance of
11 participants is associated with any particular sensitivity to punishments or rewards. High
12 sensitivity to rewards has been proposed as a possible mechanism to explain lower
13 performance (risk-seeking behavior) conversely, sensitivity to punishments has been
14 proposed as a possible mechanism for increased performance (risk-aversion behavior).

15 *The Positive and Negative Affect Schedule* (PANAS; Watson et al., 1988).

16 It consists of two 10 items-scales to measure both positive (Cronbach's alpha = .876, pre-
17 task, .921 post-task) and negative affect (Cronbach's alpha = .78, pre-task, .831 post-
18 task). Each item is rated on a 5-point scale of 1 (not at all) to five (very much). The
19 measure has been used mainly as a research instrument of affect (Crawford & Henry,
20 2004). The evaluation of PANAS before and after the IGT will help us to understand
21 whether there are affective changes attributable to the experimental conditions, or if these
22 are related to an affective state prior to the IGT.

23 *The Emotion Regulation Questionnaire* (ERQ; Gross & John, 2003).

24 It is a 10-item scale designed to measure respondents' tendency to regulate their emotions
25 using two strategies, cognitive reappraisal (Cronbach's alpha = .827) and expressive

1 suppression (Cronbach's alpha = .761). Respondents answer each item on a 7-point Likert
2 scale ranging from 1 (strongly disagree) to 7 (strongly agree). The ERQ will allow us to
3 detect any possible differences in the habitual use of cognitive reappraisal or expressive
4 suppression, which sometimes relate to performance on emotion regulation tasks.

5 *International Affective Picture System, IAPS* (Lang et al., 2008).

6 In order to induce negative emotion, a selection of 75 pictures with negative valence from
7 the IAPS (see supplemental material) were used (mean valence = 2.18; *SD* = 0.25). The
8 same set of pictures were presented in the same order to the reappraisal group and the
9 non-reappraisal group. Negative emotion was assessed by asking participants "How
10 negative do you feel?" in a numerical rating scale ranging from 1 (Not at all) to 9
11 (Strongly negative).

12 We chose to ask participants to reappraise incidental negative stimuli, rather than, for
13 example, reappraise their responses to the IGT trials themselves, for several reasons. First,
14 we wanted to have more precise control over the negative emotion to be regulated during
15 our between-subjects design conducted to test the effect of reappraisal on negative
16 emotion. By presenting negative stimuli, we decreased the individual variation in
17 negative emotion experienced during the IGT task, which differed based on choice
18 behavior, confounding emotion, and task performance. Second, we wanted to parallel our
19 previous study which used humorous stimuli to induce positive emotion (Flores et al.,
20 2019). Third, we wanted to use an established reappraisal paradigm that we know leads
21 to reliable changes in emotion (and previously resulted in gender differences) (McRae et
22 al., 2008).

23

24

25 *The IGT.*

1 In the Iowa Gambling Task, after participants choose a card out of any of four card decks
2 (A, B, C, and D), they gain (reward) or lose money (punishment). Participants must learn
3 as they play which are the advantageous decks to solve the task and are informed that the
4 goal is to win/avoid losing money as much as possible. Choosing decks, A and B
5 (disadvantageous decks) results in high immediate rewards (e. g, \$100), but over time,
6 results in accumulating little or no profit (net loss of \$250 during the 10 first trials),
7 because of occasional large monetary punishments. Decks C and D (advantageous decks)
8 result in an immediate lower reward (e. g \$50), but over time, results in accumulating
9 profit (net winning of \$250 during the first 10 trials). Given previous work indicating that
10 women require more trials to choose advantageously than men, we modified the original
11 number of trials from 100 to 450. We also modified the feedback shown to participants,
12 following Cui et al guidelines (2013) in which the presentation of win and losses observed
13 in the original task is replaced by net scores of either winning or losses.
14 IGT performance was calculated by computing the difference between advantageous and
15 disadvantageous choices $[(C+D) - (A+B)]$. Performance was computed for twenty-five
16 blocks or sets of eighteen choices.

17 ***Procedure***

18 After reading an overview of the task, participants completed a practice session during
19 which the experimenter showed sample pictures not used in the experiment. For the
20 reappraisal group, the experimenter prompted the participant to narrate aloud their self-
21 generated reinterpretation of the image. For example, in response to an image of two
22 people carrying a child whose shirt is covered in blood, the participant may reappraise
23 that: (a) the boy will be soon fully recovered and even healthier than before, (b) will be
24 recognized for their bravery with an award, or (c) this is a turning point in a bloody
25 conflict that will inspire peace and collaboration. Participants using a non-reappraisal

1 strategy (such as expressive suppression or distraction) were redirected to use reappraisal.
2 For the non-reappraisal group, participants were instructed to respond naturally and
3 during training, to report whatever thoughts and feelings they would naturally have in
4 response to the pictures. Practice sessions for the decision-making task were also
5 included, according to Bechara manual guidelines (2007), although during the practice,
6 IGT probabilities for each deck were switched to prevent learning the task (participants
7 were informed that probabilities during practice were unrelated to probabilities during the
8 task).
9 Each trial began with a written instruction, “LOOK” or “CHANGE TO POSITIVE,” for
10 the non-reappraisal or to the reappraisal groups, respectively. The instruction was shown
11 for 2000 ms, followed by a fixation cross for 1000 ms, and a negative IAPS picture for
12 7000 ms. Then the text “How negative do you feel?” was presented, with a scale ranging
13 from 1 (Not at all) to 9 (Strongly negative) with no time limit to answer to it; participants
14 indicated their response using number keys on the keyboard. Each picture was followed
15 by six decision-making trials in which participants saw four decks of cards (A, B, C, and
16 D) and chose one of the available options by clicking on the deck with a mouse. When
17 participants selected a card, its perimeter lit up in red. Then, feedback was shown for 2000
18 ms. Feedback depended on the probabilities according to Bechara IGT manual (2007).
19 During the screen showing the four-deck options, on the central superior area of the
20 screen, two bars appeared: a green bar (accumulated winnings and losses), and a red bar
21 (lent money), which were automatically updated on each trial (Cui et al, 2013).
22 Participants were told that positions and decks contingencies were fixed during the task,
23 that they could change decks at will, and that there was no association between pictures
24 and decks. Participants completed 75 pictures and 450 IGT trials (divided into 25 blocks

1 of 18 trials each). Due to the length of the task, we also programmed two brief breaks
2 (after 40% and 70% of total trials).

3 ***Data analysis***

4 *Experimental analysis.* To test whether reappraisal ameliorates negative emotion among
5 women and men (Hypothesis 1) we conducted a three-way mixed-design ANOVA on
6 negative emotion ratings, with two between-group measures [Gender (women/men) and
7 Group (reappraisal/non-reappraisal)] and one repeated measure [Block (1-25)]. Second,
8 to test whether the experimental manipulation improved IGT performance in women
9 (Hypothesis 2) and what effect it had in men (Hypothesis 3) we performed another three-
10 way mixed-design ANOVA [Gender by Group (reappraisal/non-reappraisal) by Blocks
11 (1-25)] on IGT performance.

12 *Multiway ANOVA correction procedures.* Based on Cramer et al., (2015) we implemented
13 corrections for multiple comparisons using sequential Bonferroni and Benjamini-
14 Hochberg procedures. The first one, also known as Bonferroni-Holm correction (Hartley,
15 1955), adequately controls for the “familywise error”. In this procedure, first, all p -values
16 are sorted in ascending order and are assigned a rank number from 1 (smallest) to k
17 (largest). Next, one starts by evaluating the first (smallest) p -value ($p^{(1)}$) against the
18 adjusted (α_{adj}), which is for the first p -value equal to α divided by k . If the p -value is
19 smaller than α_{adj} , then the first hypothesis $H^{(1)}$ is rejected, and one proceeds to the second
20 p -value. If the p -value is not smaller than α_{adj} then one immediately accepts all null
21 hypotheses and stops testing. Although this procedure is robust to control for Type I
22 error, it has been criticized because it reduces statistical power and thus inflates Type II
23 error (Cramer et al., 2015). For that reason, we also implemented a second method to
24 control the false discovery rate (FDR; Benjamini et al., 2001). The exact procedure
25 implemented was the Benjamini-Hochberg. In this procedure first, one sorts all p -values

1 in ascending order again. Next, one starts by evaluating the last (largest) p -value ($p^{(k)}$)
2 against the adjusted α (α_{adj}), which is for the last p -value equal to k divided by m times
3 α . If the p value is smaller than α_{adj} , then all null hypotheses are rejected and testing stops.
4 If the p -value is not smaller than α_{adj} , then one proceeds to the next p -value.
5 *Additional analysis:* In order to examine whether the effect of group on IGT performance
6 was mediated by negative emotion and whether this mediational effect was moderated by
7 gender, we conducted a multigroup path analysis with centered variables, bootstrapped
8 standard errors, indirect effects, and non-symmetric bootstrap confidence intervals using
9 the software MPlus (Muthén & Muthén, 1998-2017). We used the centered total IGT
10 performance mean scores and the centered total negative emotion mean scores because at
11 this very moment mediational analyses cannot be performed on repeated measures data
12 with more than two repeated timepoints.

13 **Results**

14 *Preliminary analysis.*

15 Before conducting any analyses, we checked normality, linearity, and sphericity
16 assumptions. In case the sphericity assumption was violated, we used the Greenhouse-
17 Geisser corrected parameter ϵ . Our significance threshold was $p < 0.05$, with Bonferroni
18 corrections for post hoc comparisons. We did not observe any significant group
19 differences in demographics (for details, see the supplemental material).

20 *STAI, SPSRQ, ERQ, and PANAS.*

21 We did not observe any significant group differences for STAI, SPSRQ, nor for ERQ
22 (for details, see the supplemental material), but did for the PANAS. For the pre-task
23 PANAS, our MANOVAs (Gender x Group) showed no significant differences in
24 positive nor in negative affect. Our separate mixed design ANOVAs examining pre- and
25 post- task differences showed only a main effect of Time (pre vs. post) on positive

1 affect, $F(1,72) = 13.26, p = .001, \eta^2 = .16$, indicating that positive affect significantly
2 decreased from pre-task to post-task ($M_{\text{pre-task}} = 26.54, SD_{\text{pre-task}} = 7.25; M_{\text{post-task}} =$
3 $23.17, SD_{\text{post-task}} = 9.36$). Additionally, results on negative affect scores showed an
4 unexpected but reasonable interaction of Time (pre vs. post) by Group (non-reappraisal
5 vs. reappraisal), $F(1,72) = 6.24, p = .02, \eta^2 = .08$, indicating that only participants in the
6 non-reappraisal group showed increasing levels of negative affect from pre-task to post-
7 task ($M_{\text{pre-task}} = 12.82, SD_{\text{pre-task}} = 3.91; M_{\text{post-task}} = 16.74, SD_{\text{post-task}} = 5.00$) as
8 compared with the participants in the reappraisal group who did not ($M_{\text{pre-task}} = 13.39,$
9 $SD_{\text{pre-task}} = 3.52; M_{\text{post-task}} = 14.28, SD_{\text{post-task}} = 4.60$). We additionally observed a
10 significant main effect of time $F(1,72) = 18.70, p < .001, \eta^2 = .21$.

11 ***The effect of positive cognitive reappraisal on negative emotion rating***

12 The ANOVA showed a statistically significant main effect of Group. This indicated that
13 participants significantly reduced their negative emotion via reappraisal $F(1,72) =$
14 $118.18, p < .001, \eta^2 = .62$ across the whole task (from Block 1 to 25). We also observed
15 a significant two-way interaction (Gender by Group) on emotional rating $F(1,72) = 9.28,$
16 $p = .003, \eta^2 = .11$, which indicates that the reduction of negative emotion through
17 reappraisal was more effective in women than in men (given that in non-reappraisal
18 women reported greater intensity when viewing negative images than men, but no
19 difference when reappraising) (see Figure 2 and Table 1). Finally, we found a significant
20 triple interaction (Gender by Group by Blocks) on emotional ratings, $F(13.24,953.14) =$
21 $2.05, p = .01, \eta^2 = .03$, indicating that in the non-reappraisal control group, women
22 reported higher levels of negative emotion than men from Block 2 onwards, see Figure 1
23 and Table 2. By contrast, in the positive reappraisal experimental group, we did not
24 observe significant differences between men and women (except in block 17) See Figure
25 1 and Table 2. This indicates a gender difference in unregulated reactivity to the negative

1 pictures, but no gender differences in the level of negative emotion resulting from
2 reappraisal.

3 [Please, insert Figure 1 and Figure 2 and Table 1 and Table 2 near here]

4 ***IGT performance (Look negative vs Change to positive)***

5 Consistent with our predictions, we observed a statistically significant triple interaction
6 (Gender by Group by Blocks), $F(8.80, 633.53) = 7.86, p < .001, \eta^2 = .09$, indicating that
7 for women, those in the reappraisal group performed significantly *better* on the IGT than
8 the women in the non-reappraisal group consistently from Block 15 onwards. See Figure
9 3 and Table 3. By contrast, men in the reappraisal group performed significantly worse
10 on the IGT, compared to men in the non-reappraisal group, from block 13 onwards. See
11 Figure 3 and Table 3.

12 [Please, insert Figure 3 and Table 3 near here]

13 These results indicate that positive reappraisal benefits women's IGT performance
14 (compared to women in the non-reappraisal group) and strikingly, that reappraisal
15 impairs men's performance (compared to men in the non-reappraisal group). Comparing
16 men and women in the non-reappraisal control group, we found that – consistent with
17 numerous reports in the literature – men performed better on the IGT than women F
18 $(1, 72) = 42.03, p < .001, \eta^2 = .37; M_{\text{men non-reappraisal}} = 12.11, SD_{\text{men non-reappraisal}} = 2.39; M_{\text{women non-reappraisal}} = 1.23, SD_{\text{women non-reappraisal}} = 4.50; 95\% \text{ CI} = 7.04, 14.72$ from Block 6
19 onwards. But due, to the opposing effects of reappraisal on men and women's IGT
20 performance, in the reappraisal group, we did not observe significant differences
21 between men and women ($F(1, 72) = .02, p = .89, \eta^2 = .00; M_{\text{men reappraisal}} = 6.91, SD_{\text{men}$
22 $\text{reappraisal}} = 7.75; M_{\text{women reappraisal}} = 6.67, SD_{\text{women reappraisal}} = 4.57; 95\% \text{ CI} = -3.6, 4.08$).
23 See Figure 3 and Table 4. The main effect of Gender (with men performing better than
24 women overall) was also statistically significant $F(1, 72) = 21.95, p < .001, \eta^2 = .23$.

1 The main effect of Blocks was also statistically significant $F(8.80, 633.53) = 40.19, p <$
2 $.001, \eta^2 = .36$ indicating an improvement in performance over time.

3 [Please, insert Table 4 near here]

4 **Multiway ANOVA corrections.** The implementation of sequential Bonferroni
5 correction to control for familywise error and Benjamini-Hochberg procedure to control
6 for false discovery rate on the exploratory three-way factorial ANOVA (Gender by Group
7 by Blocks) performed on negative emotion ratings, provided evidence to reject all null
8 hypotheses (See Table 5). The same correction analysis performed on the exploratory
9 three-way factorial ANOVA (Gender by Group by Blocks) on IGT performance also
10 provide evidence to reject all null hypotheses, except for two tests (the interaction of
11 Blocks and Group and the main effect of Group) which in the multiway ANOVA without
12 correction already showed non-significant results (See Table 6).

13 [Please, insert Table 5 and 6 near here]

14 **Multi group path analyses results.**

15 A priori, we strongly expected that the regulation of negative emotions was causing the
16 improvement on IGT performance in women. Therefore, we expected that only in women
17 the indirect effect between group and IGT performance would be statistically significant.
18 However, we never predicted that a cause of IGT impairment for men was reduced
19 negative emotion due to reappraisal. Rather, our predictions for men were theoretically
20 related to the costs of switching between tasks or using cognitive resources to follow
21 reappraisal instructions. Therefore, we never expected the indirect path to be significant
22 for men. To reflect these predictions, we fixed to 0 both the indirect effect of group on
23 IGT performance (in the case of the men) and its direct effect (in the case of the women).
24 The fit index of this model was very good (chi-square = 2.765, $df = 2$; CFI = .99; TLI
25 = .998; SRMR = .037), supporting our hypothesis. The final model is presented in Figure

1 4. The direct and indirect effects and their confidence intervals calculated using
2 bootstrapping are presented in Table 7.

3 [Please, insert Figure 4 and Table 7 near here]

4 **Discussion**

5 The objective of the present study was to explore whether ameliorating negative emotion
6 via positive reappraisal affected IGT decision-making performance, and whether this
7 effect was moderated by gender. Consistent with our first hypothesis, both the men and
8 the women in the reappraisal group were able to reduce their subjective negative emotion
9 after following instructions to use positive reappraisal. Additionally, as predicted in our
10 second hypothesis, women engaging in positive reappraisal demonstrated improved
11 decision-making on the IGT (consistently from Block 15 onwards). As we predicted, this
12 effect was stronger for women than men, as positive reappraisal had a significantly
13 detrimental effect on decision-making performance for men. Furthermore, while men
14 showed greater IGT performance than women in the control group, our results indicated
15 that men and women in the positive reappraisal group showed no differences on IGT
16 performance. Finally, an additional multigroup mediational path analysis achieved very
17 good fit, which reflected a significant gender moderation such that reappraisal benefitted
18 women's IGT performance to the extent that they successfully changed their negative
19 emotion, identifying one mechanism by which reappraisal improved women's IGT
20 performance.

21 This is the first time that men and women report such markedly different downstream
22 effects of using positive cognitive reappraisal, and the first time that a reappraisal
23 manipulation has been applied to the IGT. Despite the effort involved in implementing
24 reappraisal, women in the positive reappraisal group improved consistently their IGT
25 performance from Block 15 onwards when compared to the women in the non-

1 reappraisal group. These findings are in in line with the results of our previous study
2 (Flores-Torres et al., 2019), in which we demonstrated that humor (another way to reduce
3 negative emotion) also improved women’s IGT performance. Together, our results show
4 that reducing negative emotion can have a positive effect on women’s decision-making.
5 In addition, our findings suggest that gender differences previously found in IGT
6 performance are reversible via reducing negative emotion. Whether the source of the
7 unregulated gender differences is incidental negative emotion, task-based negative
8 emotion, both, or neither needs to be examined in future studies assessing emotion in
9 response to the IGT and including a neutral condition in which negative emotion is not
10 induced.

11 Our findings are in line with previous studies indicating that negative emotion harms IGT
12 decision making (Bagneux, Font, & Bollon, 2013; Buelow & Suhr, 2013; de Vries,
13 Holland, and Witteman, 2008; Suhr & Tsanadis, 2007). Nonetheless, none of these
14 studies considered gender as a moderator in their analyses. Future research examining
15 the effect of emotions on decision making should take into account that this effect seems
16 to be moderated by gender, and that not considering this variable can lead to misleading
17 conclusions.

18 In the case of women, the fact our well-fitting model did not include the direct effect of
19 reappraisal suggests that the vast majority of the effect goes through the mediator
20 (negative emotion). Nonetheless, other mediators may be participating sequentially. In
21 this vein, studies examining the mechanisms by which the reduction of negative emotion
22 affects IGT performance are needed. For example, the decrease in negative emotion may
23 help women to focus on the task, or decrease their sensitivity to punishment (van den Bos
24 et al., 2013), and these others factors may improve decision making.
25 Uncertainty/certainty appraisal tendencies may be another mechanism explaining the

1 effect of negative emotions on IGT performance (Bagneux et al., 2003). According to the
2 Appraisal Tendency Framework (ATF), specific emotions give rise to specific cognitive
3 and motivational processes, which account for the effects of each emotion upon cognition
4 (Han, Lerner, & Keltner, 2007). Whereas negative emotions such as fear and sadness are
5 associated with uncertainty appraisals, emotions such as anger, happiness, and disgust
6 are associated with certainty appraisals (Bagneux et al., 2003). In fact, Bagneux et al.
7 (2003) found that participants induced to feel emotions associated with uncertainty (fear,
8 sadness) decided less advantageously in the IGT than participants induced to feel
9 emotions associated with certainty (anger, happiness, disgust). According to these
10 authors, certainty-associated emotions would engage participants in intuitive processing,
11 which is necessary to lead participants to rely on emotional cues arising from previous
12 decisions and to making advantageous decisions. By contrast, uncertainty-associated
13 emotions would engage them in deliberative processing and, therefore, lead them to make
14 disadvantageous decisions.

15 Regarding men, the reason why reappraisal decreased IGT performance remains
16 unknown, and it does not seem to be related to the decrease of negative emotion.
17 Although positive reappraisal did reduce negative emotion among men, this effect was
18 not accompanied by increased IGT performance. On the contrary, positive reappraisal
19 significantly hindered IGT performance in men. This is also consistent with our previous
20 study, where we found that humor harmed men's IGT performance (Flores-Torres et al.,
21 2019). Further studies examining the precise mechanisms by which humor and
22 reappraisal hinder men's IGT performance are indeed needed. More studies with
23 different goals and tactics of cognitive reappraisal (e.g., reappraising to decrease negative
24 emotion vs increasing positive emotion) are needed to fully understand its effect on IGT
25 decision-making and potential moderation by gender. Our results are also in-line with a

1 previous study reporting that men engage regions associated with cognitive control and
2 positive emotion to a lesser extent than women while reappraising (McRae et al., 2008),
3 nevertheless, future research is needed to understand the brain regions associated with
4 reappraisal, gender and IGT performance. In the present study, it is impossible to separate
5 the cognitive processes engaged during reappraisal from the emotional outcomes of
6 successfully using reappraisal. Therefore, more research is needed to explore possible
7 psychological and neural mechanisms explaining differences in emotional and cognitive
8 processing of men and women during the IGT.

9 It has been argued that the use of cognitive reappraisal is relatively cognitively
10 demanding (Gross, 2001; Ortner et al., 2016; Ortner & Koning, 2013; Sheppes et al.,
11 2014; Troy et al., 2018), thus decreased performance in the IGT may be explained by
12 cognitive fatigue. If this would be the case, all participants exposed to this condition
13 would show impaired IGT performance compared to the non-reappraisal group by the
14 end of the task. We found no evidence supporting this hypothesis for women, who
15 performed significantly better in this group than in the non-reappraisal one. One previous
16 study reported that when men's attention is divided between the IGT and another
17 unrelated task, men had poorer performance and women had better performance on the
18 IGT (Preston et al., 2007). Therefore, is possible that decreased attention (due to
19 increased cognitive load) could be one possible mechanism by which reappraisal impairs
20 men's IGT performance, although it is still unclear why this effect is limited to men. We
21 suggest that as McRae et al., (2008) proposes, under normal conditions men could
22 regulate their negative emotions without the use of active cognitive resources. This could
23 be critical to understand what happens in men because it suggests that during IGT they
24 could rapidly allocate their cognitive resources toward solving the task and not deal with
25 the impact of negative emotions instead. Our experiment might be especially demanding

1 for men because during reappraisal the participants (men and women) were instructed to
2 use a cognitive technique to regulate their emotions, a technique that certainly could have
3 a deleterious effect on men's performance as they necessarily had to split their cognitive
4 resources between the regulation of emotions and the task, impairing as a result the
5 cognitive efficiency of men toward the IGT. This hypothesis should be tested in future
6 studies.

7 The present study has some limitations. Although our primary measure of interest was
8 decision-making performance with objective scoring, our primary measure of emotion
9 was subjective report. Future studies might examine psychophysiological or neural
10 measures of emotion to corroborate these self-reports. In addition, we compared positive
11 reappraisal to a non-regulation control condition. It is possible that comparing reappraisal
12 vs. another active emotion regulation technique (e.g., distraction, expressive suppression;
13 McRae & Gross, 2020) would show specific effects of using reappraisal. Unfortunately,
14 as our design used negative emotional stimuli, we did not collect trial-by-trial data
15 indicating which tactics participants used to change their positive emotions (McRae,
16 Ciesielski & Gross, 2012; Waugh et al., 2016). We do, however, have pre- and post- task
17 PANAS scores, indicating that positive affect decreased from pre- to post- task, but did
18 not interact with condition or gender. It is unclear whether this decrease in positive
19 emotion is a consequence of performing the IGT or a consequence of the negative
20 emotion elicited by the images in the task. Furthermore, we acknowledge that our control
21 condition included a negative emotion induction – therefore we cannot separately report
22 on the effect of negative emotion on decision-making. Future studies examining whether
23 the effect of negative emotion on IGT performance is moderated by gender should
24 include other methods to decrease negative emotion that do not require previously
25 inducing negative emotion Finally, the results of the multigroup path analysis should be

1 interpreted with caution, as they were post hoc models, and the design of the study
2 (including sample size) was not optimized for this analysis. Future studies testing the
3 mechanism underlying the effect of reappraisal in decision making, considering higher
4 sample sizes and in which several mediational factors are assessed (e. g., attentional
5 factors, positive emotions, sensitivity to punishment, uncertainty emotions) should be
6 performed.

7 Our study also has several important strengths. This is the first study examining whether
8 the effect of negative emotion on IGT performance is moderated by gender, and the first
9 examining this using cognitive reappraisal. Our results extend previous research about
10 the benefits of cognitive reappraisal (Ford, Karnilowicz & Mauss, 2017, Halperin &
11 Gross, 2011, McRae & Gross, 2020, Wang et al, 2021) to the field of decision-making.

12 Furthermore, we implemented robust analysis on our data: primarily analysis of variance
13 examining the effect of condition and gender on individual blocks of performance and
14 negative emotional scores, and ultimately to explore the mechanisms involved in the
15 effect of condition on IGT performance (considering gender and negative emotion
16 scores), a multi group path analyses testing the hypothesized direct and indirect pathways
17 of these effects. Ultimately, we conducted a well-powered study to examine emotion
18 regulation and decision-making, and observed striking moderation by gender in the effect
19 of reappraisal on IGT performance. Our results underscore the importance of examining
20 gender differences as a moderating variable which reveals important interactions which
21 may go unidentified when combining participants across gender.

22

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1 **Figures.**

2 **Figure 1:** Model. First stage of Moderated Mediation Model showing the direct effect
3 of group, mediating effect of negative emotion, and moderating effect of gender.

4 **Figure 2.** Results for negative emotion across IGT blocks by gender and group.
5 Participants were 38 men – 19 in the non-reappraisal group and 19 in the reappraisal
6 group– and 38 women – 19 in the non-reappraisal group and 19 in the reappraisal
7 group. Error bars indicate standard error of the mean (SEM). Results show a
8 statistically significant gender by group by blocks interaction, indicating that men in
9 the non-reappraisal group experienced lower negative emotion than women (A), but
10 in the reappraisal group there were no significant differences between men and women
11 (B).

12 **Figure 3:** Results for the Iowa gambling task (IGT) performance, specifically the
13 number of advantageous (C + D) minus disadvantageous (A+B) decks chosen across
14 25 blocks of 18 trials each. Plots shows performance by Gender, Group and Blocks.
15 Participants were 38 men – 19 in the non-reappraisal group and 19 in the reappraisal
16 group– and 38 women, 19 in the non-reappraisal group and 19 in the reappraisal group.
17 Error bars indicate standard error of the mean (SEM). Results revealed a significant
18 triple interaction effect (Gender by Group by Blocks) from block 15 onwards
19 indicating that for women, reappraisal improved performance compared to non-
20 reappraisal (1A), while for men, reappraisal impaired performance compared to non-
21 reappraisal (1B).